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1 SCOPE

This Specification including the contract drawings describes and illustrates the criteria to be used for the Contractor's design and construction of the locomotive hauled multi-level commuter rail passenger cars to be operated by the Railroad Division of the Southeastern Pennsylvania Transportation Authority (SEPTA). The cars shall be suitable in all respects for operation at speeds up to 110 mph. The cars will be operated by SEPTA over the SEPTA Railroad Division and portions of the Amtrak (National Railroad Passenger Corporation) Northeast Corridor and Harrisburg lines.

The cars shall comply in all respects with the requirements of the applicable laws and regulations of the United States of America especially the regulations of the Federal Railroad Administration (FRA) of the United States Department of Transportation (such as, but not limited to, Part 200 series of Title 49 of the Code of Federal Regulations), and of the states of Pennsylvania, Delaware, and New Jersey including their respective public utility commissions in which the cars will be operated by SEPTA. Testing will be conducted in full compliance with all FRA requirements. It is noted that while specific agency regulations and recommendations are called for in this Specification, they shall not be considered to be to the exclusion of all others.

This equipment must be built with components that allow for it to safely comply with the vehicle track interaction (VTI) safety thresholds prescribed in Title 49, Code of Federal Regulations (CFR) Parts 213.57, 213.333, 213.329, and 213.345 for cant deficiency greater than three (3) inches and/or speeds in excess of 90 mph. See also Section 11 for additional requirements for vehicle track/vehicle interaction safety limits. Requirements for VTI safety thresholds contained elsewhere in this Specification, if found to be more restrictive, shall apply.

Safety, reliability, and ease of maintenance shall be the primary design consideration. No component shall require periodic maintenance any more frequently than 184 days or overhauled more frequently than four (4) years. Consumables such as brake shoes/pads are needed on an “as required” basis. Air filters shall be of a size to allow change-out periods of no fewer than 92 days.

The cars shall be designed and constructed in compliance with this Specification and the requirements of the following agencies:

a. Federal Railroad Administration, including but not limited to, 49 CFR Parts 37, 38, 223, 224, 229, 231, 232, 236, 238

b. Federal Transit Administration (FTA)

c. U.S. Department of Transportation (USDOT)

d. U.S. Department of Health and Human Services

e. U.S. Public Health Service (USPHS)

f. Standards and recommendations of the Association of American Railroads (AAR)
g. American Passenger Transportation Association (APTA)

h. Environmental Protection Agency (EPA)

i. Association of American Railroads (AAR)

j. State of Pennsylvania

Unless otherwise specified, the latest revision of all documents referenced in this Specification as of the Notice to Proceed shall apply. It shall be the responsibility of the Contractor to deliver multi-level cars that comply with all applicable laws, rules, and regulations enacted as of the date of the Notice to Proceed.

In case of a conflict between requirements, applicable laws, rules, and regulations unless otherwise specified, the more stringent shall prevail. In case of other conflicts, the Contractor shall report the conflict and request clarification from SEPTA.

The design criteria and constraints that are known to SEPTA have been specified. Further definition and clarification are anticipated during negotiation. If other factors require definition after Contract award, the Contractor shall be responsible for making those definition requirements known to SEPTA in a timely manner for mutual investigation and satisfactory resolution. The Contractor shall not be relieved of the overall responsibility of providing an adequate design for the SEPTA service conditions.

Wherever possible, this Specification has been developed on the basis of the car performance required rather than specific hardware to be provided. Where specific hardware is mentioned, it is for the purpose of providing an example of concepts or designs acceptable to the Engineer. This approach will allow proposers to employ innovation and advanced technology where appropriate.

The cars designed and built under this Specification shall operate successfully under the environmental, operating, and physical conditions listed within these documents. The Contractor’s submittals to the Engineer concerning dimensional data, estimated weights, bills of material, and other required submittals as specified must be approved prior to construction.

1.1 INTENT

This procurement is for all labor, tooling, materials, parts, training, publications, support, special tools, warranty, spare parts, and apparatus required for car construction, use of all facilities needed for car construction, and the actual assembly of the cars. This procurement is also for all work needed to obtain tested cars ready for operation when presented for final acceptance. Any items of material or equipment, which are not fully described or are omitted in this Specification or the accepted Technical Proposal but are necessary for the completion of the cars, shall be considered a part of the scope of supply.
In this Specification, all references to "number of days" shall mean calendar days unless otherwise stated. References to "major systems" shall mean those products which are generically described by the title of any Section of this Specification, and references to "major suppliers" shall mean the suppliers of these major systems.

### 1.2 DEVELOPMENT

The apparatus and materials shall embody recommended practice, actual experience, compatibility of parts, and shall be of the latest service-tested and service-proven developments that can be incorporated without delaying delivery of the cars unless such delay is approved.

#### 1.2.1 Coordination

The Contractor shall be responsible for the system design of the entire car and all of its equipment. The Contractor shall be responsible to SEPTA for proper interrelation, function, and system integration of all phases of all vehicle systems and their interrelation with all other parts of the car and associated support and wayside equipment. Interfaces regarding "outside the car envelope" topics shall be coordinated with the Engineer by the Contractor. Subject areas requiring such interfaces include, but are not limited to, the wayside signal system, cab signal system, control center radio system, various communication systems, overhead power supply, maintenance facilities, the car's RFI and EMI limits, and clearances. This shall include both the SEPTA and Amtrak wayside.

The time system used by all microprocessor equipment on the car including all event and data recorders shall be Coordinated Universal Time (UTC). All time displays for the Operator or train crew shall be shown in Eastern Standard Time or Eastern Daylight Savings Time, whichever is appropriate for the given date, in 24 hour clock time. The Contractor is responsible for coordinating this requirement with all suppliers.

#### 1.2.2 Referenced Documents

Various codes and standards such as the AAR, APTA, ASME, ASTM, ANSI, IEC, and IEEE documents mentioned in this Specification are examples acceptable to the Engineer. Material standards and specifications, which are used by the Contractor unless otherwise approved by the Engineer, shall be of those organizations (such as ASME or ASTM) which are based in the United States or are generally used on a commercial basis in the United States. The applicable document revision shall be that in effect on the date of the proposal submission. Alternate recognized standards may be suggested by proposers in their detailed technical proposal if submitted with sufficient supporting information to establish equivalency.

Additionally, the specified standards of this Specification may be replaced with Engineer-approved equivalent standards proposed by the Contractor after Contract award. The Contractor shall be required to establish the equivalency and to obtain explicit approval from the Engineer for any substituted documents.
1.3 PROJECT IMPLEMENTATION

1.3.1 Submittals

All submittals except for the cab design mock up shall become the property of SEPTA. All submittals shall be made solely by the Contractor through the use of written correspondence describing the purpose of the submittal, the anticipated work and response by the Engineer, and the specific identification of the material submitted in terms of drawing/revision numbers, document numbers, etc.

All written communication and submittals unless otherwise noted shall be formatted as typed copy on 8.5 inches wide by 11 inches high paper. Hard copy documents shall be appropriately bound to preclude lost pages while allowing ease of use without special preparation by the Engineer. Documents that can be classified as manuals, reports, or analyses shall be fastened on the left side into a profile binder to allow convenient filing. The title of such documents shall appear on the front cove and shall appear on the spine of the binder if space permits. Electronic versions of submittals and correspondence shall also be submitted in electronic format as required in TS 1.23. All as-built drawings shall comply with the requirements of TS 1.9, and the Contractor shall carefully take these requirements into account when preparing review drawings which will later be part of the as-built drawing package.

Following the Notice to Proceed, the Contractor and the Engineer shall mutually agree on a common correspondence identification coding system. All correspondence shall be coded by the sender with a letter(s) from the English alphabet to designate the originator and with a unique sequence number to ensure distinct identity. All correspondence shall readily display the SEPTA purchase order number, denote if a reply is required, and the identity of coded correspondence being replied to if any. Both parties shall maintain a log to list the date correspondence is sent or received.

The documentation methodology particularly as regards to the submission of drawing and engineering changes shall be user friendly and allow for ease of comprehension and review to the Engineer's satisfaction. The Contractor shall organize the submissions in a logical interrelated fashion such that functionally or physically associated subjects are submitted in concert.

All official correspondence shall be submitted electronically in PDF form at a minimum. Information presented by the Contractor for presentations or design review meetings shall be in printed form at which time the Contractor shall supply a sufficient amount of copies for expected attendance plus one (1) copy in electronic PDF form. The Contractor shall acknowledge that only drawings, documents, topics, or other materials that have been thoroughly reviewed, considered Specification compliant, and/or are supported by the Contractor shall be communicated to the Engineer to promote concentrated efforts on issues that will benefit and progress the Program. To this end, all correspondence shall be retained for a minimum of five (5) years to reduce if not prevent the needless iteration of work already completed.

Should the Contractor’s drawings and schedules be inadequate in the opinion of the Engineer, the Engineer reserves the right to require the Contractor to supply the necessary additional drawings, details, and schedules.
After the production baseline has been achieved, engineering or manufacturing change orders or deviations shall be submitted to the Engineer for approval as they are issued. The Engineer or the Engineer’s representative(s) shall authorize the Contractor to proceed upon the written approval of drawings provided that the Contractor has notified the Engineer of all deviations. Engineer approval, however, will not relieve the Contractor of their responsibility to fulfill their contractual obligations. The Engineer will supply written reasons and explanations for disapproval of any required submittals.

Drawings and technical data submittals provided by the Contractor shall be in sequential order consistent with the schedule developed in the design review between the Contractor and the Engineer.

The Contractor shall not patent or copyright any original materials or information created by this procurement which will be submitted to either the Engineer or SEPTA as per Federal procurement regulations.

1.3.2 Language

All written communications, submittals, reports, drawings, correspondence, and oral communications to the Engineer shall be made in the English language using American vernacular and technical terminology conventional to that used in the North American transit industry.

1.3.3 Dimensions

All drawings generated in English dimensions need not have metric equivalents. The Contractor shall provide both metric and English style U.S. customary unit dimensioning for the drawings and other communications which are either generated in or use metric dimensions. Fractional measurements shall be expressed as a decimal value and unless otherwise noted and approved drawings shall be made using third angle projections. First angle projection shall be allowed provided all views are labeled including the front, top, bottom, and side views. Within a car subsystem, all dimensions shall be given in English or English plus metric. There shall be no mixing of dimension systems on a drawing. Refer to TS 1.9 for additional information.

1.3.4 Master Drawing Schedule

Within 90 days from Notice to Proceed, the Contractor and the Engineer shall jointly agree upon a drawing numbering system not conflicting with other SEPTA drawings to be used for this Contract. [CDRL 01-001] All drawing titles shall give full names without punctuation or abbreviations and should use simple key words to aid in searching. Revision levels should be in letters not numbers starting with "A" and be totally compatible with the Contractor’s configuration management plan.

A master drawing schedule format shall then be submitted for review and approval. The master drawing schedule shall list all drawings relative to their hierarchy from general arrangement though major assemblies, subassemblies, including their associated installations and connections, down to fabricated parts, and/or material specifications as outlined in TS 1.9.1. All expected drawings used by major suppliers/subsuppliers for FAI approvals shall be integrated and reflected in the schedule. The schedule shall also include a listing of all electrical circuit and integrated schematic, pneumatic, and clearance diagrams. The master schedule format shall also include the capability of reflecting submittal and approval status. [CDRL 01-002]
Drawing reviews shall be performed for the purpose of approval as directed within three (3) stages as found within the requirements of this Specification. These stages will consist of the conceptual design phase (CDP), detail design phase (DDP), and the pilot car assembly phase as described in this Specification.

30 days prior to the start of each phase, a full update of the master drawing schedule shall be submitted to SEPTA reflecting, at a minimum, the drawings required for the proposed phase along with any prior phase that might have been reviewed. [CDRL 01-003] The master drawing schedule shall grow with each stage with the intent of all drawings being identified by the time of the pilot car assembly phase. The master drawing schedule shall be constantly updated during the pilot car assembly phase with the latest submittal/approval status information and presented formally prior to the start of the pilot car FAI process. [CDRL 01-004]

The master drawing schedule shall have live document status. If any drawing is made obsolete during the life of the Contract, it shall be so listed and identified along with the identity of any superseding drawing number within the master drawing schedule.

1.3.5 Documents

A standard format shall be used for documentation that is carried throughout the duration of the Contract.

1.3.5.1 Document Requirements

Each document shall, as a minimum, contain the following:

a. A title page with a clear and concise title block which includes all pertinent references to the Contract and an accurate description of enclosed information

b. Approval signatures of the original document on the title page to serve as an easy reminder of the approval signatures required for all future revisions

c. The SEPTA purchase order number on the title page

d. The originating company's name and address on the title page

e. The overall revision level on the title page and display the varying revision levels on each consecutive page

f. The unique document number on each page of the document

g. A record of the specific changes of a revision on a dedicated page that includes space for new approval signatures for that revision without requiring the removal of the previous approval signatures
h. The revision levels of individual pages on a dedicated page for verification of proper document composition

i. A table of contents and an itemized listing of tables and figures

Depending on the type of document involved, additional provisions are stipulated in the applicable Section.

Information in the form of foldouts shall not be used. Where information cannot be reduced to the required format size while maintaining legibility of important detail, it shall be divided or formatted appropriately to allow consistent and organized presentations. Except where voluminous information is involved, only one (1) side of the paper shall be used. The use of both sides of the paper shall be restricted to text which allows graphical presentations to stand alone.

1.3.5.2 General Segments

As a whole, all documents shall be organized in the order of the following general segments to allow immediate recognition of information as it pertains to the Contract and to this Specification:

a. A statement of the purpose of the document and its relationship to this Specification

b. A summary, if applicable, of results and/or derived conclusions related to each individual provision where more than one (1) is involved

c. Discussion, if applicable, of background information, assumptions, and other factors necessary for the understanding of the information provided in the summary or in the body of information that follows when a summary does not apply

d. The body of the document which either contains the major and usually more extensive information that supports the summary or details of the topics concerned

e. All appendices providing either background information or a convenient collection of worksheets, drawings, and other reference material

1.4 ENGINEER APPROVAL

During the course of the project, the Contractor will be submitting a significant number of items for the Engineer's approval as required by the Contract and Specification ranging from drawings and procedures to hardware samples. The “Engineer” is defined as being a SEPTA entity which is primarily the SEPTA Project Manager and/or the Project Manager’s designee. The Contractor shall not interpret this process to mean that the Engineer will function as an arm of the Contractor's project management or engineering staff.

Submissions shall be structured to show how the Contractor is responding to the requirements of this Specification and not on the basis of requiring the Engineer to discover how the Contractor is not meeting those requirements.
All material being submitted shall have been reviewed by qualified Contractor personnel and judged to be suitable for submission prior to doing so. This shall be so stated in the letter of transmission or on the document particularly with regard to material that is passed through from subcontractors. Test results shall receive Contractor staff review and signature prior to submission. Submissions found to be deficient with regard to any of the above shall be immediately returned without review to the Contractor.

Submissions shall contain sufficient detail to confirm that Specification requirements are being met. However, the Contractor shall use judgment as to what level is appropriate and shall communicate with the Engineer when guidance is needed on a case by case basis. Documents with levels of detail and information considered to be beyond what is needed or time effective to confirm compliance shall be given cursory review by the Engineer and considered as background information and shall not receive formal approval. Individual submissions shall not contain material from multiple subsystems or subcontractors, and such submissions will be returned without review to the Contractor.

Submittals requiring the Engineer's approval prior to implementation shall be reviewed and classified by the Engineer as follows:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Interpretation</th>
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</thead>
<tbody>
<tr>
<td>a. Approved</td>
<td>The Engineer concurs with the information in its submitted form. The material may be incorporated into the Program. An approval shall not be construed as:</td>
</tr>
<tr>
<td></td>
<td>1) Permitting any departure from the Contract requirements or 2) Relieving the Contractor of the responsibility for any error including details, dimensions, materials, and calculations</td>
</tr>
<tr>
<td>b. Conditional</td>
<td>The Engineer conditionally agrees with the submitted information in principle but insufficient information was provided to allow a complete review or some details must be revised to make the information fully approved. The material must be resubmitted in revised form for Engineer approval.</td>
</tr>
<tr>
<td></td>
<td>In the case of drawing reviews designated for evaluation during the pilot assembly, drawings may be considered conditional pending verification during the pilot program at which time any deficiencies shall be reported pending full approval.</td>
</tr>
<tr>
<td>c. Disapproved</td>
<td>The Engineer does not concur with vital details. The Contractor shall not incorporate the material into the Program. The Engineer's objections must be reconciled and the material must be resubmitted in revised form for Engineer approval.</td>
</tr>
<tr>
<td>d. Insufficient Information</td>
<td>The Engineer does not concur due to lack of vital details. The Contractor shall not incorporate the material into the program. The Engineer's objections must be reconciled and the material must be resubmitted in revised form for Engineer approval.</td>
</tr>
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Classification by the Engineer will be assigned within 30 days from the day the submittal is received based on a rate of submittal that is reflective of the pace of an orderly, properly managed program. Priorities will be given to special cases when possible. However, the Contractor shall consider the 30 day criteria and the time requirements involved for mailing when scheduling submittals. The days used by the Engineer in design review meetings or in travel to or from such meetings shall not be included in the 30 day figure. Submittals identified as being associated to evaluation phases of the assembly shall be governed by the duration of the phase itself and not the 30 day period.

1.4.1 Rescission of Status

SEPTA reserves the right to rescind prior approval or the conditional status of drawings or documents if later it is discovered they do not meet the requirements of this Specification or the design is not compliant with its intended application.

1.5 INDUSTRIAL DESIGN PROGRAM

1.5.1 Industrial Design

The physical appearance of both the exterior and interior of the cars is of great importance to SEPTA, and the general car design shall have a modern, clean aerodynamic style with the individual elements of the car combining to present a uniform image. To ensure this, the Contractor shall be responsible for providing complete industrial design services during the design and manufacturing phases of the Contract including the services of an experienced industrial designer. The industrial designer shall have previous successful rail vehicle design experience and shall be subject to approval by the Engineer.

The practical selection and application of materials is of high priority to SEPTA. The use of materials lacking in durability, unique products which are not readily available as aftermarket parts, materials not easily cleaned requiring cleaning products not allowed due to health and safety restrictions, and so forth is of concern. Human factors’ engineering is critical. It is SEPTA’s intention that the Contractor arranges a close working relationship between the industrial designer and the Engineer so that both parties can work in close harmony regarding the car design. In general, it is expected that preliminary selection and application of materials be coordinated at an early stage in the design review process with the Engineer.

It shall be the responsibility of the Contractor with the aid of the industrial designer to create and develop the overall concept design of the car and its arrangement in such a manner that the function and appearance of the car is optimized for the mutual benefit of SEPTA and the riding public while conforming to all requirements of this Specification. Consistent with this, the industrial designer shall be responsible for the aesthetics of the design, and the Contractor shall be responsible for developing the concept into a Specification compliant car.
Industrial design activities shall address equipment layout, car exterior, and car interior design issues to produce a design which maximizes the overall functionality and appearance of the car. The industrial designer shall place emphasis on safety, human factors’ engineering (ergonomics), ADA accessibility requirements, aesthetics, manufacturability, maintainability, and cost factors when developing the design of the car. The car design shall take into consideration human factors’ engineering as specified in TS 2.1.1.

Industrial design services shall be involved with the initial conceptual design of the car and throughout the pilot and manufacturing stages. Initial presentations shall be submitted early during the preliminary design stage in adequate time to be included in the car mock up design review.

These services shall include, but not limited to:

- a. Vehicle exterior aesthetics
- b. Vehicle interior aesthetics
- c. Cab equipment arrangement and Operator's cab console
- d. Materials, colors, and finishes with special regard for durability human factors’ engineering (ergonomics)
- e. Vehicle signage
- f. Vehicle exterior graphic proposals
- g. Concept sketches and full color presentation renderings

### 1.5.2 Design Presentations

The Contractor working with the industrial designer and the Engineer shall provide a minimum of four (4) interior and four (4) exterior conceptual arrangements and color renderings for the Engineer’s and SEPTA management’s review during the preliminary design review period. [CDRL 01-005] Two (2) of the color schemes shall utilize "cool" colors and two (2) shall utilize "warm" colors. The exterior color schemes shall not require painting of any exposed stainless steel. It is desired that use of vinyl film decals utilized on the stainless steel sections of the exterior of the car not be extensive unless otherwise approved. The exterior color scheme shall recognize that the cars will be operated over highway grade crossings and that visibility in these conditions is of importance. Once the basic "family" of color schemes is determined, the Contractor shall arrange for the industrial designer to produce, as a minimum, the following renderings:

- a. Plan and elevation views of the vehicle interior upper level seating area reflecting 2 + 2 seating
- b. Plan and elevation views of the vehicle interior lower level seating area reflecting 2 + 2 seating
c. Plan and elevation views of the vehicle interior intermediate level at the A-end reflecting handicap locations, flip up seating, bicycle securements, equipment access, and transition stairs to the upper and lower levels

d. Plan and elevation views of the vehicle interior intermediate level at the B-end reflecting handicap locations, flip up seating, bicycle securements, equipment access, and transition stairs to the upper and lower levels

e. Plan and elevation views of the vehicle interior intermediate level at the F-end reflecting the cab layout, handicap locations, flip up seating, bicycle securements, equipment access, and transition stairs to the upper and lower levels

f. Interior view of the vehicle doorway and vestibule area doors open, set for high station platform

g. Interior view of the vehicle doorway and vestibule area doors open, set for low station platform

h. Interior view of the vehicle doorway and vestibule area doors closed, set for high station platform

i. Interior view of the vehicle doorway and vestibule area doors closed, set for low station platform

j. Exterior view of the vehicle doorway doors open, set for high station platform

k. Exterior view of the vehicle doorway doors open, set for low station platform

l. Exterior view of the vehicle doorway doors closed, set for high station platform

m. Exterior view of the vehicle doorway doors closed, set for low station platform

n. Operator's cab equipment and control console

o. Forward field of view showing both the field and restrictions based on a seated 5th percentile female’s and 95th percentile male’s forward view to relay design concepts being considered

p. Operator's cab appearance from the passenger seating area cab door open

q. Operator's cab appearance from the passenger seating area cab door closed

r. Conductor's control station arrangement, cover, and door both open and closed

s. Door control stations in the doorway area

t. Vehicle exterior overall view cab car

u. Vehicle exterior overall view trailer car

v. Trailer cars exterior view of the car ends and vehicle end doors
w. Cab car exterior view of the car ends and vehicle end doors

x. Set of cross-sectional views displaying space allocations and general paths of wire harnesses, cable, and piping routes in respect to roof to upper floor ceilings, upper floor through lower level through subfloor to the undercar, and intermediate levels

y. Dimensioned wheelchair path, maneuvering access, and parking areas

z. Interior and exterior signage arrangement

All renderings shall be of high graphic quality and supplied in electronic form. General arrangement views of exterior and interior renderings shall be professionally printed and mounted on presentation grade 22 x 28 (minimum) poster board. Color schemes for the printed media shall be chosen by the Engineer prior to printing but will not constitute acceptance and be considered only as a sample. [CDRL 01-006]

Material samples shall also be submitted. Sample choices of actual materials and color options shall be included. This shall consist of, but not limited to, lining materials (or laminate), floor covering, melamine surfaces, upholstery, seat back shell material, decal material for both internal/exterior applications and/or any other colored or textured surfaces found within the car's interior of a cosmetic nature.

Material samples shall be submitted in binders. Multiple binders may be used to create the material/color sets. Three (3) sets shall be provided by the Contractor for review by SEPTA. [CDRL 01-007]

The conceptual arrangements and renderings shall be the basis for the Engineer's selection of the concept that will be carried through to the production design. SEPTA will provide information regarding its graphic design standards for the Contractor's use in industrial design activities.

1.6 DESIGN REVIEW PROGRAM

1.6.1 General

The design review program is a design development and approval program which shall begin with a concept design phase (CDP) and progress through a detail design phase (DDP). The design review program shall include, but not limited to, Engineer review and approval of all design concept and arrangement drawings of the car, performance and design calculations, car and subsystem configuration drawings and design details, carbody cross section and clearance diagrams, mock ups, stress analysis reports, tests, publication preparation, and Contractor's specification.

Design review activities shall also include review and approval of substitute or equal materials not dealt with in the preproposal period and review and approval of the Contractor's test program and quality assurance program as well as all other Contractor management programs.
Design review activities shall continue throughout the entire preproduction period with each succeeding stage presenting greater amounts of detail and reflecting the progress of the designs. In addition to their own designs, the Contractor shall submit the design of all components being purchased by the Contractor for review and discussion at the design review sessions. In all submissions and at all sessions, the Contractor and supplier presentations shall be organized so as to show exactly how the design meets each specific requirement of this Specification.

This program must be completed and all appropriate drawings (entire car design) approved by the Engineer prior to the delivery of hardware. [CDRL 01-008] (Loss resulting from deviations from this principle is the responsibility of the Contractor. The approval of individual releases does not automatically entitle the Contractor to procure hardware.)

### 1.6.2 Conduct of Conferences

The Engineer shall select the location for the design review meetings which will in general be held in Philadelphia until completion of the mock ups and perhaps at the Contractor’s facility from that point on at the discretion of the Engineer. The Contractor shall provide SEPTA with at least 21 days’ notice prior to any meetings or as otherwise agreed.

All reports, correspondence, and oral and written communication shall be presented in English. If in the opinion of the Engineer the proficiency of the Contractor’s representatives in communicating in the English language is insufficient for efficient exchange of information, the Contractor shall provide a technical interpreter to remedy this situation to the satisfaction of the Engineer at the Contractor's expense.

The responsibility for taking notes at meetings and conferences between the Contractor, Engineer, and other participating parties in connection with the design, construction, and testing of the cars shall rest with the Contractor. The Contractor, after completion of any conference or meeting, will prepare and distribute within 20 days a Memorandum of Conference (MOC) which clearly and concisely details the subject matter and the conclusions reached at the conference. The Engineer shall offer written concurrence or suggested corrections within 20 days after receipt of the MOC.

### 1.6.3 Specification Review Conference

In order to ensure that the Contractor fully understands the detailed intent of the Contract documents in all areas, the Contractor shall arrange for a series of engineering meetings to be held within ten (10) days after the Notice to Proceed. These meetings shall be held at the offices of SEPTA in Philadelphia and shall be attended by representatives of the Contractor, major subcontractors, and SEPTA. At these meetings, the entire technical portion of the Contract documents shall be reviewed in depth in such a manner as to leave no doubt as to the intent of this Specification in each and every area of design, construction, and testing of the cars. Memorandum of Conference will be prepared by the Contractor covering the meetings which will include each and every understanding and agreement reached and item discussed. After concurrence by all parties, the Memorandum of Conference shall become a guiding document in any areas of the Contract documents where the intent may not be fully clear. No change shall be made to any provision of the Contract during these meetings.
Following the conference, the Contractor's project manager, project engineer, key engineering staff, and the equivalent personnel of each major system supplier shall undergo a three (3) day familiarization program on the SEPTA Railroad Division to be conducted by SEPTA personnel. Each individual will be given complete tours on the physical plant, rolling stock, maintenance facilities, Control Center, communications facilities, and operational characteristics. The Contractor shall arrange informal nightly meetings to discuss findings during the training.

1.6.4 Scheduling

After the Specification review conference, the Contractor shall submit to the Engineer for approval an outline of the proposed schedule for the entire design review program. [CDRL 01-009] All activities comprising this program shall be listed and detailed giving anticipated start and completion dates. The Contractor shall also submit a prospective schedule for all design review meetings. These activities shall be arranged in, but not limited to, the following four (4) groupings:

a. Car functional analysis
b. Concept design phase
c. Detail design phase
d. Mock up construction

Activities within each of these groupings are identified in, but not limited to, TS 1.6.5, TS 1.6.6.2 and TS 1.6.6.3. Mock up activities shall also be included in this schedule.

1.6.5 Car Functional Analysis

After approval of the minutes of the Specification review conference, the Contractor shall submit to the Engineer for approval a car functional analysis. [CDRL 01-010] This analysis shall focus on all operational areas with human interface and shall serve as a working and controlling document for all design activities. Updating of the analysis shall be continual as the design is refined or changed through the design review process. It shall define and delineate the following:

a. All normal operating functions and activities. Examples are cab controller manipulations, coupling and uncoupling cars, use of public address, use of intercom, train I.D., ATC/PTC responses, control of doors, etc.

b. Abnormal and failure-based functions and activities including troubleshooting. Examples are failure of brakes to release, failure of propulsion, loss of auxiliary power, dead car rescue, pushing and towing operations, subsystem failure indicators, etc.

The intent of the functional analysis will be to establish exactly how an activity is to be carried out, i.e., what the operating condition requiring action is, what the human inputs will be, how the system will process the inputs, how subsystems will interface and react, and what the final response is to be both to the user and to the car equipment. Design criteria for the hardware and operational procedures for the user will be evolved based upon the Specification requirements and meetings with the Engineer. The Contractor is responsible for design and human factors. Procedural information will be the basis for the future generation of supporting documents such as the Operator's manual.
The analysis document shall contain text, schematics, logic flow diagrams, etc., as appropriate for the relevant subject, shall be formatted for ease of use and reference on a functional basis, and shall be kept current by the Contractor with a minimum of time lag not to exceed 30 days from the date of a change requiring revision.

### 1.6.6 Design Development Process

#### 1.6.6.1 General

After approval of the car functional analysis, the design development process shall commence. This shall be conducted incrementally by the Contractor to evaluate the progress and Specification compliance of the selected design approaches and their compatibility with the performance and other requirements of this Specification. Submissions shall be in a format that clearly informs or illustrates how the Specification requirements are being met.

Submissions which are judged to give evidence of unsatisfactory design, random or haphazard assembly, or require the Engineer to discover what the Contractor is doing will be returned to the Contractor as disapproved.

The Contractor shall plan the design development process in two (2) phases. The initial phase will be designated as the concept design phase (CDP) and shall be a period during which the Contractor establishes all of the basic physical and systems' configurations of the cars in general arrangement drawing form. Other forms of documentation may accompany these drawings. CDP shall be followed by a detail design phase (DDP) during which the Contractor shall develop all detailed working drawings and documents required for the manufacture of the cars.

At any point during the Contract including the design phases where the Contractor or supplier proposes deviations from the requirements found within this Specification, the deviations must be approved via the SCR/SAR processes (as applicable) found in TS 1.10.1.

#### 1.6.6.2 Concept Design Phase

During the concept design phase (CDP), the Contractor shall prepare and issue to the Engineer as advance information a complete series of CDP arrangement drawings of the proposed car design a minimum of 14 days prior to the first review meeting which shall be the subject of the first series of design review meetings. [CDRL 01-011]

CDP submittals and activities shall comprise, but are not limited to, the following:

##### 1.6.6.2.1 Critical Path Method Schedule

The Contractor shall submit the first version of the Critical Path Method (CPM) plan in accordance with TS 1.11.1 giving particular attention to the entire design review program portions of the procurement. The CPM plan is to be updated by the Contractor every 30 days. [CDRL 01-012]
1.6.6.2.2 Master Drawing Schedule

30 days prior to the CDP, the master drawing schedule meeting the requirements of TS 1.3.4 shall be presented for the CDP. All drawings identified for the CDP shall be listed within the schedule as a minimum. [CDRL 01-013]

1.6.6.2.3 Arrangement Drawings and Related Documents

During the CDP, arrangement drawings, related documents of the car, and all major subsystem hardware items shown below shall be submitted to the Engineer for review and approval. [CDRL 01-014] Formal approval for the arrangement drawings shall be achieved during the CDP phase.

Drawings shall show at a minimum:

a. Dynamic clearance envelope and required wayside clearances
b. Location of all doors, access doors, and covers in relation to any enclosed equipment
c. Required space for opening of all doors and access doors
d. Location and space requirements for ventilation intake and exhaust openings and cable entrances
e. Location and space requirement for all major equipment
f. Interface drawings for all major components showing overall dimensions, orientation, center of gravity, weight, points of normal support, method of support during mounting and removal, and including sufficient information to evaluate access space requirements for maintenance, inspection, and repair
g. Truck assembly general arrangement

Interior general arrangement drawings shall be 1/4 scale transverse cross sections of the car showing the arrangement of cabs and passenger areas in both longitudinal and transverse views.

All drawings shall be dimensioned using as reference the top of the rail, coupler pulling faces, and longitudinal center line of the car.

These drawings shall be reissued by the Contractor upon any change to show the current configurations of the car and to allow the Contractor and the Engineer to have immediately at hand the latest general arrangements of the car.
1.6.6.2.4 Detailed Technical Specification

Within 60 days prior to the FAI of the pilot cars, the Contractor shall submit to the Engineer an interim detailed technical specification covering the methods, materials, and arrangements to be used for construction of the pilot cars. [CDRL 01-015] The document shall be similar in style and format to this Specification which shall take precedence in the event of any differences.

An appendix shall give a complete tabulation of all suppliers and the products they are supplying and shall also include an update to the Pre-Award Buy America submittal indicating any revisions to the manufacturer of goods, country of origin, and cost data.

After approval by the Engineer, it shall be updated by the Contractor every 90 days to continuously represent the current configuration of the details of the car including all SEPTA authorized Specification changes. A revision sheet shall contain a complete listing of the original and revised text and details of the approval given by the Engineer. Wherever the original submittal may be lacking information due to unresolved items or methods, this information shall be sent to the Engineer as soon as possible.

1.6.6.2.5 Weight Analysis

After receipt of the approved minutes of the Specification review conference and then monthly until the complete weighing of the pilot cars, the Contractor shall submit to the Engineer a report on the estimated car weight. [CDRL 01-016] This shall include the most recent weights for the car without trucks, each truck, and the complete cars. It shall also include a list of weights for every subsystem on the cars indicating its percentage of the total car weight and if these subsystem weights are based on actual scale weights of complete equipment. The Contractor shall make scale weighings of all components as early as possible.

1.6.6.2.6 Supplier Identification

The suppliers of all system and major components shall be identified as to their scope of work and products to be supplied. Each supplier shall identify their own drawing schedule which will be used for the purpose of approval at the time of their respective FAI. The Contractor shall be responsible for integration of the suppliers’ drawing schedule into the master drawing schedule and assure all changes in status or revision is maintained.

During the CDP, all supplier related design and drawing submittals shall be scheduled and FAI target dates and locations set.

1.6.6.2.7 Updated Pre-Award Buy America Submittal

The Contractor shall update the Pre-Award Buy America submittal by documenting any subsequent revisions including manufacturer of goods, country of origin, and cost data as required in 49 CFR 663.25. [CDRL 01-017]
1.6.6.2.8 CFR and APTA Compliance Matrix

The Contractor shall submit a matrix detailing its compliance with all applicable CFR and APTA requirements. This matrix shall be updated during the detail design phase to reflect the final design. [CDRL 01-018]

1.6.6.3 Detail Design Phase

After the CDP has been progressed to the satisfaction of the Engineer, a detail design phase (DDP) shall be undertaken by the Contractor during which the Contractor develops detailed working drawings for all areas of the car based on design arrangements defined during the CDP.

All of these detail drawings must be created or obtained in accordance with an approved drawing schedule (TS 1.3.4), an approved configuration management plan (TS 1.12.1), and formally submitted to the Engineer for evaluation or approval as determined by the pilot car design stage. [CDRL 01-019]

The DDP shall also include mock up construction activities as per TS 1.6.6.5 and material samples preparation as per TS 1.5.

DDP submittals and activities shall comprise, but are not limited to, the following:

1.6.6.3.1 Continuation and Updating All Activities

The continuation and updating of all activities specified as ongoing in the CDP is including but not limited to:

a. CPM
b. Weight analysis
c. Drawing schedule
d. Detailed technical specification
e. Car functional analysis
f. Structural analysis and testing
g. Arrangement drawings (continuation)
h. Schematics
i. Supplier identification

1.6.6.3.2 Detailed Drawings and Related Documents

The Contractor shall submit, as a minimum, the following detailed drawings and related documents to the Engineer for review and approval/evaluation as described in TS 1.4:

a. All top and associated sublevel release drawings properly dimensioned, detailed, to scale, and in accordance with the approved master drawing schedule as per TS 1.3.4 [CDRL 01-020]

b. All supplier system/subsystem component drawings packaged by system and component along with all documentation regarding qualification testing at an FAI level [CDRL 01-021]
c. Full set of structural carbody drawings that reflect the full details of construction and crash energy management (CEM) for the purpose of approval upon successful testing as required [CDRL 01-022]

d. Set of preliminary detailed car assembly drawings for the purpose of evaluation during both the DDP and assembly of the pilot cars as detailed in TS 1.6.1 [CDRL 01-023]

e. Single line control schematic and functional block diagrams for each subsystem and electrical wiring diagrams and schematics for all electrical and pneumatic circuits. All test points shall be displayed. The functional block diagrams shall identify the "normal" functional paths as well as the functional paths made available through cutouts, bypasses, and redundant circuits. The diagrams shall identify, as a minimum, the "key" hardware that permits safe movement of the car and essential environmental needs of the Operator. The functional block diagrams shall display the levels of hardware (as defined in Military Specification MIL-STD-280A) that identify the lowest vehicle replacement item (LVRI). The format shall be as described in the information in TS 19 for Volume 3. [CDRL 01-024]

f. Complete set of drawings related to clearance. These shall include static and dynamic envelopes relative to the wayside allowances including clearances for all parts of the truck and general arrangement drawings with all static dimensions including camber, low level platforms, high level platforms, curves, etc. [CDRL 01-025]

g. Single line piping and flow diagrams for all pneumatic circuits displaying all valves and control components. All test points shall be displayed as well as functional paths mentioned in e above. [CDRL 01-026]

h. Graphs and curves giving response and functional characteristics of the car, subsystems, and major items [CDRL 01-027]

i. Manufacturer's data and specification sheets on all control items [CDRL 01-028]

j. Maintenance allocation chart that reflects all maintenance requirements and necessary procedures for all equipment in each subsystem. These shall be listed from daily inspection and 92 day inspection to complete overhaul with frequency and time needed to service being tabulated and shall highlight all FRA required inspections. [CDRL 01-029]

k. CFR and APTA Compliance Matrix

1.6.6.3.3 Master Test Plan

A master test plan shall be submitted that shall identify all proof of design testing by both the Contractor and/or suppliers as required in TS 18. The test plan shall identify each test by name, system, location, revision, submittal reference, and approval status. All projected target dates for proof of design testing shall be included. Production testing and the test plan used to status the development of the tests shall also be included. [CDRL 01-030]
1.6.6.3.4  Stress Analysis
A stress analysis of all required areas of the car as per TS 1.6.6.6 shall be submitted to the Engineer for approval. [CDRL 01-031]

1.6.6.3.5  Publications and Training Plans
Programs requirements such as the manual development proposal found in TS 19.2 and the training program overview found in TS 19.4.8 shall be active elements during the design review. Assigned design engineers of both the Contractor and suppliers shall proactively develop and maintain both integration and system details in such a manner so that the details can be shared with the manual and training document developers to assist in providing technical manuals and training prior to the delivery of the pilot cars. Development of all manuals and training documents is of extreme importance; however particular focus shall be placed upon operations training and Qualified Maintenance Person (QMP) personnel training due to their advanced need prior to other manual and training documents.

1.6.6.3.6  Mock Up Construction
Mock ups shall be prepared as per TS 1.6.6.5 using completed and approved detail design drawings or, where required and approved, special mock up drawings. As these mock ups are progressed and reviewed, feed forward/feedback drawings and mock up revisions shall take place so that at the end of the DDP, all mock ups are in a finished condition identical with (within agreed upon limitations and parameters) the design of the production cars, and all detail drawings are updated to reflect this.

1.6.6.4  Supplier Stage 1 Certifications
During the design review process, the Contractor is responsible to secure a certificate from each of the subcontractors and suppliers which certifies that they have a full understanding of all peripheral requirements associated with this Contract pertaining to:

a. All requirements for drawings including lower level BOM fabrications as required in TS 1.9

b. Requirements for all associated materials, special processes, and workmanship associated with their products as found in TS 17

c. Full involvement and support of both manual and training documents including detailed information, internal testing and illustration art, visual aids, and bench equipment as required in TS 19

d. Each shall also recognize the requirement for keeping all information up to date based on changes made by the subcontractor or supplier when under their control throughout the warranty of the vehicles.
These certifications shall be signed by an individual having full authority to commit the subcontractor or supplier to commercial and technical issues relating to the car. The certificate shall also agree that additional maintenance requirements beyond those stated during the design review program shall not be used as a method of correcting a design or manufacturing deficiency in the apparatus discovered before or after the cars are placed in service.

Pilot car construction shall not begin until all supplier certifications have been obtained and submitted and approved by the Engineer. [CDRL 01-032]

1.6.6.5 Mock Ups

At an appropriate time approved by the Engineer during the DDP prior to the start of construction of the pilot cars, the Contractor working jointly with the industrial designer shall commence construction of three (3) full size partial mock ups and one (1) portable cab module mock up based on the vehicle types, arrangements, and details of the cars to assist in design reviews by the Engineer. The partial mock ups shall consist of a complete half-car A-end trailer car mock up, a B-end intermediate area mock up, and a cab car end mock up consisting of an exterior end, vestibule, cab, and intermediate area. The portable cab module shall consist of an enclosed full cab configuration to assist in remote reviews.

Each mock up frame shall be sturdily built to support multiple people during design reviews. Safety shall be a major factor in the construction, and barriers shall be included in the upper level and lower level cutaway areas.

All three (3) mock ups shall be located at the Contractor's U.S. final assembly facility with the exception of the portable cab module which shall be delivered to SEPTA's property for review by SEPTA's Operations Department personnel. [CDRL 01-033] The portable cab module shall be the first to be developed so it can be shipped to SEPTA a minimum of six (6) weeks prior to the main mock up design review to allow time for reviews and any changes that may be needed to be incorporated as necessary. [CDRL 01-034] It will be the responsibility of the Contractor to be present to support the reviews and/or changes in an expeditious manner. Any and all changes must be documented and coordinated to where they are immediately changed on the main cab end mock up as they happen prior to the official design review.

All mock ups shall be kept at complete current status and updated as necessary based on design review comments until the first pilot cars are completed. Then following complete documentation via industrial photography as specified in TS 1.7.6, the mock ups or their component parts shall be disassembled and all useful components salvaged if not defective. Other than the carbody structure, the mock ups shall have all components, hardware, and equipment similar or identical in appearance to those to be used on the production car to as great an extent as possible except as otherwise approved by the Engineer. Full scale models substituting for proposed hardware may be submitted on a case by case basis for approval as per limited exceptions only.

The individual mock up configuration requirements shall be as follows:
1.6.6.5.1 Main Mock Up Assembly

The main mock up assembly shall be a full-sized half-car mock up of the A-end of a trailer car. It shall consist of the vestibule, intermediate area, upper seating area, and lower seating areas. All exterior door entrances shall be included along with low platform stairwells. All trainline receptacles and/or connection points for electronic and pneumatic connections shall be included.

All areas of the mock up shall be generally finished in appearance similar to an actual car except those using a color scheme or combination of schemes as chosen by the Engineer from the design concepts presented under the influence of the industrial designer as required in TS 1.5.

The mock up assembly shall be adequately powered to allow door operation and full operation of lights and advertising simulations.

The main mock up shall have the following subjects included:

a. Exterior Areas

The exterior of the trailer car shall be limited to the end of the car only. The sides of the car may be represented primarily by graphical representations, except for the requirements listed below.

The exterior end of the car mock up shall include the diaphragm, buffer, marker lights, all electrical connection locations for intercar cabling and hose connections, and the coupler and uncoupling device.

Each exterior door entrance shall contain all FRA safety devices such as handholds and emergency door release mechanisms. Low platform lighting shall be included and lit.

All car side exterior details shall be represented via a graphic presentation for a full car. The graphic presentation shall be highly detailed and include the exterior decal package selected by the Engineer. The side graphic shall include all exterior appointments including, but not limited to, status lights, destination signs, equipment access points (including cut-out valves), vents, and crew switches. The graphic presentation shall be professionally done and sized to easily show all details in a classroom environment.

The cutaway portion (rear) of the half-car mock up, as viewed at floor level, shall show subfloor and roof to ceiling areas mocked up to represent main cable and wiring routing areas. A full isometric illustration of general cable routing and transition points shall be developed and posted on the rear of the mock up. Separation of sensitive circuits such as power vs. signal shall be reflected in the isometric illustration’s information. The cutaway shall also show HVAC supply air ducts. The opening of the HVAC cutaways may be painted a different color to identify them as air ducts.

b. Interior Areas

The vestibule areas shall be complete with trap doors, collision post door, maintenance access panels, lighting, and step well lights. All safety and handhold devices shall be included.
Operating doors shall be located at the corner and quarter point locations (two (2) total) on only one (1) side of the mock up along with all interior mounted door control stations. The remaining other side doors shall be closed and inoperable.

The vestibule/passenger area end door shall be operable.

The interior shall consist of actual car linings, ceilings, doors, floor covering, partitions, windows, luggage racks (upper level), bicycle securement devices (intermediate level), and all other accouterments required within TS 4.

All public announcement stations shall be included along with speaker grill placements.

Advertising video monitors shall be powered and simulating ads.

Advertising frames and schedule boxes shall be applied.

Main seating areas shall consist of three (3) full rows of 2 + 2 seating installed on the upper and lower levels along with any single seat applications at stairwell transition areas to show passenger flow to and from the main aisles. Actual lighting/HVAC duct/diffusers shall be installed. The upper level shall have luggage racks included.

c. Intermediate Level

The intermediate level shall consist of all equipment lockers and ceiling panels that access equipment typically located at the A-end of the trailer cars. Actual equipment or simulated equipment as agreed to by the Engineer shall exist in the lockers/ceiling so maintenance access can be evaluated. Door locks, hold open devices, and/or safety catches shall be included.

All seating shall be included including any fixed and/or flip up seating arrangements. Wheelchair accommodations and/or bicycle retention areas associated with the flip up seats shall be explained. If the bicycle retention system is not related to the flip up seat arrangements, the retention system shall be included in the mock up if located at the A-end of the car (if not, it shall be included in the B-end mock up). During mock up reviews, a full-sized 29-inch wheel sized bicycle shall be applied to the retaining device to show the effectiveness of the retention system and associated clearances for passenger flow and potential obstructions.

All actual lighting units and HVAC duct and diffusers shall be included.

Stairways leading to the upper and lower areas shall be full sized as intended. All details such as stair tread, step lighting, and any handhold devices intended by the Contractor’s design shall be included.
1.6.6.5.2 B-End Intermediate Area

A separate standalone mock up shall be made to reflect the B-end vestibule of a trailer car and intermediate area. Providing that there are no differences in intercar cabling and hose connections between the A-end of a trailer car, the low platform stairwell in addition to the underfloor trainline cable and hose connections need not be included in this mock up thus enabling this mock up to be floor level. Additionally if there are no differences between the A-end exterior end of the car, it too need not be represented.

If a manual parking brake is used, it shall be installed and located to allow simulated operation and reflect all dimensions and clearances required for its use during design review.

Both corner doors and the vestibule/passenger area end doors need not be installed; however, all door pockets shall be included along with all door control stations.

Stairwells leading to the upper and lower seating areas may be graphically shown in full size projected views.

The B-end intermediate area shall meet all of the requirements of the A-end intermediate level for equipment locations and access points.

A second level above the intermediate area mock up shall have a full scale air duct system applied showing the interface of the HVAC unit and how airflow is managed to supply air to all seating areas. The duct work must be a cutaway configuration showing interior duct details such as insulation, both volume and sound deadening dampers, splitters, adjustment points, etc., as used in the proposed system. All interior ceiling level maintenance access points shall be included in the mock up. The upper level duct system shall be viewable via an integrated exterior gantry built into the mock up’s design.

1.6.6.5.3 Cab Car F-End and Intermediate Area

The cab car mock up shall consist of an exterior F-end full vestibule and cab and include an intermediate level meeting the requirements of this Section. Providing all intercar jumper and hose connections match that of the main half-car mock up, the connection points and low platform stairwell will not be needed, and the mock up may remain at floor level.

a. Exterior

The exterior end of the cab car shall be mocked up and include all appliances such as the buffer, intercar barriers, safety barriers, collision post door with glazing, safety appliances, ditch lights, cab and non-cab side windshield, collision post door glazing, cab window, windshield wipers, destination signs, gutters, transitional roof shroud, headlights, roof mounted horn assemblies, and F-end mounted antennas as seen from the front of the car.
Both the end and side exterior details shall be represented via a graphic presentation for a full cab car consisting of both the side elevation of the car and the cab end. The graphic presentation shall be highly detailed and include the exterior decal package selected by the Engineer. The side graphic shall include all exterior appointments including, but not limited to, status lights, destination signs, equipment access points (including cut-out valves), vents, and crew switches. The graphic presentation shall be professionally done and sized to easily show all detail in a classroom environment.

All lighting shall be functional including exterior lighting and status lights and those found within the cab and vestibule. Interior lighting from the interior intermediate area shall be available to assess the potential for glare within the cab under the worst case scenario (vestibule/passenger end door open) when the cab module is attached.

b. Vestibule

The vestibule shall be lighted and exact in detail to reflect that of this Specification. Ceiling access points and any other equipment access panels shall be included. Equipment shall be mounted behind such access points to generally assess maintenance access. Corner passenger doors need not be applied; however, all door pockets and equipment access points must be included. The vestibule/passenger area end door shall be installed for cab glare reviews and need not be powered as long as the door can be easily slid open or closed.

c. Cab

The cab shall consist of a fully configured cab with all controls and associated equipment installed. The cab shall include the cab door complete with hold open device, locks and emergency egress latch, front end sheet with windshield and wiper, cab side wall with an installed operational side cab window, rear wall with any and all control/circuit breaker/bypass panels, etc. The console shall be fully equipped with controls as required by this Specification. The cab shall also contain a representation of the cab heating system, floor switches, and foot rests. The cab ceiling shall be included and contain all features such as the car system HVAC venting and any additional cab lights. An adjustable seat meeting the cab seat requirements shall be included and installed.

All interior equipment containing lighting including status indicators shall be operational. Equipment called out as having dimming functions shall be functional. Those not requiring dimming shall reflect their inherent brightness at the nominal battery voltage level for proper assessment against glare.

d. Cab End Intermediate Level

The intent of the intermediate level of the cab end is to assess cab car related interior equipment enclosures not found in trailer cars and the equipment layout including maintenance access therein. All lockers shall be in a position either along the side wall or main seating bulkhead where they will be located in an actual car. Flip up seating arrangements shall be included along with mobility device parking and/or bicycle retention devices (if applicable for this area).
Side quarter point doors will not be required in the mock up, but door pockets and/or door operator access will be required since they are included in the interior layout.

### 1.6.6.5.4 Portable Cab Module

The cab module shall be fully self-contained and be in a portable configuration where it can be transported to SEPTA’s property for review. It shall be an exact replica and meet all of the requirements of the cab as stated in the cab end mock up section shown above. The module shall be totally self-contained and include the cab door, front end sheet and windshield, side and rear walls and ceiling, and their associated equipment and features.

As in the cab end mock up, all cab equipment containing lighting including status indicators shall be operational, thus a dedicated power supply shall be included in the portable cab module’s design. Equipment called out as having dimming functions shall be functional. Those not requiring dimming shall reflect their inherent brightness at the nominal battery voltage level for proper assessment against glare.

### 1.6.6.6 Stress Analysis

A complete stress analysis of the carbody and trucks shall be performed by the Contractor using an advanced computer driven finite element analysis such as Nastran, Ansys, Strudl, Algor, or approved equal supplemented as necessary by manual or computerized calculations of stress. The stress analysis shall show the calculated stresses, allowable stresses, and margins of safety for all elements at all specified loading conditions and shall comply with all FRA and APTA requirements and recommendations in accordance with TS 3.8 and TS 11.4.9.

During design review, the finite element model to be used by the Contractor shall be submitted to the Engineer for approval. [CDRL 01-035] The element grid, all assumptions, and all input data such as loads, section properties, material properties, etc., shall be included as part of the preliminary submittal and again as part of the complete analyses. Drawings for both the structure and trucks shall be submitted to totally evaluate connections and stress points involved in the analysis.

Prior to the start of the manufacture of the carbody or truck structural parts, the Contractor shall submit a complete stress analysis report to the Engineer for approval. [CDRL 01-036] It shall consist of a complete structural diagram of the car and a complete summary of stress analyses of the carbody structure and trucks including axles and major equipment supports to show compliance with the strength requirements of this Specification. A typical stress analysis of any structural element shall consist of a sketch of the element, a statement of the specified applied loadings, a listing of the material of which the element is to be made and its thickness, an identification of critical sections, the calculated stresses at these sections and the corresponding calculated factor of safety in accordance with TS 3.3.1.1. A complete copy of the finite element analysis shall be included with the stress analysis with each page numbered and data clearly identified on each page using terms defined in the stress analysis.
The stress analysis summary shall include a structural diagram of the carbody and sheathing showing the location of all elements with their shape, thickness, and joining method along with displays of externally applied loads to the carbody. A summary of the calculated stresses in all structural framing members and shear panels shall be given along with a separate listing of all locations where calculated stress levels approach 12 percent of the criteria specified for various loadings in TS 3.3 as well as the design or operating conditions which precipitated them. A tabulation shall be given of calculated deflections of the carbody and the trucks under AW3 load and under the compressive loads listed in TS 3.3.

Analysis shall be made of the coupler attachment to the carbody, truck connection to the carbody, torsional loading of the carbody from diagonal jacking, and torsional loading during normal operation. All critical connections of the carbody’s major structural elements under AW3 loading shall be examined, and a tabulation of the Contractor's selection of allowable carbody and truck fatigue stresses and assumed applied fatigue stress ranges for structural members which are fatigue critical shall be given.

The Engineer reserves the right to require the submittal of relevant detailed stress analysis calculations prior to approval of the production structural drawings if in the Engineer’s opinion the structural adequacy of the proposed construction is questionable.

1.6.6.7 System Component and Material FAIs

All FAIs for system/subsystem components and other parts and materials as listed within the approved FAI schedule shall be performed during the DDP phase. It shall be the responsibility of the Contractor to create and maintain a list of major/subsystem components and an associated schedule for the purpose of creating an FAI status of all subsystems and components. All requirements for FAI activities must be met prior to the commencement of the FAI for the product scheduled. The system/subsystem inspections shall take place at the supplier’s factory before shipment of the equipment. Electrical and pneumatic power shall be applied as appropriate, and the equipment shall be cycled through all modes of operation at a minimum or type testing as required in TS 18.2.

1.7 PILOT CAR PROGRAM

Following the successful completion of all design review activities, the Contractor shall begin production of the pilot cars which shall be the first car of each type: cab car and trailer car. The pilot cars shall be considered a "proof of design" first article after being exercised in test and revenue service, and the adequacy of all aspects of the design and manufacturing activities have been substantiated. The pilot car program shall be conducted in three phases:

1.7.1 Phase 1 – Pilot Car Assembly

The pilot cars shall be assembled based on design proposals, drawings previously approved during the design phases, and the assembly drawings submitted for evaluation.

During the assembly of the pilot cars, SEPTA representatives will monitor the build process to evaluate the effectiveness of the configuration and compliance to the materials and workmanship requirements found in TS 17 of this Specification.
The pilot car shells shall be treated as a singular major component with its own design review, assembly evaluation, and testing. Drawing approvals shall be achieved as found in TS 1.8. General assembly of a full car shall not commence until the structural shell has been provisionally approved.

Installation of all major systems, subsystem components, and equipment must have an approved FAI status prior to installation. Special care shall be taken in the evaluation of the installation and mounting of such system equipment. The supplier/subsupplier shall be responsible for the certification of installation and integration as detailed in TS 1.7.4 during this period and prior to the pilot car FAIs.

The Contractor shall closely coordinate with local onsite SEPTA representatives to assure a thorough review of the pilot car assemblies is achieved using the proposed assembly drawings. Prior notice shall be given to SEPTA personnel to review any area that will be later covered and inaccessible. Any area mistakenly covered or enclosed shall be reopened for SEPTA’s review if deemed necessary by SEPTA at the Contractor’s expense.

Any discrepancy found during the assembly shall be investigated to discover its root cause, and appropriate action will be taken to remedy the problem. Issues discovered shall be identified as either quality or engineering related. Engineering related issues shall be defined as items in need of change due to fit, form, function, materials, circuitry, or software changes where the configuration of the car will change as shown in drawings, schematics, or software revision levels. Those deemed as quality issues shall be tracked and monitored within a separate list, investigated for root cause, and quickly corrected during the assembly phase.

All changes to the proposed assembly drawings and schematics shall be recorded within the pilot assembly engineering comments list (PAECL) maintained within the local SEPTA field office as described in TS 1.8.3. Any Specification issues found that may result in an exception or change of the requirements found within shall be handled via the change process as described in TS 1.10.

All production related testing and additional pre-delivery testing as required in TS 18.3 and TS 18.4 shall be fully pretested during the assembly prior to the pilot car FAIs. Any changes resulting from testing such as circuit changes, software, or test procedural changes shall be handled via the PAECL. Changes shall be made prior to the official FAI production testing to allow confirmation of the changes’ effectiveness.

### 1.7.2 Phase 2 – Pilot Car First Article Inspection

Each pilot car shall undergo a First Article Inspection consisting of a pre-FAI audit, physical inspection, and pre-delivery testing to identify the configuration status for the purpose of setting the production baseline. The establishment of this baseline shall occur at the Contractor's facility.

This formal examination shall be gauged against the production drawings, pre-delivery test results, Specification, design review minutes, and engineering comments’ list developed during the design and assembly process.
30 days prior to the pilot car inspections, the Contractor shall submit to the Engineer an engineering data package in sufficient detail to allow the Engineer to compare physical attributes of the cars with the engineering documents which describe them. [CDRL 01-037] This package shall serve to clarify any discrepancies between the design drawings and the manufacturing process with respect to subassemblies and the packaging of equipment. The package shall contain the following information:

a. Drawing Package

A complete updated master drawing schedule, which includes all drawings by suppliers and subcontractors used during system/component FAIs, shall be submitted. The schedule must be in hierarchal form as described in TS 1.3.4. All revisions levels must be included and up to date. The approval status of all drawings requiring full approval during the design reviews and system/component FAIs shall be included. The Contractor shall be responsible for auditing SEPTA’s electronic PDF drawing file collection within the local SEPTA field office and providing any drawing files that have not been updated to the latest revision level.

b. Subsystem FAI Status Report

A subsystem FAI status report must be submitted reflecting the status of all subsystems as having had their initial FAI and presently found to be totally completed or commented upon and awaiting final modifications. Those not totally completed must be accompanied by a list of items yet to be completed and a proposed schedule for completion.

c. Pilot Assembly Engineering Comments List (PAECL)

The status of the PAECL shall be audited for closure of all associated items. Any open issues not yet resolved prior to the FAI shall be presented to SEPTA with written commitments as to corrective action plans for each open item prior to presenting the car for its first article inspection.

SEPTA reserves the right to postpone the pilot car FAI until each of the above mentioned requirements have met SEPTA’s satisfaction.

Upon satisfactory completion of the audit and physical inspection of the pilot cars, any objectionable issues found either in the physical configuration or operation due to circuitry or software shall be recorded, and corrective action resulting in changes in drawings, schematics, and/or software shall be committed to in writing. Such drawings or schematics that are pending change shall be highlighted in the master drawing schedule until completion of the change is completed and approved by SEPTA.

Upon the completion of a pilot car FAI at the Contractor’s facility and with the update of any addendums, PAECL, test result open issues, and master drawing schedule, SEPTA shall determine the status of pilot car. Successful completion of this first inspection process will provide the Contractor with provisional approval of the car’s design and assembly level drawings pending any further changes due to post-delivery pilot car proof of design testing.
The Contractor shall assume the full responsibility, risk, and expense for any procurement or manufacturing action initiated prior to receipt of the Engineer’s approval of the production baseline and for any subsequent changes made to the production baseline resulting from verifying the vehicles’ capability to meet the requirements of this Specification during the entire pilot car and train testing program.

1.7.3 Testing of Pilot Cars

Upon arrival at SEPTA, the pilot cars shall be visually inspected for shipping damage and then onsite tested for required functional characteristics.

After visual inspections have been completed, full static commissioning testing shall be performed on the pilot cars as outlined in TS 18.5. Upon full completion of the static commissioning testing, the car shall then undergo a full 92 day inspection.

After the successful completion of the 92 day inspection, proof of performance testing shall commence as outlined within TS 18.6.

1.7.4 System/Major Component Supplier Stage 2 Certifications

The suppliers of systems and major components shall review and monitor the operation during the pilot assembly and pilot testing of their systems both at the Contractor’s facility and pilot testing performed at SEPTA. They shall certify that the application and operation of their equipment is being properly applied and is working correctly in respect to the approved design performances required by this Specification.

Major components are identified as being major elements of the car such as, but not limited to, floor panel applications, floor covering, interior linings, etc.

Trucks shall be classified as major components and their associated certification shall cover mechanical build, design, car interface, and acceptance of ride quality testing.

1.7.5 Post-Pilot Program Deliveries

Delivery of any production cars shall not commence until the pilot car program has been completed and proof that any adjustments/changes found necessary during the pilot car program are properly documented and incorporated into the production car configuration. SEPTA reserves the right to disallow shipment authorizations thus restricting delivery until all pilot car program items have been either closed or dispositioned in an agreeable manner to SEPTA.

It is intended that except where otherwise approved or required by the Engineer, the pilot cars’ manufacturing quality level shall be the standard for all following cars. Each following unit shall be an exact counterpart of the pilot car in every material and design respect. In the event that the Engineer discovers any material or design deviation from an approved pilot car’s configuration in the succeeding production units, the Contractor, unless otherwise approved by the Engineer, shall correct such deviation in all affected production units at no additional cost to SEPTA.
1.7.6 Photographs

The Contractor shall supply to the Engineer by the time of the delivery of the pilot cars one (1) set of unmounted digital photographs of the car in electronic format and a hard copy to further document the car’s configuration. The photographs shall be taken by a professional industrial photographer. [CDRL 01-038]

The professional digital photographs shall be scaled to print at high resolution on 8 inch by 10 inch paper. All prints shall be printed on a glossy medium with a white border of archival quality. Each photograph shall be arranged by location and subject in a binder using clear sleeves of archival quality plastic suitable for long term storage of photographic material designed to display each item individually. It shall be possible to easily remove or insert a photograph from the binder. Each photograph shall be captioned with the car identification, car number, and location in the car which it depicts on the rear of each photograph.

The photographs shall include side and end elevations in addition to three quarter views of the exterior and be suitable for use in publicity. These publicity views shall show a car in ready to run condition with a non-distracting background.

Photographs shall also be made of all individual major structural components such as roofs, sides, end frames, and floor structures. The remaining photographs shall consist of the roof exterior and all areas of the car interior, various phases of construction, and after all of the equipment has been installed. A minimum of 75 photographs shall be in the set. In addition, a similar set of professional digital photographs of the mock ups shall be provided as defined in TS 1.6.6.5 containing approximately 40 photographs and shall be sent to the Engineer. [CDRL 01-039]

The photographic views shall be approved by the Engineer. [CDRL 01-040] All photographs shall become the property of SEPTA.

1.8 DRAWING APPROVAL

Drawing approvals shall be performed using the following milestones to achieve full approval for a production baseline:

1.8.1 Design Phase Drawing Reviews

Drawings, as called out in the conceptual and detail design phases as found in TS 1.6.6.2 and TS 1.6.6.3, are required for this stage of review.

1.8.2 Pilot Car Assembly Phase Drawing Reviews

Car assembly drawings shall go through an evaluation process during the pilot car assembly phase.

It is the responsibility of the Contractor to assure such details contained within the drawings meet the requirements of this Specification. Any changes or exceptions to the Specification requirements shall be limited to those covered under SCR or SAR approvals as referenced in TS 1.10. The Contractor shall bear any schedule delay caused by nonconforming issues discovered.
The car assembly phase drawing reviews shall be done in two (2) parts:

a. Structural

The first part shall include the structural drawings provided during the detail design phase. Detailed part drawings must then be added to the master drawing schedule and provided at the start of assembly. [CDRL 01-041] These drawings shall be evaluated during the design phase, and the actual assembly of the car to be structurally tested via visual comparison and inspection by SEPTA. Any drawing deficiencies and/or objections shall be recorded on the PAECL and immediately corrected prior to testing. Upon the completion or agreed disposition of all design and/or structural testing issues as recognized by SEPTA, the structural drawings’ package shall be provisionally approved for production of the car shells.

b. General Car Assembly

General assembly shall be defined as the assembly of a full car starting with an approved structural shell. 30 days prior to the start of the general assembly of the pilot cars, the Contractor shall submit an updated master schedule consisting of all drawings used to build the car. [CDRL 01-042] The schedule shall include fabrication parts, assembly and installation drawings, and schematics. Copies of all drawings contained in the schedule shall accompany the schedule as defined in TS 1.3.4.

Upon receipt of the schedule and drawings, SEPTA shall commence a drawing evaluation stage where the drawings and product will be evaluated for both execution and compliance to the agreed designs and Specification requirements via reviews and visual inspections.

During this evaluation, SEPTA shall institute a pilot assembly engineering comments list (PAECL) as described in TS 1.7. Any nonconformance issues found that affect the production baseline drawings shall be added to the PAECL by related drawing number and revision for disposition. The Contractor shall contribute to properly identify any and all applicable drawings that will require change to correct such comments, and expeditiously work with the SEPTA representatives to identify corrective action and revise drawings accordingly prior to each pilot car FAI.

Upon successful completion of all open items forthcoming from the design review addendums, system/subcomponent FAIs, pilot car FAI, proof of design and performance testing, and the associated PAECL, SEPTA shall consider all drawings deemed for evaluation to have a provisional approved status and the production baseline set.

After approval of the production baseline, all changes to the car configuration, whether mechanical, electrical, software, or test procedures, must be handled via the ECP process as described in TS 1.10.

1.8.3 Pilot Assembly Engineering Comments List

The pilot assembly engineering comments list (PAECL) shall be created and maintained by SEPTA at the SEPTA field office at the Contractor’s facility. It is meant to be supplemental to any other open items lists from design reviews or supplier FAIs.
During the assembly of the pilot cars, any perceived discrepancy to the car’s configuration in regards to requirements of this Specification or approved design phase documentation shall be added to this list. It will also include problems with equipment interface or tolerances found during inspection, audits and/or supplemental drawing reviews shall be listed and described in the list. The list shall also contain proposed corrective action to be filled in during change discussions with the Contractor. Additional columns shall include the governing drawing or document at the time of the listing, including revision level and an associated column denoting document change status and revisions at the time of closure.

The PAECL shall be shared with both the Contractor and SEPTA’s project management upon any changes and/or updates. The intent of the PAECL is meant to be a working document between SEPTA and the Contractor to track corrective action of issues to the configuration of the car design found during the assembly of the pilot cars. Corrective action shall result in the change of controlled documents (drawings, test procedures, etc.) under the requirements described in TS 1.10.

Upon successful completion of changes to the associated documents and physical verification on the vehicle, SEPTA shall close the associated issue.

### 1.9 DRAWINGS

#### 1.9.1 General

The Contractor shall be responsible for providing drawings for all equipment consisting of structures, all components, assemblies, and parts used within the configuration and design of the car by both the Contractor and all suppliers/subsuppliers. The drawing hierarchy scope shall be complete from the top car level basis down to the component’s installation, unit assembly, and continue down to the lowest level part or fabrication element. The drawing hierarchy for the car and all components shall be included in the master drawing schedule as described in TS 1.3.4.

Parts and components deemed as catalog items may be exempt from the drawing requirements provided they qualify as being catalog items defined by being commercially available from at least three (3) general purpose catalog outlets existing in the U.S. In these cases, the Contractor and/or supplier or subcontractor shall organize a collection of specifications where such material’s information in respect to type, size, material, and/or operational properties shall be stored and later provided to SEPTA.

Drawings shall be prepared in accordance with ANSI Y14 drawing standards. Individual sheets with a maximum size of 3 feet 8 inches wide by 2 feet 10 inches high shall be used when printed full size unless otherwise approved by the Engineer. Refer to TS 1.8 for additional details. Drawing number series shall be used as agreed upon with the Engineer and included in the master drawing schedule as required in Section 1.3.4.

Each drawing shall be in an Engineer-approved format and shall be detailed, dimensioned, and contain a complete bill of material that provides quantities, materials, original component manufacturer name, and part number of the actual supplier of the part. Common catalog items shall reflect the material, grade, rating, size, etc., to fully identify the properties of the parts. All drawing dimensions shall meet the requirements and projection views as found in this Section and TS 1.3.3.
Until the delivery of “as-built” CAD drawings at the end of the contract, PDF copies of drawings shall be used for submissions and day to day use.

All drawings within the master drawing schedule shall be submitted via official contract correspondence that includes a listing of all drawings being submitted by number, name, and revision level. Actual individual softcopy PDF files for each drawing shall accompany the correspondence as attachments with each file named by the Contract correspondence number in which the drawing was listed within during its submittal, drawing number, and revision level to allow automatic sorting within a computer directory.

Distillation settings of the drawings into PDF shall be adjusted and performed using the drawing’s plotter dimension as the paper size to retain full details. Paper copies where required shall be supplied in 11 x 17 tabloid sized paper (or smaller as appropriate) using Acrobat software to fit to page when printing where drawings are needed for design review submittals or presentations. Multiple page drawings may be contained within the individual files. Drawing attachments may be received in ZIP file format, DVD, or USB mass storage device sized to hold larger collections.

It is the intent that all drawings required in this Section be submitted as outlined in the design phases and/or car assembly with a full set culminating prior to a pilot car FAI in PDF softcopy formats (softcopy at a minimum, additional hard copies as requested). Official authoring (CAD) file deliveries shall be delivered per TS 1.18 covering as-built drawings.

Changes to drawings during the pilot car assembly phase will be controlled via the PAECL as described in TS 1.8.3 until the production baseline has been agreed to formally or provisionally. Any and all changes that result in a drawing change after the baseline has been set (including those that were open items on the PAECL at the time of setting the baseline) must be submitted for approval via the engineering change proposal (ECP) procedure as described in TS 1.10.

1.9.2 Circuit Diagrams and Integrated Circuit Diagrams

The Contractor shall furnish SEPTA with complete circuit and integrated schematic diagrams of all car electrical, electronic, pneumatic, and hydraulic apparatus including a full description of each of the components with its value, quality, voltage levels, waveforms, pressures, and tolerances for SEPTA’s use in maintenance and repair of the cars. Each line on the drawing shall be labeled and shall identify the nominal values for voltage, current, pressure or airflow used in normal car operation. If a line continues off a page, the continuing page number shall be identified. Each device shall have its individual connections identified and its nominal operating values given on the drawing and a complete schematic drawing showing its transfer function shall be an appendix. A tabulation of all electrical devices with their component values, their location on the wiring diagram and on the car, and a functional description of each input and output shall be provided, with a similar tabulation for all pneumatic devices A narrative shall be included to instruct the user in the use of the documents.

Full integrated schematic diagrams for all printed circuit boards shall accompany the car level schematics as a separate appendix. All components on printed circuit boards shall be individually shown in the schematics.
Appropriate test parameters and troubleshooting instructions shall also be furnished for each assembly and subassembly based on its associated car system. This information shall be provided in maintenance manuals and training guides.

1.10 CHANGES

1.10.1 Specification Changes
During the design and pilot car phases of the Contract, discussions may arise where specific Specification requirements are not being met, however the Contractor feels the spirit of the Specification could be met using alternate means or materials. If during the course of these discussions SEPTA indicates it will entertain the possibility of change, the Contractor shall be allowed to submit an SCR or SAR, whichever is applicable, for approval:

Specification Change Request (SCR) – SCRs are used in the event where specific changes are made to requirements that extend throughout the Specification.

Specification Adjustment Request (SAR) – SARs are used when the change is limited to a particular instance only and does not change the basic requirement used throughout the Specification.

The formats for both SCR and SAR proposals shall contain the following information:

a. The specific Specification requirement to be changed (in text form)

b. Alternate Specification wording for the proposal (SCR) or descriptive instance of the item to be changed (SAR)

c. Justification for the proposal

d. Technical information attachments as applicable

e. Identification of all applicable drawings to be affected by the change

f. Cost, weight, or schedule impact

During the drawing review process, the Contractor shall submit to the Engineer a continually updated list of manufacturing, supplier, interconnection, and assembly drawings that would be affected by such changes. Any Specification changes after the pilot car baselines have been set must be submitted via the ECP process found in TS 1.10.3 if the controlled document such as a drawing or procedure is affected.
1.10.2 Changes to Drawings and Controlled Documents

The Specification, design review MOC’s, and the PAECL, in addition to approved drawings and test procedures identify the procurement baseline for the car. Once the baseline has been set and agreed to by SEPTA, all changes to the procurement baseline shall be documented by a change to the controlling document which reflects the baseline requirement in the form of drawings, procedures or, software revision levels.

The processing of these changes shall be performed using an Engineering Change Proposal (ECP) in accordance with the procedures described TS 1.10.3. All ECPs shall be reviewed by the Contractor’s configuration control department prior to submittal to the Engineer for review and approval.

1.10.3 Engineering Change Proposal (ECP)

Prior to the setting of the production baseline, the Contractor shall control and maintain an engineering change process that will ensure all changes are made to drawings and other controlled documents so they reflect the most up to date revisions.

After a pilot car FAI where the production baseline has been set and agreed to, all technical changes shall be proposed in the form of a written Engineering Change Proposal (ECP) which shall be submitted to the Engineer for approval prior to starting any implementation of those changes.

A proposed engineering change to any item shall be classified as a major change (within a technical context) whenever one (1) or more of the following areas are affected:

a. Form, fit, function, or interchangeability
b. Reliability or maintainability
c. Weight or balance
d. Safety
e. When retrofit is required
f. Sources of repairable and/or replaceable items (source control drawings)

Any engineering change not affecting form, fit, function, or interchangeability, nor falling within the preceding definition of a major change, shall be designated as a minor change (within a technical context).

In addition to the revised drawing or procedure, the ECP shall also contain the full details, instructions, tool list for post-production changes, parts list, procedures, and drawings necessary for the performance of the work, shall reference all software (publications, drawings, training program, etc.) which must be changed giving the revised information, and also describe any needed revisions or modifications for interim use.

Any field modification instructions (FMI's) or other documents needed to make the change shall be included in the ECP. The ECP after Engineer approval shall be known as an Engineering Change Notice (ECN).
Any action or cost necessary to correct problems in the product or documentation arising from the Contractor's misclassification shall be borne by the Contractor. The Contractor shall also be responsible for classifying and controlling changes originating from their subcontractors. The Contractor shall submit the ECP to the Engineer accompanied by the technical documentation and cost information necessary to fully evaluate and approve the change. An ECP shall describe changes to the Specification when applicable with the inclusion of an approved SCR or SAR as described in Section 1.8.3.

All technical changes that affect safety shall be immediately reported by the Contractor to the Engineer. Technical changes that affect operation shall also be expedited. Both safety-related and operational changes are considered to be major ECPs. All other technical changes based on production and/or material changes will be considered to be minor ECPs.

The Contractor shall identify the change by ECP number and, if reported verbally, shall confirm the change in writing to the Engineer within two (2) days. All ECPs shall be submitted to the Engineer in writing accompanied by all technical information and proposed drawing changes. Every ECN shall identify the cars or software involved. Any ECN not performed on every car must include supporting rationale and shall be subject to the Engineer's approval.

Once an ECP has been approved, all ECP information including cover sheets, rationale, updated drawings, and technical information shall be sent to SEPTA via official contract correspondence.

1.10.4 Accountability

The Contractor shall maintain records such that the configuration of any item being delivered shall be definable in terms of its component part numbers. Differences between the as-built configuration and the release records and documentation shall be known and accounted for, and the status of change approvals and incorporations shall be known and recorded at any point in product development, test, production, or operational usage.

A serialization and configuration control record shall be maintained by the Contractor for each vehicle. The Contractor shall make every effort to incorporate changes at the Contractor's facility prior to shipment. A full configuration report must be delivered to the SEPTA personnel at the SEPTA field office located on the Contractor’s facility prior to any final shipment inspections.

If any changes are deemed impossible to complete based on material concerns, SEPTA at its discretion may allow shipment with the change as a shipment exception. If the shipment exception is authorized, the Contractor will need to provide information for plans for the change to be retrofitted after delivery or to be scheduled in a recognized retrofit campaign agreed to by SEPTA.

The Contractor shall maintain an effective system to track all changes. All retrofit changes shall be recorded on a fleet-wide basis as to the vehicles they were installed on in a controlled manner.
1.11 PROGRAM MANAGEMENT

The Contractor shall submit to the Engineer for approval within 45 days after the Notice to Proceed a program management plan. [CDRL 01-043] It shall contain, as a minimum, an organizational chart providing a definition of personnel responsibilities, the methods and communication to be used to control the program (its schedule, technical performance, program changes, subcontracts, material procurement, and field engineering support), and details concerning the critical path method (CPM) scheduling plan for the contract work as described below.

The Contractor shall organize the conduct of the Project in an effective manner. At a minimum, there shall be a project manager, project engineer, and assistant project engineer as primary staff. The Contractor shall propose selections for approval from a group having considerable pertinent experience in work of the type involved. This primary staff shall have full authority from the Contractor's higher management to make the final commercial and technical decisions and commitments for this Procurement. The assistant project engineer shall have sufficient stature and authority within the organization to represent the project engineer, direct the Contractor's field personnel, and provide a decision making liaison with the Engineer. The individuals approved for these positions shall not be changed without the approval of the Engineer. The project engineer shall ensure that any work relating to safety critical circuits and subsystems is assigned to experienced staff with strengths in this area and that the responsibility is not fragmented.

The program management plan shall have a live document status. Any and all changes must be submitted to the Engineer during the next monthly progress report covering the time period the change took place as referenced in TS 1.10. Changes will be subject to approval by the Engineer. Lack of notification or changes deemed compromising the intent of the Specification shall be cause to revoke the approval status of the plan.

1.11.1 Critical Path Method Plan

The Contractor shall use an approved state of the art personal computer driven critical path method (CPM) plan to schedule both its and its subcontractors' and major suppliers' work for this Contract. The Contractor shall supply the Engineer with five (5) copies (including manuals) of the CPM plan software and associated plotting software both licensed under SEPTA's name with the initial submission of the overall project schedule and maintain the licenses for the life of the Project. Each submission from the Contractor shall consist of a time scaled network diagram, accompanying computer generated mathematical analysis, and a copy of the computer data file. It shall be possible for the Engineer to run the plan with modified dates to check the plan's final results.
The CPM plan shall have a precedence type network with the start date being the Notice to Proceed, with every milestone listed in the delivery schedule provided in the terms and conditions being listed including the delivery of each car. All intermediate milestones shall be shown in proper logical sequence. The CPM plan shall include all of the Contractor’s work activities with sufficient detail such that all interfaces with all direct and related parties of the project are highlighted. The work of subcontractors and suppliers shall be shown on the schedule and updated whenever necessary. A high priority shall be given to keeping the plans accurate and up to date. Major procurement activities shall be indicated including submittal and approval of shop drawings and delivery of all material. Interruption of service, delivery of equipment, project phasing, and any other Specification requirements must be included. No schedule activity shall have a duration greater than 30 work days (except procurement lead times). Activities with durations of less than five (5) work days shall be held to the absolute minimum. The minimum activity information required in the CPM plan includes the following:

a. A unique work item number for each activity that includes each suppliers’ identification
b. A concise description of the work represented by the activity
c. A work area code identification
d. Expected activity duration in workdays based on intended work force
e. Early and late start and finish times calculated according to CPM principles
f. The total float shall be indicated for each activity. The critical path shall be indicated on the logic diagram.
g. Manpower required in average number of workers per day

Activity precedence relationships consistent with proper logic shall be shown with lag codes. The Contract milestones and Contract completion date shall be input as mandatory finish dates and agree with the dates specified in the Contract. Activities shall be described such that the work is readily identifiable for the assessment of start and completion. Descriptions shall utilize physical locations such as column lines, stations, and elevations where possible to define the work. Activity descriptions of "start", "continue", "completion", or similar will not be allowed. Historical dates for activities shall be used upon the reaching of each milestone for each activity. A revision number and/or date of issue shall identify each updated version of the plan.

Computer produced mathematical analysis calculated according to CPM principles shall accompany the submission of the CPM plan. They shall include all activities organized in the following activity sorts:

a. Activity number
b. Total float then early start
c. Grouped by subcontractor and supplier responsibility and then sorted by early start
d. Grouped by area and then sorted by early start
The network displayed on the diagram shall depict the exact detail of the CPM network and computer reports. The diagram shall be drawn by using early dates and shall be time scaled. The length of the activity representation shall be proportional to the activity duration. The calendar for the network diagram shall be the same as the computer master file. The activity display shall include the activity description, activity number, activity duration, activity total float, and the activity subcontractor and supplier code.

The Contractor shall require that its subcontractors and suppliers the information needed to properly update the plan at a maximum period between updates of 30 days and then pass the updated plan to the Engineer. Particular attention shall be given toward the early detection of any supplier delay to allow proper response to be made by the Contractor as early as possible.

The activities which are displayed on the network diagram shall be grouped into major components of work as defined by the activity work area coding. The description of these components shall appear on the left hand side of the plot. The diagram shall be a maximum of an "E" drawing size with multiple sheets or long size plotting acceptable, and the vertical distance between activity displays shall be a minimum of 0.5 inch. The critical path shall be identified on the plot. Vertical lines indicating the start and the end of each month or quarter shall be drawn. The date shall be indicated on the plot. This shall be done in the activity display and title at the top or bottom of the plot. Completed activities shall be indicated on the plot.

The Contract number and title shall be displayed on the plot. A legend shall be provided which indicates the various symbols used and their meanings. Contract milestones shall be indicated by a prominent symbol. Different lines shall indicate critical path and completed activities. These may include dashed over marking, several line widths, or different colors.

Whether or not the CPM Plan is accepted, it shall be updated a maximum of every 30 days using a Contract skeleton form. The Contract skeleton form is prepared by entering the historical record of actual start and actual or expected finish for activities worked on during the revision period. The number of units in place or percent complete will be indicated for each line item for each reported activity as approved by the Engineer. Revisions to activities not worked on during the period, including changes in duration, or revisions to activity relationship are to be considered logic revisions. If any logic revisions are made, a new computer analysis with the updated information and logic changes and a time scaled network diagram shall be submitted. A copy of the revised computer master file shall be submitted and shall be accompanied by a letter from the Contractor which explains the revisions. When in the Engineer's opinion the CPM plan fails to reflect the Contractor's actual plan and method of operation or the Contractor's completion date as indicated by the CPM plan is more than one (1) month behind the Contract completion date, the Engineer may require that the Contractor submit for review within 14 days a revised CPM plan for completion of the remaining work within the Contract completion date. The format shall be as specified above.
1.11.2 Monthly Progress Reports

In addition to the requirement for updated versions of the CPM plan to be submitted to the Engineer, the Contractor shall submit to the Engineer a monthly progress status report in the form of updated computer printouts and narrative reports. [CDRL 01-044] In the narrative report, the Contractor shall state the percentage of work physically completed and include a description of the physical progress during the report period; plans for the forthcoming report period; problem areas, current and anticipated; delaying factors and their impact; and an explanation of corrective actions taken or proposed. Specifically addressed in the report shall be the status of uncompleted activities which have less than 30 calendar days float and which are either in progress or scheduled to be started within the next reporting period. At the request of the Engineer, the Contractor shall participate in pre-update conferences to verify progress and review modifications to the detailed network schedule prior to the formal monthly submittal. This report shall also include the work done by major suppliers and subcontractors.

1.11.3 Audits

During the evaluation of design, the Engineer will monitor the Contractor's efforts to determine the degree to which the objectives of the Contract are being achieved through the use of reviews and audits. The reviews and audits shall be conducted jointly by the Engineer and the Contractor. In all cases, approval by the Engineer shall not constitute relief from contractual obligations.

1.11.4 Post-Delivery Changes

The Contractor shall contain within its program management plan a system to identify, design, and install in every car any modifications made necessary by defects discovered during the warranty period of the last car as defined by the warranty category outlined in the Contract. This shall start with the delivery of the pilot cars and shall pay particular attention to the outcome and results of the extended testing of the pilot cars, as well as later discovered defects on any cars. The configuration management plan shall be a part of this effort. A weekly report shall be submitted to the Engineer identifying every defect on each car during the previous week, its resolution, and the status of each car involved in any required retrofit including any necessary changes to publications, drawings, or education programs.

1.12 CONFIGURATION MANAGEMENT

1.12.1 Plan

It is a basic requirement that the Contractor assures that the configuration of the fleet remains the same for all changes. The Contractor shall develop and submit to the Engineer for approval a configuration management plan within 45 days after the Notice to Proceed. [CDRL 01-045] The plan shall illustrate how the Contractor intends to meet the configuration management requirements and shall include as a minimum:
a. Flow charts of paperwork for design changes prior to and following design reviews and drawing approvals

b. Forms to be used to convey, track, and account for the design changes whether approved or not

c. Description of the methods and communication to be used to control hardware configuration identification for purposes of receiving inspection, installation, test, retrofit, reliability, safety, and inventory control

d. Description of the forms and methods to reflect the current modification status of every car

e. Detailed processes on how changes are introduced into production of the cars, on delivered vehicles, and on spare parts

f. Detailed process of updating spare parts to the latest revision changes

g. Detailed techniques to visually identify component revision level changes to equipment due to modification upgrades and processes to implement such identifiers

h. Method to be used to make required revisions to publications, drawings, education programs, photographs, and any other program software

The configuration management plan shall have a live document status. Any and all changes must be submitted to the Engineer during the next monthly progress report covering the time period the change took place as referenced in TS 1.10. Changes will be subject to approval by the Engineer through the ECP process defined in TS 1.10.3. Lack of notification or changes deemed compromising the intent of the Specification shall be cause to revoke the approval status of the plan.

1.12.2 Reports

The Contractor shall submit a report a minimum of every 45 days to the Engineer to reflect the status of documented design changes and retrofits and to provide a current configuration list of hardware classified as lowest vehicle replacement items (LVRI) as well as their next higher assemblies (NHA).

[CDRL 01-046]

1.12.3 Provisions

The Contractor shall maintain accurate and current configuration records which shall be available to the Engineer throughout the period of the Contract and for a three (3) year period after final Contract payment. The Contractor shall ensure that its suppliers’ equipment incorporated in the car design complies with all the related provisions that follow. The guidelines provided by DOD-STD-480A and MIL-STD-483 shall be adapted to the program in a responsible and disciplined manner consistent with good maintenance practices.
1.12.4 Identification

The Contractor's technical documentation shall be capable of defining the approved configuration of hardware and computer software under development, test, production, or in operational use. The technical documentation shall identify the configuration to the lowest level required to ensure repeatable performance, quality, and reliability.

The Contractor's release records and documentation shall indicate the composition of any part number at any level in terms of subordinate part numbers, all NHA part numbers of any part, and the specification document, specification control drawings or source control drawing numbers associated with any subsupplier and vendor, or Contractor part numbers. This shall apply down to the level at which lower level components are standard and not unique. Such parts shall not be required to have NHA identification.

The Contractor's release records and documentation shall identify engineering changes and retain the record of superseded configuration requirements affecting items which have been formally released for test or production. The Contractor shall employ a system of identifying numbers for specifications, drawings, and associated documents which shall ensure that differing parts, assemblies, and installations are uniquely identifiable. The Contractor, subcontractors, and suppliers shall provide a permanent means of identifying a specific item as having a specific configuration. As a minimum, the items at the lowest level of repair and replacement, as well as their next higher assemblies to the vehicle level, shall be identified in this manner.

All items identified by the same part number shall have the same physical and functional characteristics, shall be equivalent in performance and durability, and shall be interchangeable without alteration to themselves or associated items other than normal field adjustments. An item shall not be considered interchangeable if it requires selection for fit or performance.

The Contractor shall permanently mark, as a minimum, the items at the lowest level of repair and replacement as well as the next higher assemblies to the car level. The hardware identification marking shall at all times coincide with the officially released engineering data by revision level.

Serial numbers shall be included on the items and shall be in a unique numerical sequence. Duplicate serial numbers shall not be used within a specific part number. Serial numbers may be alphanumeric and shall not exceed six (6) characters in length to be compatible with SEPTA's computer reporting system.

All serial numbered equipment that becomes modified through changes must have the revision level of the change reflected in the part number portion of the serial number tag. This tag shall be permanent and easily identifiable.
1.13 QUALITY ASSURANCE PROGRAM

1.13.1 Plan

The Contractor shall develop and submit to the Engineer for approval a quality assurance plan for the Contractor and those of all major subcontractors and suppliers at the time of the design review. [CDRL 01-047] The plan shall illustrate how the Contractor intends to meet the quality assurance requirements of this Specification and shall include as a minimum:

a. An organizational chart including a definition of the responsibilities of personnel thereon for receiving inspection, defect material handling (especially related to material found malfunctioning during production conformance testing), production conformance testing verification, process specification implementation, equipment calibrations, etc.

b. Methods and procedures used to control the daily manufacturing processes and material quality

c. Flow charts of paperwork for the acceptance or rejection of material, identification and disposition of unacceptable items resulting from inspections, the specific accountability of material found malfunctioning during production conformance testing, configuration verification of the constituent car items to be included in the car history book, etc.

d. Forms to be used to convey, track, and account for design changes implemented in the cars regardless of their state of completion and any other forms necessary for the program. Each form shall be serial numbered

The quality assurance plan shall have a live document status. Any and all changes must be submitted to the Engineer during the next monthly progress report covering the time period the change took place as referenced in TS 1.10. Changes affecting the project will be subject to approval by the Engineer. Lack of notification or changes deemed compromising the intent of this Specification shall be cause to revoke the approval status of the plan.

1.13.2 Reports

The Contractor shall submit a report at least every 30 days to the Engineer that shall document the results of audits made within the Contractor’s, subcontractors’ and suppliers’ quality assurance functions; identify unsatisfactory conditions encountered with the design or equipment during its manufacture and/or installation; itemize all field modification instructions (FMI) with a status of their incorporation and cross referenced to the related engineering change notice (ECN); and identify material part numbers, part designations (if any), serial numbers, configurations, and descriptions that were found malfunctioning during production conformance testing. The list shall be cumulative in nature but shall communicate discernible trends in the increased stabilization or reduction of conditions encountered. The car number shall be used as a primary means of identification of summary lists of defects if possible.
1.13.3 Organization

The Contractor and their major subcontractors and suppliers shall establish a quality control program based upon ISO 9001-2008 adapted to the program in an approved manner or an approved equal. The organization of the contractor's quality assurance (QA) program shall have sufficient well defined responsibility and organization. The QA director shall report directly to the general manager of the Contractor's facility or the Contractor's project manager. In any case, it must be completely independent of the Contractor's manufacturing or purchasing divisions. The QA personnel shall have complete freedom to identify and evaluate problems; recommend solutions; verify implementation of solutions; and control further processing, delivery, or installation of a nonconforming or deficient item until proper and documented disposition has been obtained.

The QA organization shall be arranged to promote a control function that operates in an independent objective manner unbiased by schedule, cost, and authority limitations imposed by personnel other than the Contractor's high level management starting with the general manager or equivalent.

1.13.4 Certification of Personnel

The Contractor's quality assurance personnel performing inspections and tests shall be certified for such work. Certification of personnel shall be by the virtue of those skills which are obtained by experience or training and verified by testing. Manufacturing personnel performing special processes such as welding, brazing, etc. shall be certified for such work. Records of personnel certifications shall be maintained and monitored by the Contractor's quality assurance personnel. These records shall be made available to the Engineer for review.

1.13.5 Evidence of Compliance

The Contractor's QA personnel shall maintain objective verifiable evidence of compliance with this Specification as it pertains to hardware configuration, purchasing, inspecting, handling, assembling, fabricating, production conformance testing, storing, shipping, and warranty/repair work in the interest of quality.

1.13.6 Material Certificates of Compliance

The Contractor may use certificates of compliance for certain materials and products in lieu of the specified sampling and testing procedures as approved by the Engineer for demonstrating proof of compliance of materials delivered. Each shall clearly identify the lot so certified by the certificate and be signed by an authorized representative of the supplier or subcontractor stating the material complies in all respects with the Contract requirements. Accompanying the certificate of compliance shall be a certified copy of test results or a statement that such test results are on file with the supplier or subcontractor and will be furnished to the Engineer on request. Each certificate shall contain the information specified for samples, name and address of the organization performing the tests, date of the tests, and quantity of materials shipped.
1.13.7 Calibration
The Contractor shall demonstrate an effective time or usage cycled calibration program for testing of measurement equipment and tools. Validity of measurements and tests shall be ensured through the use of suitable inspection, measurement, and test equipment of the range and type necessary to determine conformance of items with Contract requirements. At intervals established to ensure continued validity, measuring devices shall be verified or calibrated against certified standards that have a known traceable relationship to the U.S. National Institute of Standards and Technology (NIST) or the local country’s similar organization. Tooling used as a media of inspection shall be included in this program. Furthermore, every device so verified shall bear an indication attesting to the current status and showing the date (or other basis) on which inspection or recalibration is next required. Devices suspected of being out of calibration before the stated recalibration date shall be promptly recalibrated. Inspections performed with devices proven to be out of calibration must be reinspected. All calibration certifications shall be recorded and become part of the quality assurance records.

1.13.8 Procedure Documents
The Contractor shall establish and maintain written procedures defining the quality assurance program. The procedures shall encompass all phases of the program to include, but not be limited to, control of subcontractors, receiving inspection, production and process control, functional testing, discrepancy control, measuring and test equipment calibration, configuration control, quality assurance records, shipping inspection, and other quality specifications to meet the requirements of the Contract. All such documents shall be made available to the Engineer upon request.

1.13.9 Quality Assurance Activities
The Contractor shall address, as a minimum, the following activities and shall provide a means of self-correcting any shortcomings in the quality assurance program.

1.13.9.1 Procurement
The Contractor shall document in writing the methods to be used for the selection and control of the suppliers. These methods shall identify a means of:

a. Selecting qualified procurement sources through the evaluation and assessment of their quality assurance programs

b. Communicating and approving all product quality requirements and changes thereof

c. Monitoring the supplier's quality performance through the evaluation of procured items against purchase order requirements and through audits

d. Providing for early and effective information feedback and correction of nonconformances especially of items found malfunctioning during production conformance testing

e. Approving special processes
The Contractor shall require each supplier to be responsible for maintaining and retaining records. Furthermore, the Contractor shall require each supplier, as a minimum, to submit with each shipment appropriate certifications, final inspection results, and test results. Requirements shall be included for chemical or physical testing records in connection with the purchase of raw materials by the subcontractors. The Contractor's purchase orders shall contain a requirement for the supplier to notify and obtain approval from the Contractor of changes of design of the products which affect fit, form, or function, or substitution of materials.

1.13.9.2 Manufacturing Inspection

Inspection shall occur at appropriate points in the manufacturing sequence to ensure quality consideration for compliance with drawings, test specifications, process specifications, and quality standards. The Engineer may designate inspection hold points into the Contractor's manufacturing or inspection planning upon review of the Contractor's efforts. Inspection shall be 100 percent or upon prior approval a statistical sampling plan may be used. Nonconforming materials shall be identified as discrepant and shall be segregated and reviewed for disposition.

1.13.9.3 Production Conformance Testing

The Contractor's quality assurance personnel shall witness the performance of all production conformance tests (see TS 18.3) and verify proper configuration of the equipment tested. If any item does not satisfy all performance or design criteria, the item shall be retested until the tests are passed with the necessary adjustments or repairs documented and certified by a witness. In the case of subsystem and vehicle tests, the Engineer's representative shall be included in this process and concurrence shall be obtained as a permanent part of the certification.

1.13.9.4 Receiving Inspection

The Contractor's receiving inspection activity shall provide for the inspection of all incoming materials. These inspection measures shall be used to preclude the use of incorrect or discrepant materials and to ensure that only correct and accepted items are used and installed. Upon prior approval from the Engineer, statistical sampling may be used. All material certifications and test reports used as the basis for acceptance by the Contractor shall be preserved. Inspection measures shall identify any item at any stage of production to an applicable drawing, specification, or other pertinent technical document. Permanent physical identification shall be used to the maximum extent possible.

1.13.9.5 Shipping Inspection

The Contractor's quality assurance program shall provide and enforce procedures for the proper inspection of all products to assure completion and conformance as required by the Contract prior to shipment. The Contractor's QA personnel shall be responsible for the collection, verification, and submission to SEPTA a full accountability of the configuration as reflected in as-built drawings, applied ECNs, and the test status of each car prior to the presentation to SEPTA for shipment inspections. All shipments shall be prepared as required to preclude damage during shipment. The inspections and preparation for shipment shall be verified by the Contractor's quality control personnel. The authorization for the delivery of the car shall be approved by the Engineer. [CDRL 01-048]
1.13.9.6 Statistical Sampling
Statistical quality assurance sampling per ANSI/ASQC Z1.4-2003 used in inspection shall be fully documented and based on generally recognized and accepted statistical quality assurance practices. Prior to the use of statistical sampling, the Contractor shall submit the proposed statistical sampling plan to the Engineer for approval. [CDRL 01-049] Sampling plans may be used when tests are destructive or when quality trend data, inherent characteristics of the product, or the noncritical application of the product indicate that a reduction in testing or inspection can be achieved without jeopardizing quality. Any sampling plan used shall provide valid confidence and quality levels and shall be approved by the Engineer.

1.13.9.7 Changes
The Contractor shall ensure that inspections and tests are based on the latest approved revision or change to drawings and specifications. A procedure shall be maintained that embraces the adequacy, completeness and updating of drawings, and the control of changes. This procedure shall be in coordination with the change control system as provided in TS 1.10. The Contractor shall ensure that requirements for the effectivity point of changes are met and that obsolete drawings and change requirements are promptly removed from all points of issue and use. Means of recording the effective points shall be employed and made available to the Engineer.

The quality assurance program shall ensure that there is complete compliance with Contract requirements for proposing, approving, and effecting engineering changes. The Contractor's responsibility for drawings and changes shall extend to the drawings and changes provided by the suppliers for the Contract.

1.13.9.8 Identification of Status
The Contractor shall maintain a system for identifying the progressive inspection status of materials, components, subassemblies, and assemblies as to their acceptance, rejection, or non-inspection. The system shall provide for ensuring that required inspections and tests are performed and that the status of items with regard to inspections and test performance is known throughout manufacturing, installation, and testing. Nonconforming items shall be identified by physical segregation and status indicators such as tags, serialization, markings, stamps, and inspection records. The identification system shall ensure that only items that have passed the required inspection and tests are used or installed.

1.13.9.9 Handling
The Contractor's quality assurance program shall provide for adequate surveillance work and inspection instructions for the handling, storing, preserving, packaging, marking, and shipping to protect the quality of products as required by the Contract.
1.13.9.10   Nonconformance

The Contractor shall establish and maintain an effective and positive system for controlling nonconforming material and workmanship including procedures for its identification, segregation, and disposition. Dispositions allowing the use or repair of nonconforming material or workmanship shall require the Engineer’s approval. All nonconforming issues shall be positively identified to prevent unauthorized use, shipment, or intermingling with conforming material. Holding areas and procedures mutually agreeable to the Contractor and the Engineer shall be established by the Contractor.

Corrective action and related information shall be documented and made available to the Engineer upon request. Corrective action shall extend to the performance of all subsuppliers and include as a minimum:

   a. Analysis of data and examination of discrepant products to determine extent and causes with corrective action implemented in an expeditious manner prior the next shipment, order, or inspection

   b. Introduction of required improvements and corrections, initial review of the adequacy of such measures, and monitoring of the effectiveness of the corrective action taken

   c. Analysis of trends in processes or performance of work to prevent nonconforming products

1.13.9.11   Quality Assurance Review

At his discretion, the Engineer will review the Contractor’s quality assurance program and its functions to determine compliance with the approved quality assurance plan. During its initial review, the Engineer will inspect the various manufacturers’, subcontractors’, and suppliers’ quality assurance functions. Subsequent examinations shall be performed by the Contractor for the same purpose. The Contractor will be notified of all nonconformance issues determined during the review. Nonconformance with any part of the approved quality assurance plan may be cause for rejection of the Contract work being performed by the responsible entity (i.e., if the Contractor is responsible, the work on the Contract may be rejected. If a subcontractor or supplier is responsible, the work by that subcontractor or supplier may be rejected).

Whenever the Engineer determines a nonconformance condition with the quality assurance plan (whether in the Contractor’s own plan or that of its subcontractors or suppliers), the Contractor shall promptly correct the nonconformance and request approval by the Engineer. Any schedule delays caused by nonconformance with the approved quality assurance plan, whether on the part of the Contractor or its subcontractors or suppliers, shall not serve as a basis for an extension of the Contract time requirements.

Quality assurance reviews of the Contractor’s, subcontractors’, and suppliers’ efforts shall be made by the Contractor’s QA personnel and may be witnessed by the Engineer. As a minimum requirement, the reviews shall be made as a condition of a subcontract or purchase order prior to the start of any work by a subcontractor and also within a 30 day period prior to the formal acceptance by the Contractor of the first article inspection or the services being supplied by the subcontractor or supplier.
The Contractor shall prepare a report for its review and shall submit a copy to the inspected organization. The Engineer shall be informed of each review. The report will describe the scope of the review, the procedures followed in conducting the review, a statement of all deficiencies found and keyed to the approved quality assurance plan, the corrective action required for each deficiency found, and the date by which corrective action is required.

### 1.13.9.12 First Article Inspections

The Contractor’s quality assurance program shall include a procedure for conducting first article inspections (FAIs). Successful conduct of an FAI shall precede any shipment of material by a subcontractor. FAIs shall be conducted on all parts, subassemblies, and assemblies as reflected within the different levels of drawings and prints and/or schematics. All parts and assemblies manufactured by subcontractors shall have an FAI performed. The procedure shall include the following requirements as a minimum:

a. A tracking system shall be developed and maintained which will identify each FAI subject and accurately reflect the present status of each inspection.

b. FAIs shall be performed on actual samples considered to be complete by the manufacturer and reflecting the approved baseline drawings. Successful completion of qualification tests per TS 18.2 and production tests per TS 18.3 for the subsystem is a prerequisite for conducting the FAI.

c. The FAI shall be performed using the approved baseline drawings in conjunction with this Specification reflecting specific requirements of the subject along with any special tools and/or equipment needed to verify the design requirements, configuration, and operation (if applicable) of the item being inspected.

d. All technical data required for maintenance manuals and/or parts catalogs shall be submitted as initial drafts in authoring files and PDF file formats per TS 19 prior to the full acceptance of the FAI. The initial drafts shall contain sufficient information to adequately maintain the equipment during the pilot car program and initial production car delivery.

e. The Engineer shall be given notice of an upcoming FAI at least four (4) weeks before its schedule date.
1.14 PERFORMANCE OF THE WORK

1.14.1 Contractor’s Responsibility

Performance of the work under this Contract shall be done in strict conformance with the Contract documents and consistent with the best past practices of the Contractor and the North American rail equipment construction industry for the manufacture and assembly of cars and their component parts whether or not expressly set forth herein. The Contractor alone shall at all times be responsible for the adequacy, efficiency, and sufficiency of their plant, equipment, and employees and those of their subcontractors and suppliers; shall have the ultimate responsibility for the methods used for the manufacturing and assembling of the items of material or equipment being furnished; and shall maintain records of all engineering changes.

To ensure that ordered material meets Specification requirements, the Contractor shall forward to the Engineer a copy of all purchase orders or changes in existing purchase orders issued (with price data omitted) giving a complete bill of material description of the material ordered from any major supplier, or to obtain equipment which is specifically identified in this Specification by brand or model number, or for certain components identified previously by the Engineer. [CDRL 01-050] All equipment specifically identified in this Specification (or its Engineer approved equal) must be so identified by brand or model number on relevant purchase orders even when it would be included within a major supplier's complete system.

The Contractor shall take full responsibility in assuring that the purchase orders reflect conditions where all suppliers for parts, components, and services meet the terms and requirements of this Specification in regards to design, materials, and workmanship (as applicable) in addition to ancillary items such as participation in manuals and training.

Each major supplier (those whose equipment is generically described by the title of a Section of this Specification including seating supplier) selected by the Contractor shall appoint a program manager and a product engineer to be responsible for their respective products. They shall be the prime supplier contacts for the Contractor (and through them to the Engineer) and shall attend all design review meetings for which their products are involved. They shall coordinate first article inspections, all tests, and all design reviews of their products. The program manager and the product engineer shall have ready access and full authority to commit the supplier to commercial and technical issues relating to the construction of the cars and components.

The Contractor and their subcontractors and suppliers shall make use of commercial industry standards and codes (i.e., ANSI, ASME, ASTM, NFPA, SAE, etc.) to the greatest extent possible in their designs of material or equipment under this Contract. Where the Contractor or their subcontractors and suppliers do not utilize such commercial industry standards and codes but rather utilize their own standards or specifications, they shall be prepared at the request of the Engineer to demonstrate that their own standards or specifications are equal to or surpass the commercial equivalents. When requested, such information will be considered confidential.
Whenever the Contractor or a manufacturer refers to a material or process by their own specification number, they shall also list the commercial equivalent. If there is no commercial equivalent, they shall provide the Engineer with copies of their own specification, which will be considered confidential in nature.

1.14.2 Design Responsibility

The Contractor shall be responsible for the detailed design of the cars and their component parts and shall prepare all necessary detail drawings and schedules for the Engineer's approval prior to assembly of any items of material or equipment. Consequently, the Contractor or subcontractors shall not deviate in their material or equipment purchasing from the approved drawings and schedules. SEPTA shall not be liable for any additional costs or delays caused by the Contractor's failure to secure the prior approval of the Engineer where required by the Contract documents.

The Contractor, as part of its responsibility for the system design of the entire car and all of its equipment, shall be responsible for the proper interrelation, function, and system integration of all phases of all vehicle systems, their interrelation with all other parts of the car, and their interrelation with the wayside and shop facilities during the design, manufacturing, and testing phases of the Contract. The Contractor shall provide the services of a full time systems' integrator and shall be responsible for coordinating all electrical and mechanical interfaces between the different vehicle subsystems, the vehicle and the wayside and shop, and electrical interference control.

1.14.3 Manufacturer's Duties

The Contractor shall require that each manufacturer of components, apparatus, or parts shall make, assemble, and completely test ready for installation by the Contractor the component or apparatus to be furnished by said manufacturer as per the Contractor's instructions.

The Contractor shall ensure that all cars are identical in all respects except as otherwise agreed to by the Engineer. The Contractor shall ensure that all the material produced by all subcontractors is in accordance with approved drawings and identical throughout the production run except as otherwise agreed upon in order to implement modifications and improvements which will be retrofit on earlier production cars.

1.14.4 Cooperation

The Contractor shall require that all subcontractors, suppliers, and manufacturers of all materials, apparatus, and parts shall cooperate to the fullest extent during design, construction, and testing to ensure proper use or installation of their products. The integrated performance of all equipment within the car is required. The subcontractors shall give prompt notice to the Contractor if the use or installation proposed by the Contractor is not satisfactory to them. No agreement with respect to the above shall be made without a conference at which the Engineer and the Contractor are each represented. The Contractor shall ensure that each major supplier is provided with an updated complete copy of these Contract documents.
1.14.5 General Workmanship

Whenever under the Contract documents it is provided that the Contractor shall furnish materials or manufactured articles or that it shall do work for which no detailed specifications are set forth within said documents, the materials or manufactured articles shall be of the best grade in quality and workmanship obtainable within the market from firms of established good reputation or, if not ordinarily carried in stock, shall conform to the usual standards for first class materials or articles of the kind required with due consideration of the use to which they will be put. In general, the work performed shall be in full conformity and harmony with the intent to secure the best standards in the work as a whole or in part.

The work performed by the Contractor and all subcontractors shall be executed in conformity with the best accepted standard practice of the trade so as to contribute to maximum efficiency of operation of the material and equipment purchased, accessibility of all parts and components, a pleasing appearance of the material and equipment, and minimum cost of maintenance.

Whenever it is necessary for whatever reason for the Contractor to modify a part used on the car or in any spare parts following the shipment of the pilot cars, the Contractor shall undertake a retrofit program at its own expense to modify all cars and spare parts as necessary so that each similar part has an identical part number, is interchangeable, requires the same troubleshooting procedures and levels of maintenance, and performs identically. The Engineer may waive this requirement on an individual case basis.

1.14.6 Substitution of Materials

Whenever items of equipment and/or materials are specifically identified in this Specification by using the name of a proprietary product or of a particular manufacturer or vendor, any material or article which will in the opinion of the Engineer perform interchangeably the duties imposed by the general design including its life cycle costs will be considered equal and satisfactory, provided the material or article so proposed is of equal substance and function in the Engineer’s opinion. Written approval of the Engineer is required for any substitution.

Any request for the use of a substitute or an alternate to the items specified in these Contract documents must be submitted in writing to the Engineer. It must be accompanied by full descriptive and technical data on the material or equipment proposed as well as a complete analysis showing that the substitute’s maintainability, reliability, and life cycle costs are equal or superior to that of the product listed in this Specification.

1.14.7 Defective Workmanship or Materials

Whenever the Engineer determines that any of the work being done under the Contract or that the kind or quality of materials supplied in connection therewith are not fully and completely in accordance with any requirement of this Specification, the Engineer shall give notice of such noncompliance to the Contractor in writing, and the Contractor shall immediately upon receipt of such notice do all things required to remedy such noncompliance. This does not relieve the Contractor from having and enforcing its own quality assurance program.
1.14.8 Furnishing of Warranty Parts

The Contractor has sole responsibility under this Contract to maintain sufficient warranty spare parts in their stock to support the warranty period requirements. SEPTA is under no obligation to provide spare parts to the Contractor for warranty purposes. The Contractor shall keep onsite at the SEPTA Frazer Shop, or other location in the SEPTA Railroad Division so designated by the Engineer, a sufficient quantity of spare parts to expedite the repair and return of the cars to service.

In the event that the Contractor does not have needed warranty spare parts on hand, SEPTA on an individual item basis and in kinds and amounts solely within their discretion, may permit their spare parts to be used by the Contractor in performance of warranty work. Any spare part from SEPTA’s stock that is used for warranty by the Contractor shall be replaced by the Contractor with a new part of original quality to the latest configuration and with a new original warranty.

The Contractor and all of their subcontractors and suppliers must also maintain in stock in their warehouses sufficient levels of consumable and routine maintenance spare parts to allow SEPTA to purchase them and have timely delivery to support their preventive maintenance activities. SEPTA shall maintain a sufficient level of preventive maintenance parts based upon replacement schedules contained within the publications and a level of consumable parts based upon pilot car experience and Contractor recommendations.

1.15 SUPPORT EQUIPMENT AND SPECIAL TOOLING

1.15.1 Support Equipment

The Contractor shall examine the existing support equipment inventory at the maintenance and repair facilities of SEPTA and shall submit to the Engineer by the delivery of the pilot cars a list of common support equipment recommended to be purchased to effectively maintain and repair the cars. **[CDRL 01-051]** Support equipment is defined as the usual hand tools, generic test equipment, jacks, hoists, cranes, etc., that are required in order to maintain, operate, and overhaul the cars and their components and which are considered common shop equipment used in the United States available as standard catalog items from at least two (2) domestic U.S. suppliers.
1.15.2 Special Tools

The Contractor shall supply four (4) complete sets of all specialized tooling, jigs, fixtures, measurement devices, and so forth which are necessary for the inspection, testing, maintenance, removal, replacement, repair, disassembly, assembly, lubrication, or overhaul of any equipment on the car that are not commonly available from commercial tool suppliers as standard catalog items. [CDRL 01-052]

The Contractor shall assume that SEPTA will be responsible for the purchase of any tooling or equipment which is available as a standard (non-specialized) commercial grade catalog item from at least two (2) domestic U.S. suppliers. Any items beyond this shall be the responsibility of the Contractor. Items shall be of heavy duty commercial grade quality. These shall include those tools and devices not normally found in a mechanic's or electrician's standard tool kit. Examples include fixtures needed for the disassembly and repair of the trucks including drive assemblies and wheels, wire connector assembly or disassembly tools, hydraulic pullers for motor shaft couplings, clearance gauges, special lifting fixtures, special assembly benches or fixtures, wrench adapters, bearing pullers, guide sleeves, etc. Emphasis shall be placed on specialized tooling for the overhaul of electrical, mechanical, pneumatic, and electromechanical equipment. Complete manuals explaining the use of each gauge or tool and its care and maintenance shall be included. Drawings for all fabricated special tools shall be included in the drawings database showing all dimensions and materials and part lists shall also be supplied. The Contractor shall provide part numbers and prices for all special tools and maintenance equipment to enable SEPTA to purchase additional quantities. The Contractor shall submit a listing and description of all special tooling to the Engineer for approval. [CDRL 01-053] All items shall be delivered by the delivery of the last production car.

1.15.3 Spare Parts

The Contractor shall provide spare parts for all apparatus and components of the cars in the quantities and configuration listed in the price proposal. All assemblies shall be delivered as called out in the delivery schedule. All items shall be identical with corresponding items as supplied on the cars, and any changes to parts made on the cars before or during the warranty period shall be made by the Contractor on applicable spare parts at no cost to SEPTA. Where appropriate, all parts shall be packaged for long term and/or protected storage.

The Contractor shall also provide an electronically controlled recording medium such as a database or spreadsheet where all parts and materials are listed by name, contractor part number, supplier part number, and quantities. A full record of deliveries and extractions from stock shall also be recorded within the medium as parts and materials are delivered or used. [CDRL 01-054]

As part of its base cost, the Contractor shall supply a quantity of consumable type spare parts other than lubricants required to support operation of the base quantity of cars for a period of six (6) months from delivery of each car. These parts shall be based upon the consumable parts identified in the maintenance manuals such as HVAC filters, compressed air system filters, brake shoes and pads, windshield wiper blades, interior lamps and exterior bulbs including indicator LEDs, pantograph carbons, and the like required to support all daily, periodic, preventative, and any other type of scheduled maintenance. Also to be included are two (2) Operator seats and two (2) car sets of side windows including handles and elastomers. Other parts to be included are two (2) car sets each of the following items: all pneumatic hoses, coupler electrical cables and tappet valves, and overhead heater protective thermal fuse elements. The consumable parts list shall be provided during the detailed design review with the consumable spare parts delivered prior to the delivery of the pilot car. [CDRL 01-055]
1.15.4 Printed Circuit Board Extenders
Printed circuit board extenders (50 sets of each type) shall be provided by the Contractor for all rack-mounted circuit boards. [CDRL 01-056] The Contractor shall provide detailed maintenance and bench test troubleshooting procedures for each board in the maintenance manuals including wave forms and voltages at critical locations of the circuitry. [CDRL 01-057] Nonrepairable or “throw away” circuit boards may be supplied only by approval of the Engineer. In making this request for approval, the Contractor shall focus on the advantages to SEPTA of this approach. Where use of nonrepairable circuit boards is granted, the Contractor shall supply to SEPTA spare circuit boards of each type in number either equal to 15 percent of those employed on the equipment of one (1) car multiplied by the number of cars supplied under this Contract or equal to a percentage determined by the failure rate through the warranty period prorated to the number of failures predicted over 20 years of service, whichever is greater, in order to compensate for the lack of repairability.

1.16 TECHNICAL SERVICES
The Contractor shall provide at the SEPTA Frazer Shop or other location on the SEPTA Railroad Division so designated by the Engineer the full time services of one (1) competent Contractor’s field site manager who is proficient in the English language, fully qualified in the maintenance and operation of the cars, and capable of directing a field service staff. The Contractor’s field site manager along with Contractor field service personnel shall assist SEPTA in overcoming any difficulties in the operation or maintenance of the cars and shall assist and explain troubleshooting techniques to SEPTA personnel.

The Contractor’s field site manager shall have full authority to approve any component failure claims, the need for car modification, and supervision of the modification process or warranty claims. Status review meetings shall be held every seven (7) days with the Engineer or designated personnel and shall include representatives of any subcontractor or supplier whose equipment is either receiving field modification, has problems identified requiring modification to correct, or which has performance problems which will require engineering effort to correct. Failure analysis of every defective component unless otherwise approved by the Engineer shall be performed by the Contractor within 30 days. A written agenda shall be received by the Engineer at least 24 hours prior to each status review meeting.

The Contractor’s field site manager shall be available from the delivery of the first pilot car to the end of the basic warranty period as extended. Suppliers shall provide assistance to the Contractor as required to assist in support of their equipment’s operation through the warranty period. The Contractor shall supply an office trailer for its staff’s use and shall be responsible for its transport, electricity, and telephone service. A separate telephone line with recording device shall be included to allow 24 hour receipt of messages from the Engineer.

To handle technical and warranty issues which are beyond the ability of the Contractor’s field service personnel, the Contractor at no cost to SEPTA shall continuously make available to SEPTA, no more than 48 hours after notice from the Engineer, the services of qualified subcontractor service personnel during the term of this Contract and the warranty period as extended for the purpose of handling such service or warranty problems. The Contractor shall also make available at no cost to SEPTA such additional specialized technical assistance as may be required from time to time during this period. This assistance shall continue until the issue in question is resolved to the satisfaction of the Engineer.
1.17 LOGISTICAL SUPPORT

A description of a Contractor-administered plan to implement warranties and provide technical assistance and repair parts during the lifetime of the cars must be submitted and approved by the Engineer prior to shipment of the pilot car. [CDRL 01-058] As part of the plan, the Contractor must provide a complete listing of every supplier used to provide parts on the car; the location of suppliers’ parts depot(s); identification of the suppliers’ personnel that SEPTA should contact to purchase spare parts or to obtain price information for all Contractor and supplier components and their related parts; and the methodology the Contractor and their suppliers will use to process and track customer orders.

The plan must also detail how the Contractor intends to implement the warranty program. This shall include the administrative control of the flow of warranty related defective parts from SEPTA to the Contractor and the repair parts return to SEPTA, the availability of those parts and components which the Contractor and their suppliers will need to support warranty without dependence on SEPTA purchased spare parts, the method of control for submittal, review and approval of SEPTA warranty claims, and payment of claims to SEPTA.

The Contractor shall furnish to the Engineer prior to delivery of the first pilot car a list of the type and quantity of standard replacement parts and incidental hardware which SEPTA should keep in current stock based on the Contractor’s knowledge of the car design and ordering lead times. [CDRL 01-059] The list shall be submitted a second time with updated information prior to the delivery of the first production cars. Both listings shall be in a format acceptable to the Engineer. [CDRL 01-060]

The Contractor’s field site manager shall be given full authority to act on behalf of the Contractor and their suppliers to approve SEPTA’s warranty claims as necessary for payment to SEPTA. Action on claims submitted by SEPTA’s field representative to the Contractor’s field service personnel must be taken within seven (7) days of claim submittal. In the case of disputed claims, the Engineer and the Contractor shall review, negotiate, and resolve such claims on a monthly basis. Invoices for approved claims will be submitted by SEPTA on a monthly basis. Payment shall be made to SEPTA within 30 days of the receipt of the invoice by the Contractor.

1.18 AS BUILT DRAWINGS

1.18.1 Drawings

Within one (1) year following the delivery of the final car, the Contractor shall supply the Engineer with complete and approved sets of every as-built drawing used in the manufacturing and construction of the cars and for all other items of material and/or equipment supplied. Two (2) complete sets of the drawings shall be supplied on computer CD-ROM (including any special font files) and two (2) complete sets of the drawings shall be supplied as hard copy drawings plotted on vellum. [CDRL 01-061]
All electronic versions of drawings shall be prepared using AutoCAD software, the version as approved by the Engineer. [CDRL 01-062] Each electronic drawing must be capable of being opened and have editing capabilities using the software selected. The drawings shall be completely updated via the Contractor’s configuration management system (see TS 1.12) until the end of the warranty including any extensions. See TS 1.23 for additional information on software and file format requirements. Each AutoCAD drawing should look exactly as intended when opened with a standard AutoCAD 2002 program. Whenever possible, the drawing creator shall not use any exotic or special fonts in place of standard easily translatable text styles. If any special fonts are used, the font files must be supplied on each CD-ROM. The quantity of drawing "layers" shall be kept to a reasonable minimum. Each drawing shall be drawn to a full 1 to 1 scale whenever possible. Dimensions should always be at the proper scale after "exploding" block entities.

Each drawing shall have a maximum size of 3 feet 8 inches wide and 2 feet 10 inches high. A limited number of drawings in larger roll sizes for electrical or pneumatic schematics may be supplied if approved by the Engineer. Every drawing shall have a SEPTA title block containing the notation "SEPTA Multi-Level Car", drawing title (including system or subsystem identification), drawing number, Contractor’s name, revision number, and dates of all revisions listing the changes made in each revision. A bill of materials shall also be provided for each drawing number which shall contain the part number identification for each individual part, drawing number for individual parts where drawings have been assigned, drawing number showing the next higher assembly, and weight for each part. All drawing formats shall be approved by the Engineer. [CDRL 01-063]

The drawing sets submitted to the Engineer shall contain a copy of every drawing used by the Contractor, every subcontractor, and every supplier in this procurement except as otherwise agreed to by the Engineer. This shall include all "off the car" material and/or equipment supplied under this Contract, all diagnostic tools, and all special tools. The drawing sets shall be organized in a logical drawing tree system based on the physical configuration of the cars. This shall include both fully dimensioned manufacturing part drawings as well as dimensioned assembly drawings for all parts, subassemblies, assemblies, and arrangements.

Circuit board level detail, installation, and connection drawings shall be included. Also included shall be general arrangement drawings, color schedules, and clearance drawings. Drawings shall be prepared in accordance with ANSI Y14 drawing standards using third angle projections. First angle projection shall be allowed provided all views are labeled including the front, top, bottom, and side views. Electrical schematic drawings shall indicate all wire numbers, references to other drawings of any and all manufacturers to which connections are made, nominal voltages, currents and frequencies, significant resistance values, and the rating of all loads. Devices shall be labeled in agreement with the identification appearing on the actual device, and their locations on the cars shall be shown. Pneumatic schematic drawings shall be prepared in a similar fashion.

If there are any drawings which the Engineer agrees cannot be supplied in electronic format, the Contractor shall supply two (2) complete sets of these drawings on clear approved static free polyester drafting film 0.003 inch thick with a matte finish on both sides. Plastic lead or black ink shall be used. Two (2) complete sets of these drawings shall also be supplied on 35 mm microfilm aperture cards meeting Military Specification MIL-9869B. The microfilm itself shall conform to Military Specification MIL-M-9868B for type 1 silver halide microfilm, class I for first generation usage. Each aperture card shall have printed on the top "SEPTA Multi-Level Car", the drawing title, supplier name (if not a Contractor drawing), drawing number, revision level, and date of the last revision.
1.18.2 Database

A drawing and bill of material (BOM) database shall be created that will contain all associated drawings and materials used by the Contractor and suppliers of equipment for the cars which shall be accessible by the Engineer prior to delivery of the first production car. All drawings associated to the configuration and assembly of the vehicles must be included. [CDRL 01-064]

1.18.2.1 Database Drawings Fields

Minimum fields associated to the drawings shall contain the following subjects:

a. Contractor's drawing number
b. Electronic file name
c. Supplier's drawing number (as applicable)
d. SEPTA's drawing number (if applicable)
e. Drawing size
f. Number of sheet and total number of sheets (i.e. 2 of 4)
g. Revision level (in letters starting with "A")
h. Official title (without punctuation or abbreviations)
i. Description in layman's terms using keywords to aid in searching
j. Drawing number of the next level of assemblies
k. Contractor/supplier name
l. System, subsystem, major component (as applicable)

1.18.2.2 Database BOM Lists Fields

The BOM lists shall be complete and capable of creating, displaying, and printing indented parts’ lists from the component or system level chosen. Minimum fields associated to the BOM shall contain the following subjects:

a. Part number
b. Drawing number for each listed part
c. Contractor/supplier name
d. System, subsystem, major component (as applicable)
e. Unit of measure
f. Description
g. Quantities and item number in relation to the associated drawings (and/or sheet numbers) where they are used
1.18.2.3 Database Reports, Queries, and Forms

Reports and queries shall be developed and designed to find, cross reference, and sort the information by drawing number, drawing description, BOM part number, individual part drawing number, system or major component, Contractor, or supplier. If the drawing was made obsolete during the length of the Contract, it shall be so listed and identified along with the identity of any superseding drawing number. One (1) extra additional field of 11 characters shall be included to accommodate the SEPTA class and lot numbers for future use. A form shall be designed to input the SEPTA class and lot numbers into the associated field. The design of the reports, queries, and form shall be submitted to the Engineer for approval. [CDRL 01-065]

1.19 DELIVERY AND ACCEPTANCE

1.19.1 Authorized Shipment Inspections

The Contractor shall submit to the Engineer or Engineer’s designee an authorized exception sheet a minimum of three (3) working days prior to pre-shipment inspection for review. [CDRL 01-066] Line items on the sheet shall consist of items not performed at the Contractor's facility due to lack of materials, open ECP documents effective at the time of shipment for the car ready for pre-shipment inspection, or any other item within the work scope of the Contractor's facility, which the Contractor feels does not affect the vehicle’s safe and complete operation or passenger comfort, thus hindering shipment. Included with each item there shall be a full description of why the work cannot be completed prior to shipment, what work is to be included, and a schedule of when the work will be performed.

Shipping exceptions will not be viewed as an alternate avenue for the Contractor to ship. SEPTA reserves the right to enforce all work to be performed at the Contractor's facility, to be performed there prior to shipment, decline any request for authorization of any exception, or require the exception(s) to be completed prior to either performing the pre-shipment inspection or final acceptance of the car.

1.19.2 Release for Shipment

When the pre-shipment inspection specified in TS 1.19.1 has been concluded to the satisfaction of the Engineer’s representative and any defects discovered are fully corrected, the Contractor shall present a release for shipment authorization document to the local SEPTA representative for the purpose of obtaining SEPTA’s authorization to ship. No shipment of cars or other completed material shall be made by the Contractor to SEPTA without such a document. The Shipment of cars without a SEPTA-authorized release for shipment document may result in the refusal of delivery on SEPTA’s property.

Neither a pre-shipment inspection nor a release for shipment will be considered by the Contractor to constitute acceptance of a car or other material. The Contractor shall prepare each car for shipment in such a way as to allow it to be placed in service immediately upon arrival following removal of any necessary shipping devices and installation of any removed parts. Any parts removed for shipment or other necessary special equipment needed for shipment shall accompany each car.
All cars or other material shall be properly packaged or otherwise prepared for any shipment made during any phase of assembly. If shipment is by sea, all material including the carbody shall be shipped below deck. If this is not possible, carbody shipment on deck may be made if approved by the Engineer only if special arrangements are made to ensure that no damage or exposure to the marine environment will take place under worse possible storm conditions.

### 1.19.3 Acceptance Testing and Inspections

As items of material or equipment other than the cars are received, the Engineer will have performed such acceptance inspections and tests as are deemed necessary to determine if each item is in conformance with this Specification both as to configuration and performance parameters. Certain procedures may be performed on a sampling basis, and others may be performed only on material or equipment which give indication of marginally acceptance performance, reliability, or quality. Representatives of the Contractor may witness acceptance tests and inspections. Any damage or defect discovered during the acceptance inspections shall be corrected immediately by the Contractor.

As the cars are received, the Engineer will oversee acceptance tests on each car as provided for in TS 18.5. These tests, including performance testing, shall be performed by the Contractor or under its direction and at its expense except for the SEPTA provided items listed below. The Contractor shall provide all personnel and instrumentation necessary to monitor and record the test results. SEPTA shall provide all track facilities and operating personnel at no charge to the Contractor for these tests. All tests shall be conducted in the presence of the Engineer and at times agreeable to SEPTA and the Engineer. Any damage or defective condition discovered during the acceptance testing shall be corrected immediately by the Contractor. No car shall be accepted if it contains any defects or if not in a complete ready to run in revenue service condition. At the option of the Engineer, a car, which was acceptance tested and had defects which were later corrected by the Contractor, may be required to be retested repeating some or all of the original procedure, if the Engineer has reason to believe that the original defects were of a serious nature or if there are some questions as to the nature of the repairs.

### 1.19.4 Notification of Acceptance

When acceptance inspections for items of material or equipment other than the complete car have been completed, the Engineer will provide the Contractor within ten (10) days either a certificate of acceptance document or a rejection notice. Any and all deficiencies discovered during acceptance inspection or subsequently shall be corrected as provided in the Contract documents. When each car has properly completed all acceptance testing and contains no known defects, the Engineer will promptly issue a certificate of acceptance document to the Contractor.

### 1.19.5 Defects

If any item of material or equipment is delivered incomplete, does not meet applicable federal safety and emission standards, contains any defective or damaged parts, or fails in any other way to meet this Specification, the Contractor shall arrange that the item be completed or deficiencies corrected or damaged parts removed and new or repaired parts consistent with the requirements of a new item installed without any cost whatsoever to SEPTA.
1.19.6 Suspension of Deliveries by SEPTA

During the period of car delivery, SEPTA will not allow more than eight (8) unaccepted individual cars on its property at any time. If there are more than eight (8) unaccepted individual cars already present, through no fault of SEPTA, the Engineer may suspend delivery of any additional cars until there are no more than eight (8) unaccepted cars on property. If for any reason a 9th (or more) unaccepted car(s) is (are) physically delivered onto SEPTA's property, the Contractor shall immediately at its expense remove such car(s) from SEPTA property if required by SEPTA. The Contractor shall bear sole responsibility and expense for coordinating car delivery, and shall ensure compliance with the above requirements.

For items of material or equipment other than the cars, the Engineer may at any time require the Contractor to suspend shipment of individual items after receipt of written notice to do so, if three (3) or more of the same items delivered to SEPTA under this Contract are not acceptable for safe and efficient operation in regular service, or do not meet the requirements of the Technical Specification. The Engineer will attempt to give the Contractor reasonable advanced notice of the occurrence or discovery of deficiencies, failures or defects which may cause such suspension. The Contractor may at his own option and risk continue to ship items of material or equipment to SEPTA, but SEPTA will not be obligated to receive, store, protect, inspect or accept any items shipped after receipt by the Contractor of the notice to suspend shipment. The Contractor shall resume suspended shipments within ten (10) days after receipt of written notice from the Engineer ending the suspension. Suspension of shipments shall not be considered a valid claim for additional time extensions to the Contract time requirements.

1.20 CAR AND TRUCK HISTORY BOOKS

The Contractor shall provide the Engineer an “as-built” “car history book” within 30 days following a car’s acceptance. [CDRL 01-067] The car history book shall include all Contractor and SEPTA in-process and final inspection sheets and test data records for each vehicle.

The car history book shall contain two (2) types of volume information; the first being a history of the physical car and the second being individual truck history books for each truck. The full car history book will thus consist of three (3) volumes to cover the car and trucks as delivered to SEPTA as a single unit.

Each book shall contain the following, as a minimum, as applicable for the volume type:

a. Car number and Contractor's construction number if used

b. Certified car weight records (full car weight with trucks)

c. Serial numbers and configuration of all major units and major individual assemblies installed on the car. The items listed shall be approved by the Engineer. Item part numbers and description shall be included.

d. A listing of all as-built drawings by revision level to define the level of assembly of the car as-built in the production assembly process

e. A listing of all modifications either pending or completed that apply to the car containing the following in numerical order:
1) Each engineering change notice

2) Each field modification instruction with a cross reference to the engineering change notice

3) Concise description of the modification or change

4) Date of completion

f. A summary of each inspection performed on the car or any part thereof including disposition and Engineer approval (refer to the quality assurance provisions and the production conformance test requirements for details)

g. All original data sheets from the production conformance and vehicle acceptance tests

h. All documents related to car shipment

i. Provision for inspection, servicing, and maintenance records during the warranty period (including space for dates, description, and comments)

The truck history book shall be an individual standalone truck history separately published by file and binder. Each truck history book shall be supplied as part of the collection of the car history book covering the car’s delivery to SEPTA. Each individual truck history book shall be identified by the truck frame number and contain at a minimum:

a. All component serial numbers
b. Copies of all testing documents
c. All inspection records with completed measurements and data
d. Wheel, journal bearing, and gear unit axle mounting records and material certifications

Documentation shall be distilled into Adobe Acrobat PDF electronic file format. A single file shall be created as a car history file for each car starting with a title page containing the notation "Car History Book" and the car number. Each car history shall be updated by the Contractor every 45 days until the conclusion of the warranty period. The serial number and configuration list shall include the date installed and shall allow for future revisions arising from retrofits and from maintenance actions. A concise table of contents listing all subjects of data to the lowest levels shall be developed and used as the main bookmark for the file. Car history data that is available in electronic form shall be distilled from the authoring (originating software file) document. Other data forms that have been used for shop use or test sign off that contain actual signatures that cannot be distilled from authoring documents may be scanned into PDF format. All scanned images shall be properly aligned and not skewed. Each record distilled shall be inserted into the main car history file for that car in the order of the table of contents to allow sequential printing of the car history book if necessary. The appropriate bookmark for the subject shall be linked to the corresponding page. To keep the size of the file reduced, distillation shall be performed at an appropriate setting to accommodate clear distinctive images from both screen and average desk top printing. During the actual distillation of files into the PDF format, a DPI setting of 300 for distillation process is recommended.
If the file size becomes unmanageable, alternate methods may be submitted for review such as external links to separate section files for the car history data. However, under no circumstances are external links to be used for single individual page files containing data other than a master PDF file used to link separate section files together to create a full car history book format. The lowest level file shall contain a section of the car history at a minimum. An additional PDF file shall be created which lists all car history files for the cars produced. External links shall be made to each car’s main car history file making this file an overview of the car history files for the fleet. A complete plan of the architecture, TOCs, and file formats shall be submitted to the Engineer or his designee for approval. Each car history shall be submitted to SEPTA in electronic format individual to each car’s history. [CDRL 01-068]

1.21 ENGINEER’S INSPECTION TEAM

The Contractor’s quality assurance operations shall be subject to Engineer verification at any time. Verification will include surveillance of the operations to determine that practices, methods, and procedures of the Program are being properly applied; inspection to measure quality of items to be offered for acceptance; and inspection of items awaiting release for shipment to ensure compliance with all requirements of the Contract documents.

1.21.1 Field Office Requirements

The Contractor shall provide the Engineer and field representatives’ private office space for a SEPTA field office on the Contractor’s facility at the cost of the Contractor. If work is performed extensively at more than one (1) facility either on the Contractor’s property or subcontractor’s location, additional offices shall be provided as needed. Space requirements shall be determined for subcontractor satellite offices on a case by case basis.

The offices shall be private and located within a reasonable distance from the work being performed preferably within or directly adjacent to the final assembly building. The office shall be modern, clean, painted, efficiently lighted, heated, and air conditioned. Office cleaning shall be maintained by the Contractor. When one (1) to four (4) SEPTA representative(s) are present, the office space shall be sufficient to accommodate a minimum of four (4) personnel including desks, file cabinets, and associated office furniture. Desks and file cabinets shall be lockable, and all keys submitted to SEPTA. Amenities for bottled water, a microwave, and a small refrigerator will also be included within the office for support of the representatives. All office equipment shall be functional, in good condition, and subject to SEPTA’s review and acceptance. In the event the number of the SEPTA’s inspection team is increased to accommodate the Contractor’s work schedule, office space, furniture, telephone, and computer equipment shall be expanded to meet the needs of the additional staff. Also within the office, there shall be a conference table capable of seating a minimum of eight (8) individuals for conferences during visits by the Engineer and for daily activities. The field office shall be securable with keys distributed to SEPTA’s field representatives and the facility security and maintenance personnel as applicable.
Telephone lines shall be provided for each desk within the site office to supply voice communications in addition to a dedicated fax line. Speaker conferencing capability shall be provided at the conference table. Communication equipment including telephones, answering machine, and a fax machine shall be provided for by the Contractor. Long distance and international telephone service shall be provided by and at the cost of the Contractor. If video conferencing is used for meetings, the Contractor will be responsible for all audio visual additions, as necessary, to conduct meetings from the field office’s conference table.

A photocopy machine capable of high quality copies shall be provided either within the field office or in a nearby (adjacent) area.

1.2.1.2 Computers

The Contractor shall supply computers in the field offices for the use of SEPTA’s representatives. A computer shall be provided at each representative’s desk as determined by staff requirements to cover local activities. One (1) computer shall be provided at satellite offices where two (2) or less are assigned; however, if three (3) or more full time representatives are needed, the requirements for the Contractor based field office shall be followed. While in use in SEPTA’s field offices, the computers shall be considered to be under SEPTA’s control and not networked to the Contractor’s facility.

The computers shall be desktop style built by a Gartner Group Tier 1 manufacturer with the latest PC processor technology and architecture. Eight (8) gigabytes of RAM size shall be supplied within the units, at a minimum, or more if needed to accommodate the multitasking of multiple major software programs without reduction of speed or interruption of the operating system. Hard drive space size shall be sized to accommodate all program software used during the execution of the Contract in addition to large format data storage capabilities while offering sufficient space to allow smooth operation. High speed DVD-RW with CD-RW capability drive (or drives) shall be included in addition to any other high capacity removable drive formats used by the Contractor for information exchange. Monitors shall be flat screened and 22 inch diagonal at a minimum. Each unit shall be USB 3.0 capable.

The office shall contain a network adaptable laser jet printer capable of printing multipaper sizes with color printing and scanning capabilities. If such a unit is unavailable, additional peripheral items shall be provided per office as follows: one (1) scanner (1200 DPI minimum); one (1) desktop color printer capable of producing graphic photo images with the capacity of printing in 11 inch by 17 inch format; and one (1) black and white laser jet printer for general use. Hard wired networking hubs and software shall be provided so that each computer station will have full use of the equipment.

General use software in addition to any virus protection programs shall be provided by the Contractor as necessary as covered in TS 1.23.

Maintenance, troubleshooting, and technical support of the computers used at the Contractor’s facility and any local computer systems used within the office shall be performed by the Contractor. Removable disk drive media blanks and printing supplies shall be provided by the Contractor as needed.
1.21.3 Internet Access

The Internet shall be heavily used as a communication tool during the duration of the Contract. The Contractor shall provide and maintain a high speed connection, T1 or better, to all major SEPTA field offices during the Contract. Access shall be independent of the Contractor’s connection, and/or internal networks Internet connections shall be provided using a high speed wireless router with full speed CAT5 capabilities for desk top computers. Security access for the wireless network shall be controlled by SEPTA.

1.21.4 Data Access

The Contractor shall be responsible for entering inspection and test discrepancy data into a central database where it will be listed by the car number and area of inspection, for mutual use by the Contractor and SEPTA. Provisions for status and comments shall be provided for each item. SEPTA will have the right to receive electronic versions of the database on a scheduled basis or by request via removable storage equipment. Queries, forms and reports shall be designed for use with the database per SEPTA’s request by the Contractor. The design of the database must be approved by the Engineer.

The Contractor and associated subcontractors shall provide SEPTA’s field representatives with all information, tools, and test equipment necessary to perform their tasks of controlling conformity of the material or equipment to this Specification. Upon request, SEPTA’s field representatives shall have access to current prints, drawings, material lists, production control documents, QA/QC reports and audits, or any other document involved in the activity of the development of the car and/or fleet production thereof. SEPTA’s field representatives reserve the right to request, receive, and maintain copies of such documents.

1.21.5 Function and Authority

It is the intent of this Specification that the inspection of components be the responsibility of the Contractor and manufacturers. This inspection will be performed at the plant of the manufacturer giving them every opportunity to correct under factory conditions any inadequacies found. The function of SEPTA’s field representatives is to provide engineering representation for the Engineer at the site of the Contractor and its subcontractors as required to interface with the Contractor’s project management concerning daily operations, perform technical liaison functions, verify and approve the work as it progresses, witness production conformance and quality assurance tests, and conduct the pre-shipment inspection of the cars and components. The field representatives will include the Engineer and others designated in writing. The field representatives shall have complete access to any and all workshops at all times when work is being performed on this Contract including subcontractor workshops where any major components, subassembly, or assembly is being fabricated or assembled.

The use of field representatives by the Engineer does not in any way relieve the Contractor and its subcontractors from the requirements of the quality assurance program. At all times, the Contractor and its subcontractors bear the sole responsibility of the inspection and testing of the cars during assembly, and the presence (or lack thereof) of field representatives does not lessen this responsibility. The field representatives will not be used as substitutes for the Contractor’s or any subcontractor’s work force. When repetitious rejections must be made by the field representatives of either a manufacturer’s or the Contractor’s work to maintain proper quality, this condition will be cause for the Engineer to withdraw the field representatives and to consider all work stopped until a satisfactory agreement is reached.
1.21.6 Field Representative Availability

Verifications, inspections, or testing of the cars shall not be conducted by the Contractor for the Engineer after SEPTA’s normal business hours or on a Saturday, Sunday, or holiday except for specific tests or inspections as approved by the Engineer by prior written agreement. Failure by the Contractor to comply with this provision shall be considered a reason to reject a car. Subsequent inspections shall be rescheduled at the convenience of the Engineer any penalty clause notwithstanding.

The Contractor shall give the Engineer 14 days’ notice prior to any testing and/or inspections under the following conditions:

a. All engineering tests, production tests, first article inspections at the car component, systems, and full car levels during the pilot car program

b. In the event there is no full time SEPTA representative present at the Contractor's facility

During the manufacturing sequence of the cars if a field representative is already present at the Contractor's facility, prior notice of inspections or testing must be given to the field representative at least 24 hours prior to the event at which time the inspection shall be scheduled at SEPTA's convenience.

1.21.7 Verifications and Inspections During Manufacturing

It is the Engineer's intention to have one or more field representatives present at the site of the Contractor's shops continuously monitor and/or witness the manufacture or assembly of the items of material or equipment. The presence of SEPTA personnel for these purposes shall in no way reduce the Contractor’s responsibility for a properly staffed and effective quality assurance/quality control program.

In any event, a field representative will be present at the Contractor's work site for a sufficient portion of the time during performance of this Contract so as not to unnecessarily impede, interrupt, or disrupt the manufacture and delivery of the material or equipment according to the Contractor's delivery schedule due to lack of coverage. Rework due to discrepancies found by field representatives during the manufacturing, testing, and/or final inspection periods shall not be considered as an interruption to manufacturing, and the Contractor shall absorb any schedule loss due to such action.

SEPTA’s field representatives reserve the right to identify “hold points” and make prior arrangements to verify completed work at specific stages of construction. These hold point may be based on established Contractor QC in process inspection points or other stages of manufacture as deemed fit by SEPTA.
During the assembly phase, each event shall be considered to be a verification of compliance to the approved design, materials, and workmanship of the car and a gauge of the effectiveness of the Contractor’s quality assurance/control activities. Prior notice of intent will be given to the Contractor identifying which area has been chosen for verification. Requirements for such a verification will be totally completed work for the area(s) identified within the notice of intent. Inspection of the area must be complete and the results must be presented at the time of the verification and the area(s) offered for verification during normal (SEPTA) working hours. Lack of response to a verification request will lead to the area in question being exposed by the Contractor prior to SEPTA performing a pre-shipment inspection thus effecting the car’s shipping authorization. The Contractor will bear the expense for such action since the request was submitted prior to the area’s enclosure.

When a field representative is at the Contractor’s facility and in the event pre-delivery testing, production verification, and/or a pre-shipment inspection conflict upon the field representative as being offered simultaneously, the Contractor shall choose the priority of either pre-delivery testing or pre-shipment inspection. The verification request shall take least precedence. The field representative shall start and complete the function determined as the priority prior to performing the next function.

Prior to SEPTA performing a verification, test, or inspection, the car(s) shall be properly lighted and/or powered to accommodate the function as needed. Access to the underframe shall be provided by a clean, dry, and well lighted pit when deemed necessary for verifications and is a prerequisite during the underframe portion of a pre-delivery inspection. Inspection data and status updates shall be performed by the Contractor.

1.21.8 Pre-delivery Testing
All pre-delivery testing required by TS 18.4 shall be pretested and documented on authorized test forms prior to the test being offered to the field representative for official testing thus creating a time for final adjustment and showing reliability during the official test. The pre-delivery testing shall not be in piecemeal, and once started it shall be continued to completion. In the event a field representative is not onsite to witness such testing, the testing shall still be performed (pretesting is still required); however, a waiver shall be issued from the Engineer or the Engineer’s designee for a Contractor’s QC representative to take his place as the witness to the test. Test data and status updates shall be performed by the Contractor.

1.21.9 Pre-shipment Inspections
The Engineer will assign a field representative to perform a pre-shipment inspection upon the completion of each car using a printed inspection form. The Contractor shall arrange the schedule for shipment of each car to provide a minimum of two (2) days for inspection of the car after it is fully completed and has had a comprehensive final inspection performed by the Contractor’s quality control personnel. All pre-shipment tests must have been completed and accepted. All Contractor QC inspection discrepancies must be reworked and complete, the car cleaned, judged ready for shipment, and free of all workers.
Prior to the pre-shipment inspection, the Contractor shall present the following items:

a. Authorized Exception Sheet – The Contractor shall submit an authorized exception sheet a minimum of three (3) working days prior to pre-shipment inspection for review as required in TS 1.19.1.

b. Copies of all Contractor Final Inspections/Tests – At the time the car is presented to SEPTA for the pre-shipment inspection, a representative of the Contractor’s quality department must present to the field representative a copy of the total final inspection performed by the Contractor's QC personnel. All discrepancies must be signed off as acceptable thus denoting that the reinspection and associated rework has been found acceptable. In addition to the inspection, one (1) copy of each pre-delivery test signed as being accepted by an authorized SEPTA field representative shall be submitted. [CDRL 01-069]

c. A full configuration as-built status report reflecting the level of build for the individual car including all ECN/ECPs which have been installed and a full accounting of those yet to be installed shall be submitted. [CDRL 01-070]

A pre-delivery inspection shall be performed on the total roof, exterior, interior, and underframe of each car. Inspection results shall be logged on the inspection forms mentioned above and submitted to the Contractor for rework/disposition. After the rework has been completed, each item will be inspected by the Contractor's QC personnel. When the discrepancy list has been totally reworked, the area can then be offered again to the field representative for reinspection. Inspection data and status updates shall be performed by the Contractor.

1.22 DEFECTIVE WORK

Should the Engineer have reasonable evidence that defective work or material has been permitted by the Contractor or a subcontractor in an area which was not covered by a verification notice as mentioned above, the Contractor or subcontractor shall furnish the appliances and labor for making such investigation and inspection as may be required by the Engineer in writing. Any imperfect construction or materials which may be disclosed shall be corrected promptly. During any period of time from construction to acceptance, any inadequacy of design, construction, testing, or any damage by any cause whatsoever except that which was caused directly by SEPTA shall be corrected by the Contractor at no cost to SEPTA. If the investigation discloses no defects, the expense of such investigation will be borne by SEPTA, and the delay caused by such investigation will be considered as being beyond the Contractor's control.

1.23 ELECTRONIC INFORMATION CONTROL

The Contractor shall compile, store, and transfer documents via electronic files whenever possible. Official correspondence and/or technical submittals required in printed form by this Specification shall be accompanied by the electronic copy of each document in a software format agreed to by the Engineer. Acrobat PDF formatted files shall be used as the standard electronic format medium for submittals and correspondence. Upon SEPTA’s request, the Contractor shall supply the originating authoring file to assist in reviews and data assessment on a case by case basis.
All general use software shall be designed to run on Microsoft Windows platform based PCs. The following software shall be used as a guideline:

a. Project Management Correspondence, Databases, Spreadsheets, and Presentations
   - Microsoft Office

b. Drawings and Schematics
   - AutoCAD 2002 compatible

c. Manuals and Training Documents
   - Adobe FrameMaker

d. PDF File Creation and Viewing
   - Adobe Acrobat

e. Graphics and Digital Pictures
   - Adobe Photoshop

f. Project Scheduling
   - Primavera or software meeting the requirements of 20.7.1 as approved by the Engineer

The Contractor may request to use alternate programs in lieu of those listed by submitting the alternate program to the for Engineer approval. However, if approved, the Contractor shall bear the cost of the new software and the cost of training SEPTA’s project and support personnel both in the Philadelphia offices and in the field on the use of the software.

### 1.23.1 PDF Files

Adobe Acrobat PDF files shall be used as the standard electronic (“softcopy”) format for written communications, presentation submittals, drawings, schematics, manual publications, and training documents. PDFs shall be distilled from the authoring binary files from software as referenced in TS 1.23. The originating authoring binary files shall also be considered as deliverables as applicable for their type and subject as required in this Specification.

Distillation of the authoring files shall be performed using standard dpi distillation using the Acrobat 7.0 or higher setting. All distillations shall result in PDF documents that have the ability to be indexed and searched for text. When distilling, the proper paper size for the subject shall be used as a distillation setting. This is particularly important for distilling drawings. Drawings should be distilled based on the plotter setting for the drawing to maintain details. Printing of large format drawings shall either be performed by a plotter or reduced in size to 11 x 17 (tabloid) using the print to fit-function in Adobe Acrobat Reader.

In cases where single file PDF submissions originate from multiple files, the files shall be imported into the parent PDF by using the “Merge into a single PDF” command resulting in all pages being shown within the file and all information being available for searches by the user and the capability of being included in Adobe index file development. Internal attachment of files within the PDF shall be limited to binary files if required or requested (such as spreadsheets where data can be indexed or sorted during reviews).
Any PDF covering large amounts of information shall contain internal bookmarks to aid in the navigation to the particular subsections. Publications for manuals and training shall be fully bookmarked for use on the SEPTA Vehicle Technical Information Library (VTIL) System as referenced in TS 19.3.4.5. For this purpose, it is recommended that Adobe Acrobat software be used for distillation and installed on computers using software as required in TS 1.23. This will allow a macro to be installed where if headers and styles are used in the binary files, settings and adjustments can be made to automatically produce a full hierarchy of bookmarks during the distillation process. If not, the Contractor will be responsible for creating the bookmarks manually.

Creation of PDF files from scanned images only will be restricted to those allowed by the Engineer or as required by this Specification. PDF files of scanned information may not be used for formal publications or training. The Contractor is responsible for ensuring that all information for these documents is distilled from parent editable documents using software as required in TS 1.23.

Scanned documents shall be limited to archival documents which contain handwritten initials and/or stamps denoting sign offs for steps within the manufacturing, testing, or inspection of individual cars or components. Any document that contains recognizable text in its image shall be run through Adobe Acrobat’s OCR recognition to capture what might be available as text. When documents are scanned, careful attention will be taken to not allow misalignment of the pages.

Documents agreed to be compiled primarily of scanned images such as car history books shall have bookmarks created in the form of a detailed table of contents down to the lowest document level. The TOC bookmarks shall be linked to the documents to allow particular records to be identifiable and accessible by clicking on the bookmark to view the subject matter.

Scanned “no text” information in the form of document attachments may be allowed to be imported into an existing PDF file that is searchable and capable of indexing if the information is supplemental to the context of the file and not the primary means of communicating the subject’s information.

The Engineer and Contractor shall appoint a designee to coordinate efficient use and control of the PDF files for items such as file naming conventions, security levels, bookmarks, revision level controls, other individual file format requirements, and the use of digital signatures. All details associated to PDF files and their use shall be approved by the Engineer.

### 1.24 DELIVERY LOCATIONS

All material and equipment to be delivered by the Contractor to SEPTA shall be shipped prepaid at the Contractor’s expense using a common or contract carrier of the Contractor’s choice. SEPTA shall not be liable for the payment of any shipping, transportation, delivery, customs, or unloading costs under this Contract.
All written or printed matter to be delivered to the Engineer such as technical correspondence, submittals, publications, drawings, etc., and all computer equipment shall be delivered to:

SEPTA Rail Engineering
New Vehicle Programs
1234 Market Street
Philadelphia, PA 19107-3780

All cars shall be shipped freight prepaid on their own wheels to SEPTA, Frazer Facility, Frazer, Pennsylvania. Each car delivered must be fully assembled, tested, and ready to run following the removal of any special shipping equipment or requirements. The Contractor shall make all arrangements to use its own reporting marks for car movement and to have these reporting marks properly registered with the AAR UMLER reporting mark database. In addition, the Contractor shall equip both sides of each car with a properly encoded AAR radio frequency transponder (electronic tag) unit mounted on the underside of the carbody for shipping encoded with the Contractor’s reporting marks which the Contractor shall remove following delivery.

All spare parts, specialized tooling, diagnostic test equipment (other than computers), and other hardware, material, and equipment shall be shipped freight prepaid to:

SEPTA Wheatsheaf Facility
2045 Wheatsheaf Lane
Philadelphia, PA 19124

The Contractor shall be responsible for making all arrangements for delivery of all Contract material at its own expense. Every shipment of materials, spare parts, etc. shall have a fully itemized packing slip detailing all contents by quantity, name, part number, etc.

### 1.25 CONTRACT DELIVERABLE REQUIREMENTS LIST

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2 DESIGN CRITERIA AND REQUIREMENTS

2.1 GENERAL

This Specification including the Contract drawings describes and illustrates the criteria to be used for the Contractor’s design and construction of multi-level commuter rail cars to be operated by the Railroad Division of the Southeastern Pennsylvania Transportation Authority (SEPTA). The cars will be operated by SEPTA over the SEPTA Railroad Division and portions of the Amtrak (National Railroad Passenger Corporation) Northeast Corridor line and Harrisburg line. Included are configuration, capacity, dimensional, performance, environmental, noise and vibration, weight, and other requirements which impact the car system and subsystem design. These requirements apply to all aspects of car and equipment design.

2.1.1 Human Engineering

The car design shall be based on human factors’ engineering. Special emphasis shall be placed on all vehicle interactions with members of the train crew in order to maximize their effectiveness, comfort, and efficiency. All switches and controls shall be designed for ease of logical use. The cab shall be spacious, well insulated from sound, and arranged to have the most ergonomic layout possible to avoid repetitive motion injury. Exterior safety appliances shall be designed for maximum ease of use. The design of the cab, train crew controls area, vehicle maintenance locations, and other crew and passenger areas shall accommodate the 5th percentile female to the 95th percentile male of current United States adult general population anthropometric data with normal vision and hearing. Specifics may be found in "Humanscale 1/2/3, 4/5/6, 7/8/9" (3 volumes), by Different, Tilley, Harman, and Bardagjy of Henry Dreyfuss Associates (published by MIT Press, Cambridge, MA).

2.1.2 ADA Requirements

The Contractor and their industrial designer shall ensure that the cars comply in all respects with the requirements of the Americans with Disabilities Act of 1990 and the regulations contained in 49 CFR Parts 27, 37, and 38, sub-parts A and E, and 36 CFR Part 1192 which are in effect at the time of the Proposal submission. The Contractor shall confirm and certify this in writing to the Engineer prior to delivery of the first car. [CDRL 02-001]

Meeting the spirit of the ADA requirements is of great importance to SEPTA, and the industrial designer shall work in close cooperation with the Engineer in this regard. Walking surfaces shall be non-slip. Adequate boarding, movement, and parking space for two (2) wheelchairs shall be provided adjacent and inboard of a quarter point doorway vestibule.

Special attention shall be given to passengers with reduced visual acuity by providing them with visual and audio cues. Floor and interior surfaces should have high contrast colors in this regard, and high contrast signage and striping patterns at folding seats, doorway thresholds, step risers, handholds, and the like shall be provided as approved by the Engineer.
Door closing signals shall be provided at the individual door opening to provide an audio “steering” guide for passengers with reduced vision acuity. Provisions shall be made for elderly and handicapped passengers including the blind, deaf, etc. Audio tones disturbing to canine guides shall be avoided. Any Specification requirement, which conflicts with any ADA requirement, shall be brought to the immediate attention of the Engineer for final disposition.

### 2.1.3 Metrication

The designs, components, and fasteners used on the new vehicle shall be of United States inch standards wherever possible. While the use of ISO metric standards will be permitted where necessary, requests for their usage defined at the subcomponent level must be submitted to the Engineer for review and tracking.

As a general requirement, each major system on the car shall be designed and manufactured to a single standard (either inch or metric), and there shall not be a mixture of inch and metric parts or fasteners within any enclosure or on any component or subassembly for a major system. The carbody shall be designed to the inch standard, and all components and fasteners used in its construction shall be of that standard unless otherwise approved by the Engineer. Due to the inability to source replacement material in the United States in metric thickness, all metal sheet and plate material used in the construction of the carbody shell shall be specified on drawings and bill of materials in inch standard thickness.

Subsystems and components affixed to the carbody or the truck shall use either unified inch screw thread fasteners or fasteners of the same standard as used on the affixed apparatus. All drawings, manuals, and publications which use metric quantities shall also include the equivalent inch standard dimension quantity (“dual dimension”). The Contractor shall ensure that the application of any metric fasteners used in the car or on any subsystem is coordinated so as to use the minimum number of different fasteners.

### 2.1.4 Design Life

The vehicle shall be designed and manufactured to perform satisfactorily for a minimum of 30 years. The carbody and all its structural elements including trucks and running gear shall have a minimum design life of 30 years of operation. The design and selection of materials shall prevent corrosion damage including the effects of winter ice/snow melting and salt during the 30 year design life.
2.1.5 Maintenance Periods

Safety, reliability, and ease of maintenance shall be the primary design consideration as referenced in TS 2.4 and TS 2.7. No component shall require periodic maintenance any more frequently than 184 days for trailer cars and 92 days for cab cars and shall not require overhaul more frequently than five (5) years. Consumables such as brake shoes/pads are needed on an “as required” basis. Air filters shall be of a size to allow change out at periods of no less than 92 days.

Subsystems shall be selected for maximum endurance between inspections and for ease and quickness of inspection. Car structure and equipment shall not require periodic underframe washing to obtain proper functioning, long life, or to avoid corrosion.

2.1.6 Equipment Access

All car equipment, which requires inspection or maintenance, must be readily accessible and replaceable. All underfloor equipment, where possible, shall be arranged to provide simple easy access from the side of the car. Major equipment shall not be located outboard of the trucks, if possible, due to the increased possibility of accident and debris damage in this location with the exception of the disc brake rotors. SEPTA would prefer that these components of the friction brake equipment be mounted outboard of the wheels in order to facilitate regular inspection.

If maintenance pit access is required, special attention shall be given for access such that opened covers, access doors, etc., provide sufficient room for a maintainer to stand within the running rails of the pit. Any equipment, which requires crew attention or access in the event of an emergency during car operation, unless otherwise specified, shall be accessible from the car interior. If approved by the Engineer on a case-by-case basis, access from the side of the car may be used.

In general, the frequency of required service shall determine the degree of equipment accessibility. The Contractor shall prepare for the Engineer’s approval during the initial design review sessions a tabulation of all controls or resets which an Operator may need to access in order to restore a disabled locomotive or train to service. [CDRL 02-002]

2.1.7 Interchangeability

Cars shall be designed and manufactured to be identical in respect to configuration, individual parts, and subassemblies. Model numbers for identical components shall be identical. Replaceable components of any such apparatus shall be fully interchangeable without adjustments to any part or system being necessary. Microprocessor hardware units, which are physically identical except for the software, shall have identical part numbers. An Engineer approved subpart number may be used to identify differences by software. Such units, which require location specific module inputs, shall have this performed by carbody wiring configuration and not by the use of DIP switches or similar. Specific approval shall be obtained from the Engineer during the design review or each part whose replacement may require an adjustment, and such approval may be granted only where it can be shown to be absolutely necessary.
2.1.8 Compatibility

The cars shall be compatible with existing SEPTA commuter rail passenger cars and locomotives. The cars procured under this Contract shall be suitable in all respects to operate safely in revenue service when used in a train consisting of any combination of these cars and SEPTA’s existing commuter rail passenger cars. The cars shall be fully compatible and fully functional for normal operation in dedicated consists of up to 14 cars. All systems shall interface and operate at the car level and train level with SEPTA’s existing commuter rail passenger cars and locomotives to provide corresponding functionality and performance. Basic function shall be maintained with older equipment in the event the multi-level controls are advanced beyond the capabilities of the older systems. The Contractor shall submit a compatibility plan with supporting analysis, diagrams, etc., to show the manner proposed for achieving the required command, control, and functional compatibility. The plan shall be part of the requirements traceability matrix and report. Tests shall be required to demonstrate compliance. [CDRL 02-003]

Each multi-level car shall be equipped with a compromise coupler suitable for use in coupling a multi-level car consist to any SEPTA EMU consist for the purpose of train rescue. [CDRL 02-004]

2.1.9 Car Numbers

Cab cars covered under this Specification shall be numbered as a 2400 series, numbered consecutively, beginning with the pilot car 2421. Trailer cars covered under this Specification shall be numbered consecutively, beginning with the pilot car 2601.

2.1.10 Car Configurations

The multi-level cars shall be constructed in two (2) configurations:

a. Trailer Car – the trailer car shall consist of a coach car with open vestibules at each end with passenger doors capable of both high and low platform capabilities via hinged trapped doors. The end of the car containing the parking brake shall be determined as being the A-End of the car and the opposite end as being the B-End.

b. Cab Car – the cab car shall consist of a coach car with one (1) corner within a vestibule dedicated to a fully operational cab for remote operation of the locomotive and train. Each car shall contain its own equipment for operational safety systems, braking, and propulsion control along with all of the requirements of TS 7 of this Specification. The cab shall be located on the right side of the car at the end where the parking brake is installed. The cab end shall be identified as the F-End of the car and the opposite end as the B-End.

Wheels and door leafs shall be numbered starting from the F-end with all odd numbered components on the same side of the car’s axles, and trucks shall be numbered starting from the F-end and/or A-end. The identification system shall be approved by the Engineer.
## 2.2 DESIGN CONSIDERATIONS

### 2.2.1 Operation

The car shall be capable of operation at maximum allowable speed on trackage which meets only the minimum requirements of the FRA Track Safety Standards (49 CFR 213) for each class of track based on:

a. Diameter of wheels: 36 inches maximum

b. Gearing: to be geared for a top service speed of 110 mph

Cars shall be designed to operate over the curves specified in TS 2.2.10.

The car shall be designed for high speed operation on tangent track and on curves having curvatures up to and including six (6) degrees at minimum design cant deficiency per TS 2.2.8.

During operation over these limits, there shall be no metal to metal contact of truck stops or components.

Under all operating conditions including worn wheels and broken springs, the proposed car shall comply in all respects including all projecting appurtenances with Amtrak’s clearance diagram, A-05-1355 Rev. E, and SEPTA’s clearance diagram, B-4163. Where any conflict exists between these two (2) drawings, the more stringent requirement shall apply. The Contractor shall prepare and submit for approval an analysis of the car clearance with all possible combinations of failed suspension elements indicated.

[CDRL 02-005]

Under the most unfavorable conditions of track curvature, track geometry (allowed by the FRA Track Safety Standards), wheel wear, broken springs, as well as lateral and vertical motion and roll, a clearance of at least a half (1/2) inch exclusive of positive stops shall be maintained between truck parts and carbody parts.

Under the most restrictive track conditions and maximum buff loading, the clearance between two (2) coupled cars coupled in any orientation shall not be less than three (3) inches except at buffers, couplers, and side barrier fixtures.

For determining vertical clearances due to wheel wear, the decrease in wheel diameter shall be from new condition to worn wheel condition as defined by the manufacturer.
2.2.2 Weights and Supplies

2.2.2.1 Cars

In order to minimize operating costs and the loadings on existing wayside structures, the Contractor shall by making maximum use of their technical expertise and the most weight efficient designs available produce a car of minimum weight without compromising vehicle integrity or the Specification requirements. A weight control plan shall be submitted to the Engineer for review and approval and kept current on a monthly basis. [CDRL 02-006]

It is desired that the design weight of a car empty of passengers and crew but ready to run not exceed 140,000 pounds for a cab car and 133,000 pounds for a trailer car. These weights shall establish the AW0 weights for each car respectively.

Based upon the above, the following weights are used in this Specification to denote various load conditions of the car based on a seated passenger weight of 165 pounds each and a wheelchair passenger weight of 350 pounds each:

The following formula shall be used by the Contractor to establish the following AW categories:

a. AW1 – Weight of vehicle’s AW0 with a fully seated load
b. AW2 – Weight of vehicle’s AW0 with a fully seated load plus standees at four (4) passengers/m2
c. AW3 – Weight of vehicle’s AW0 with a fully seated load plus standees at six (6) passengers/m2

Whenever weights are referred to in this Specification, the weight of the cab car shall be used unless the trailer car is at a higher weight in which case the higher weight shall govern.

2.2.2.2 Car Weight and Balance Distribution

Each car shall be balanced laterally and longitudinally. The calculated lateral unbalance shall not exceed 30,000 inch-pounds. The truck to truck weight difference within a car shall not exceed five (5) percent. The load on each axle of a car with a AW0 load in a ready to run condition shall be between 24 and 26 percent of the car weight. The use of additional ballast weight is not allowed to compensate for imbalance conditions. Balance shall be obtained through equipment placement without compromising maintenance access.

The Contractor shall not permit the performance or structural factors of safety to be degraded by the as-built weight exceeding the weight estimates used during design. The Contractor shall require the full cooperation of their subcontractors in this effort and shall require weighing of sample components at the earliest possible dates.
2.2.2.3 Weight Estimates

The Contractor shall develop and submit to the Engineer for review and approval a weight and weight balance program and test procedure and report for determining the center of gravity for each car type during detail design.

A weight estimate and weight balance estimate for each car type shall be updated at least monthly during the design phase, shall include any changes resulting from pilot car testing, and shall be submitted to the Engineer for review and approval. This shall continue monthly until the first production car of each type is weighed. [CDRL 02-007] The weight, balance estimates, and center gravity shall be validated on the pilot cars and the first completed production car of each type prior to shipment from the Contractor’s plant. This information and the status of the program shall be addressed in the monthly weight control plan report identified in TS 2.2.2.1.

The weight distribution shall be obtained by weighing the car with a load cell at each wheel as described in TS 2.2.2.4 and shall be submitted to the Engineer for review and approval. [CDRL 02-008] The final weight balance and placement of equipment shall be approved by the Engineer. [CDRL 02-009] If the weight imbalance on the first car of each type is greater than allowed, the Contractor shall prepare a plan for correction of the imbalance to the specified level for the approval of the Engineer, and the car shall be modified to the approved plan. If after completion of the modifications the car is compliant, the weight control plan shall be revised to reflect the modifications made and submitted for approval. All cars from the second car of each type shall be manufactured to the revised and approved weight control plan.

2.2.2.4 Car Weighing

Each car shall be weighed with load cells at each wheel per end simultaneously. Both ends shall be added to determine the total car weight. During the pilot car phase, the pilot car of each car configuration shall be weighed at the approximate point of ten (10) percent and 75 percent completion of production for comparison and submitted to the Engineer for review and approval. [CDRL 02-010] The procedure for weighing the ends at the truck locations shall also be submitted to the Engineer for review and approval. [CDRL 02-011]

Both the end to end weight and lateral balance requirements shall be assessed. If the weight of the comparative ends of the pilot car varies by more than five (5) percent, the Contractor shall prepare a plan to bring the weight within the five (5) percent requirement by applying the weight correction measures. If lateral imbalance is found or the weight difference still exceeds five (5) percent, no further manufacturing or assembly shall be performed until the cause of the weight difference is identified and corrected and equipment has been repositioned to meet the imbalance requirements. The correction(s) shall be validated by weighing the next five (5) cars and comparing each car’s weight and balance information.

Once the official car weight has been determined in respect to all weight corrections and approved by SEPTA, all remaining production cars shall be within one (1) percent of the recognized weight for that type of car configuration.
Each production car’s official car weighing shall be performed only after all car assembly, testing, and final inspections have been completed, and the car is officially ready for delivery. The official car weight shall be recorded in the “Car History Book” and on the car marking plate.

### 2.2.3 Truck and Carbody Clearances

#### 2.2.3.1 General

The following shall apply with the wheels and suspension system at the dimension which is the worst case for the particular condition. No parts of the car shall exceed the dynamic clearance envelope determined by the dimensional outline shown in Amtrak’s clearance diagram, A-05-1355 Rev. E, and SEPTA’s clearance diagram, B-4163. In addition, the car must comply with Amtrak’s static lean allowance requirements. When measured at the plane of the top of rail on level tangent track under both normally-inflated air suspension conditions (with all leveling valves then locked in the neutral position) and fully deflated air suspension conditions, no part of the car at both AW0 and AW1 load condition shall extend more than 5 feet 8 inches from track centerline when one rail is then superelevated 6 inches. Truck components shall clear the running rails by a minimum of 2.75 inches with fully worn wheels and AW3 load. Sufficient clear access to the axle ends to allow wheel truing without the removal of any parts shall be provided. The car shall be designed so that the carbody and its underfloor equipment shall clear the running rails in the event of a derailment with the wheels resting on the ties.

#### 2.2.3.2 Trucks and Underfloor Equipment

The carbody and attached equipment shall be designed to provide positive clearance for the trucks under worst case operating conditions except for any stops attached to the carbody for the purpose of limiting truck movement in case of derailment. Worst case conditions will result from such factors as horizontal and vertical curves, track superelevation, worn wheels, sway, derailment, suspension system failures, etc., either singly or in combination. Sufficient clearance shall be provided in the truck areas such that if one (1) axle of the car is lowered eight (8) inches as in a derailment, there shall not be contact with any wheel by any part of the car when air springs are deflated. All underfloor mounted equipment unless otherwise required shall clear the running rails under normal conditions by a minimum height of eight (8) inches to prevent excessive damage during a derailment.

#### 2.2.3.3 Clearance Diagram

The car design and construction shall conform to Amtrak’s clearance diagram, D-05-1355, Revision E, and SEPTA’s carbody construction limits drawing, B-4163, under the worst case combination of dynamic excursion, wear, and failure of any one (1) suspension element.

The Contractor shall prepare and submit for approval an analysis of the car clearance with all possible combinations of failed suspension elements indicated within 180 days after NTP. [CDRL 02-012]
As part of the initial design review efforts and continuing thereafter, the Contractor shall prepare a complete set of clearance diagrams for the car. [CDRL -02-013] These shall include static and dynamic clearance envelopes relative to wayside allowances, lean allowance, clearances for all parts of the truck, and identification of the center of gravity and roll center. A diagram shall be included of the car superimposed on the Amtrak clearance diagram along with all supporting calculations and necessary cross sections which shall show worst case clearance to the outline including offset due to curve compensation. All supporting calculations and conditions shall be provided. The roll angle shall comply with 49 CFR Part 213.57 (d).

### 2.2.4 Safety Appliances

All steps, grab irons, and other safety appliances (including connection/mounting styles) must comply with Federal Railroad Administration requirements.

### 2.2.5 Environmental Factors

The cars shall be designed and constructed to operate successfully under the environmental conditions present in the continental U.S. Car systems affected by extremes in climate conditions shall be designed to account for the following at a minimum:

- **Temperature range (degrees F):**
  - Average minimum (January): 24 degrees
  - Average maximum (July): 86 degrees
  - (93 degrees DB, 75 degrees WB)

- **Degree days (65°F base):**
  - Heating – 5600
  - Cooling – 1450

- **Possible sunshine:** 56 percent

- **Mean daytime sky cover:** 62 percent

- **Average days per year of:**
  - Precipitation – 117
  - Heavy fog – 23
  - Snowfall over 1 inch – 6

- **Relative humidity:**
  - Average – 48 to 83 percent
  - Range – 35 to 100 percent

- **Precipitation:**
  - Annual average – 3 feet, 6 inches
  - Maximum in 1 day – 6 inches
  - Maximum in 1 hour – 2 inches
  - Average snowfall – 2 feet 4 inches
  - Maximum 1 day snowfall – 1 foot 9 inches
  - Freezing rain – up to 0.5 inch ice
h. Wind speed: Average – 10 miles/hour
Maximum over 1 minute – 73 miles/hour

i. Solar radiation (mean daily average): 527 Langley (June)
157 Langley (January)

j. Maximum wind chill: -80 degrees F

k. Rain acidity (pH): 4.0

l. Chloride content: Modified marine environment

The temperatures above represent only ambient conditions. The ambient is defined as the temperature, humidity, and environment of the area around the car. Actual temperatures and conditions within the equipment compartment or above or under the car may be more severe and can reach 150 degrees FDB.

The effect of increased temperature due to solar radiation on the car and heat produced during operation of equipment under the extreme conditions shall not result in degradation of equipment performance or reduced reliability levels. Additionally, the effects of prolonged exposure to low temperature extreme or wind shall not result in degradation of equipment performance or reduced reliability levels.

Conditions for the design of the heating and air conditioning systems shall be in accordance with TS 8.1.

The car shall operate as specified in the continental U.S. environment which includes operation in the salt laden atmosphere along oceans and through areas with heavy industrial air and water pollution. The most common contaminants are silica, iron, carbon, oil vapor, water vapor, ozone, copper, nitrous oxide, hydrogen sulfide, sodium chloride, fuel oil, and both alkaline and acidic cleaning solutions.

Equipment and enclosures mounted underfloor and in the vestibule areas shall be watertight even when subjected to wheel spray, car washing, hose cleaning, driving rain, and fine snow. Seals shall be service proven with respect to material and design with a service life of not less than ten (10) years. The enclosures shall have drain holes fitted with cotter keys or other approved simple drain mechanisms for discharge of condensation and leakage due to damaged or deteriorated seals.

A car that has been cold soaked in dead storage conditions (completely non-powered) at -7 degrees F shall not be damaged or create any unsafe conditions when power is applied. Full performance in accordance with all specified requirements shall be obtainable immediately for all components of all subsystems (including electronic systems). Cold soaking at temperatures below -7 degrees F followed by activation shall not cause any equipment damage, but full performance may be delayed for electronics warm up.

The air conditioning system condensers and other components may be exposed to elevated ambient temperatures up to 140 degrees F and must operate successfully at those temperatures as detailed in their respective Sections. Techniques proposed for meeting these requirements shall be submitted for the Engineer’s approval. The car must be able to operate without damage or failure of any equipment in water up to two (2) inches in depth above the top of the rail at speeds up to ten (10) mph.
2.2.6 Electronic Equipment Design Requirements

Electronic equipment shall conform to IEEE STD 16-2004 and EN 50155 unless otherwise approved by SEPTA. All type tests shall be performed.

2.2.7 Performance Requirements

2.2.7.1 Design Speeds

The Contractor shall design and construct the cars for operation at the following speeds:

a. Maximum revenue service speed with fully worn wheels: 110 mph
b. Maximum design speed: 115 mph

Mechanical overspeed shall be set five (5) percent greater than the maximum design speed.

2.2.7.2 System Voltages

All apparatus except where otherwise stated shall have operating characteristics which will provide a ratio of actual performance to specified performance not less than the ratio of actual voltage (within the limits specified in the following paragraphs) to the rated operating voltage of the apparatus.

2.2.7.2.1 Primary Voltage

The primary source of electric power supply for the cars will be a dedicated head end power (HEP) alternator or inverter on the locomotive. This system generates nominal (depending on the locomotive type) 480 VAC +/- 10 percent, 60 Hz, 3-phase power. This system is designated “480 VAC” throughout this Specification. Power shall be distributed to the cars through the three (3) phase trainlines which are described in TS 10.2. Heating, air conditioning, battery charging, and lighting transformers shall operate from this source.

2.2.7.2.2 Secondary Voltage

Power at a secondary voltage shall be 120 volts 60 Hz three (3) phase delta connected which shall be obtained from three (3) single phase transformers connected to the 480 VAC trainline on each car as described in TS 10.4. This system shall supply power for HVAC control, convenience outlets, and other miscellaneous loads. This system is designated 120 VAC throughout this Specification.
2.2.7.2.3 Low Voltage

A low voltage DC power supply and battery charger operating from the 480 VAC system and batteries shall be provided on each car. The low voltage system shall be regulated for a nominal 74 VDC +0.5 VDC, and the nickel cadmium storage batteries shall be of a nominal 64 VDC. Control, low voltage lighting, and emergency services shall be energized from these sources and shall be capable of operation from 55 to 80 VDC and shall not be damaged by the continuous application of voltages between zero (0) and 55 VDC. This voltage system is designated 74 VDC throughout this Specification.

2.2.7.2.4 Design Requirements

All equipment shall be protected from damage and improper operation due to high voltage transients across the supply terminals of that equipment and from high voltages impressed between supply terminal and the carbody. All equipment shall be protected from damage and improper operation from long term overvoltage and undervoltage conditions from any cause including equipment failure.

The Contractor shall develop an efficiency review plan for all electrical equipment provided on the car to minimize the requirements of the HEP system. The plan shall be submitted within 150 days of the NTP and shall be updated monthly until each pilot car is tested and the design is complete. Any changes that affect the as-tested condition shall be addressed in the revised plan submitted to the Engineer. [CDRL 02-014]

2.2.7.3 Brake Performance

The performance requirements for the full service and emergency deceleration rates shall be met with a train consisting of six (6) multi-level cars with at least one (1) cab car and a SEPTA electric locomotive. The rates shall be met for all passenger load levels up to AW3.

The parking brake system performance shall conform to the requirements of TS 12.22 and shall indefinitely hold a worst case load of either a fully loaded AW3 cab or a fully loaded AW3 trailer car on a three (3) percent grade.

The deceleration rates for both cab and trailer cars shall be as follows:

a. Full service – The average full service braking rate shall be 2.35 mphps, +10 percent/-0 percent from 110 mph to 0 mph. The maximum instantaneous rate during a stop shall not exceed 2.50 mphps. Full service braking shall be controlled so that the maximum change in deceleration (jerk rate) during application shall not exceed 1.50 mphpsps.

b. Emergency – The minimum emergency braking rate to stop shall be 2.75 mphps from 80 mph to 0 mph for all load conditions. Above 80 mph, the minimum emergency braking rate shall be as determined by the characteristics of the braking friction materials, but in no case shall be less than 2.5 mphps. The maximum rate during a stop shall not exceed the limit of clean dry rail adhesion. Jerk rate limitations shall not apply in emergency braking.
2.2.7.4 Braking Criteria – General

The specified brake performance shall be subject to the following:

a. System pressures – The maximum design pressures for the air brake system are:
   1) Main reservoir: 150 psi (1034 kPa)
   2) Brake Pipe: 110 psi (758 kPa)
   3) Brake Cylinder: 100 psi (689 kPa)

b. Unless otherwise specified, braking rates shall be achieved on dry rail and level tangent track.

c. All braking rates shall be measured from the time of initiation of movement of the brake controller handle to the time of complete zero (0) mph stop.

d. All specified brake performance requirements shall be met without electro-pneumatic propagation.

2.2.7.5 Thermal Capacity Requirements

The friction brake system shall have sufficient thermal braking energy dissipating capability to permit unrestricted operation.

During all operating conditions, the following requirements shall be met:

a. Disc temperatures shall not exceed the limits recommended by the manufacturer.

b. Brake pad and brake shoe temperatures shall not exceed the limits recommended by the manufacturer.

c. No car components shall be exposed to excessive heating due to the friction brake system.

To demonstrate compliance, dynamometer tests and road tests shall be performed as required in TS 18.

2.2.8 Cant Deficiency

The design cant deficiency shall be nine (9) inches. Revenue operations shall be conducted at a maximum of six (5) inches of cant deficiency.

The Contractor shall provide analysis and test data indicating the location of the force vector resultant at one (1) inch increments in levels of superelevation for operation up to nine (9) inches of cant. Therefore in the case that the static lean is at nine (9) inches of superelevation, the lightest wheel must have at least 60 percent of its static load remaining. In the dynamic case, the lightest wheel must have at least ten (10) percent of its static load remaining. (Any changes in these values as a result of the enactment of new regulations shall be the subject of design review.)
2.2.9 Route Characteristic

2.2.9.1 West Trenton Route
Track charts for SEPTA’s West Trenton Line shall be provided to the Contractor after Notice to Proceed for purposes of truck and suspension design.

2.2.9.2 Philadelphia – Harrisburg Route
Track charts for the Philadelphia – Harrisburg rail line shall be provided to the Contractor after Notice to Proceed for the purposes of truck and suspension design.

2.2.10 Track and Physical Characteristics
A significant feature of the SEPTA Railroad Division is that most of its rights-of-way are bordered by deciduous trees common to the Middle Atlantic region of the U.S., especially red and white oak trees. SEPTA suffers severe problems each autumn with the running surface of the track being contaminated by tree sap excretions as well as by resin from crushed leaves. The resulting resin accumulation, commonly called “black rail”, greatly reduces available rail adhesion frequently under conditions of light moisture accumulation such as from frost or morning dew. Effective adhesion levels under these situations have not been precisely measured but are estimated to be as low as five (5) percent or lower. The Contractor is required to provide braking systems which are specifically designed to maximize car performance especially minimization of braking distances under these conditions.

The SEPTA portion of the Railroad Division is operated in compliance with FRA Track Standard Classes 1 through 4 and over Amtrak Northeast Corridor and Harrisburg Line track with FRA Track Standard Classes 1 through 6. The car design considerations for maximum track deviations shall be based upon the appropriate FRA class and maximum permissible speed. Refer to the Federal Railroad Administration (USDOT) Track Safety Standards, 49 CFR 213, for detailed information on allowable track geometry. No warranty is made by SEPTA that track will be maintained in its present condition. The car shall be designed to operate at an unbalanced curve superelevation of four (4.0) inches in accordance with 49 CFR 213.57(d).

a. Track Characteristics

1) Rail type: 115 RE (80 percent) and 132 RE (20 percent) rail weight
   Joints: welded (90 percent) and bolted (10 percent)
   Tie plate cant: 1 in 40

2) Any horizontal curve of radius equal to or greater than 440 feet on main track and 250 feet on yard track

3) Facing No. 8 turnouts arranged to form an “S” curve with a minimum of five (5) feet of tangent between switch points

4) 2,000 foot vertical curve (main line)
5) 1,600 foot vertical curve (yard, no passengers, and functioning primary suspension)

6) Most severe reverse curve conditions (crossovers):
   a) Main track: R1=800 feet, T=0 feet, R2=800 feet
   b) Yard track: R1=450 feet, T=0 feet, R2=450 feet

7) Maximum vertical gradient of 1 in 20

8) Nominal track gauge of 4 feet 8 1/2 inches

9) Minimum track spacing of 11 feet 9 inches

10) Minimum overhead catenary wire height of 15 feet 0 inches
    (The SEPTA Railroad Division and Amtrak Northeast Corridor and Harrisburg Line use
    fixed tension catenary systems except for one (1) segment of constant tension catenary
    on the SEPTA R1 Airport Line. All wire heights are measured from the top of the running
    rail to the bottom of the contact wire. Minimum wire height is for 11,500 vAC catenary;
    any future 25,000 vAC catenary will have proportionally increased wire height.)

11) Minimum frog number – crossover between tracks on #6-1/2
    12 feet 0 inch centers with cars coupled

12) Maximum superelevation 6 inches

b. Passenger Stations

1) The SEPTA Railroad Division and Amtrak Northeast Corridor and Harrisburg Line use
   both high level and low level station platforms.

2) Design height of high level platform above top of rail 4 feet 0 inch

3) Minimum distance of high level platform edge to centerline of track 5 feet 7 inches

4) Design height of low level platform above top of rail 8 inches

5) Minimum distance of low level platform edge to centerline of track 5 feet 1 inch

In addition, the cars shall comply with the requirements of 49 CFR 213.329 and shall undergo the
qualification testing detailed in 49 CFR 213.345. If questions or conflicts arise within this Specification,
SEPTA shall be notified by the Contractor so that the subject questions or conflicts can be resolved
without impact to the design and manufacturing schedules.
2.2.11 Car Characteristics

Listed in this Section are the required basic car dimensions, the characteristics of the track on which the cars will be operated, and the cars’ normal loading conditions under which the cars will be operated. This data combined with the drawings and performance characteristics included in this Specification comprise the descriptive requirements for the cars. Areas where wheelchair and mobility aid users are to be accommodated shall comply with all applicable requirements of the ADA. If the Contractor requires clarification to meet component interchangeability with the existing SEPTA commuter rail cars as required by the Specification, a sample of the car(s) in question will be made available by SEPTA for inspection by the Contractor at a designated SEPTA facility. The following characteristics shall apply to cab and trailer car types unless indicated otherwise:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of car over pulling face of couplers</td>
<td>85 feet-0 inches</td>
</tr>
<tr>
<td>Truck centers</td>
<td>59 feet-6 inches</td>
</tr>
<tr>
<td>Width of carbody over threshold (at floor)</td>
<td>10 feet-0 inches</td>
</tr>
<tr>
<td>Maximum width of carbody</td>
<td>10 feet-6 inches</td>
</tr>
<tr>
<td>Minimum interior width of carbody</td>
<td>9 feet-5 inches</td>
</tr>
<tr>
<td>Minimum clear width of aisles</td>
<td>23 3/8 inches</td>
</tr>
<tr>
<td>Height top of rail to top of intermediate level finish floor at bolster new wheels</td>
<td>51 inches(+1/2 inches, -0 inches)</td>
</tr>
<tr>
<td>Maximum height top of rail to top of roof new wheels empty car</td>
<td>14 feet 8 inches</td>
</tr>
<tr>
<td>Minimum vertical clearance inside car under ceiling and on stairs including projections below the ceiling clear height after full assembly</td>
<td>6 feet-4 inches</td>
</tr>
<tr>
<td>Coupler height above top of rail (nominal)</td>
<td>34 1/2 inches</td>
</tr>
<tr>
<td>Maximum height above floor bottom of window glass</td>
<td>34 inches</td>
</tr>
<tr>
<td>Minimum height window opening</td>
<td>24 inches</td>
</tr>
<tr>
<td>Side door clear opening at corner post location</td>
<td>32 inches to 36 inches</td>
</tr>
<tr>
<td>Side door clear opening at quarter point location</td>
<td>32 inches to 36 inches</td>
</tr>
<tr>
<td>Minimum height of side door and vestibule end door opening above floor clear height after full assembly</td>
<td>6 feet-4 inches</td>
</tr>
<tr>
<td>Minimum clear width of body end door opening</td>
<td>32 inches</td>
</tr>
<tr>
<td>Minimum height of body end door opening</td>
<td>6 feet-4 inches</td>
</tr>
<tr>
<td>Wheel diameter</td>
<td>32 inches to 36 inches</td>
</tr>
<tr>
<td>Wheel gauge back to back</td>
<td>53 3/8 inches</td>
</tr>
<tr>
<td>Truck wheelbase</td>
<td>8 feet 0 inches to 8 feet 6 inches</td>
</tr>
<tr>
<td>Minimum clearance above top of rail for all carbody elements (except wheels) under all conditions</td>
<td>2 3/4 inches</td>
</tr>
</tbody>
</table>
### 2.2.12 Structural Strength

As a minimum, the car shall comply with all FRA regulations and APTA standards for the design of carbodies in accordance with 49 CFR Parts 229, 238 and APTA PRESS.

### 2.2.13 Operating Requirements

#### 2.2.13.1 Operating Cabs

The cab car shall be equipped with a fully functional operating cab at the F-end.

#### 2.2.13.2 Compatibility with Other Rolling Stock

The car shall be mechanically and electrically (HEP, Communication, and MU) compatible with any combination of SEPTA locomotive and coach and cab cars. The cab car may operate lead, trail, or push pull and shall be able to operate connected to all standard or fixed cables on SEPTA’s rolling stock.

Couplers (including air connections), brakes, hoses, and trainline electrical cables shall interface directly with SEPTA’s locomotive and Bombardier’s coach and cab cars in a manner which shall permit safe operation of train consists with any mixture of the car types. Electrical receptacles as well as plug location and length shall interface directly with present SEPTA equipment.

The cars shall be able to negotiate worst curve and track conditions specified in TS 2.2.10. The coach and locomotive draft gear travel shall be considered.

### 2.2.14 Ride Quality

#### 2.2.14.1 General

Trucks shall be suitable for operation at all speeds up to 110 mph with six (6) inches of cant deficiency with qualification to 115 mph with six (6) inches of cant deficiency and shall provide a comfortable ride at all speeds compliant with the ride quality and maximum safe operating speed test requirements of TS 18.2.3. The vehicle shall meet the requirements of 49 CFR 213.345 and APTA-PR-M-RP-009-98, Section 6.

The ride quality of the car shall be sufficient to not exceed a ride index value of 2.75 computed separately for vertical and lateral accelerations. Measurements shall be conducted over the SEPTA Paoli/Thorndale Line for a round trip between Jefferson Station and Paoli making all local stops while operating at normal scheduled speed.
The ride index shall be defined as: \( R = 7.07(V_i)^{0.1} \)

Vi for the vertical and lateral directions varies independently with frequency as follows:

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Vi Vertical</th>
<th>Vi Lateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero (0) to Six (6) Hertz</td>
<td>0.32 ( f \cdot a^3 )</td>
<td>4.32 ( a^3 )</td>
</tr>
<tr>
<td>Six (6) to 20 Hertz</td>
<td>400 ( a^3 / f^3 )</td>
<td>650 ( a^3 / f^3 )</td>
</tr>
<tr>
<td>Above 20 Hertz</td>
<td>( a^3 / f^3 )</td>
<td>( a^3 / f^3 )</td>
</tr>
</tbody>
</table>

*Where \( f \) equals the frequency in Hertz and \( a \) equals the amplitude \( g \) peak (1g = 32.2 feet/second^2)

The ride index calculations shall be based upon FFT analysis of at least 400 lines having a 0.25 Hertz resolution. The data shall be averaged over 32 averages to minimize statistical error (use of 16 averages shall be permitted for comparative evaluations only). Use of weighing filters are acceptable provided that the integration is performed over 10-15 second periods, and the integrated values are recorded over at least the distance between Overbrook and Paoli and are reported as a mean and a sample variance.

Should the cars fail to satisfy the above mentioned requirements, a program for correcting the deficiencies shall be submitted to the Engineer for approval within ten (10) working days together with a proposed schedule for completing the suggested correction. If in the opinion of the Engineer the program and/or schedule are inadequate, unsatisfactory, increase maintenance costs, or otherwise affect the serviceability of the cars, the modifications will not be approved, and an acceptable program and schedule shall be resubmitted within five (5) working days. If the revised program and schedule are not submitted in time or are still unacceptable, SEPTA will return the cars to the Contractor's plant at the Contractor's expense.

Should the cars after correction still fail to produce the riding qualities specified, SEPTA will have the right to require the Contractor to make further modifications to bring performance to the required standards.

### 2.2.14.2 Ride Quality Analysis

The Contractor shall perform a three (3) dimensional dynamic simulation of the car to show by analysis that the design meets the specified ride quality requirement. The dynamic simulator shall be selected by the Contractor based on their experience with similar analyses of high speed rolling stock.

Track geometry input data shall be actual vertical and lateral rail position data from the Northeast Corridor running from Newark, Delaware to Trenton, New Jersey.
Prior to performing the analysis, the Contractor shall submit a description of the dynamic simulator for SEPTA’s approval. Included with the description shall be a list of the input data based on the specified location as mentioned above which shall be used for the track geometry input data, a sketch showing a sample representative physical model, a list of possible output with samples of each, a list of previous projects where the proposed dynamic simulator was used, and a summary of the results of any calibrations of the proposed dynamic simulator. [CDRL 02-015]

The Contractor shall prepare a final report of the results of the dynamic simulation in accordance with this Section. The report shall include an update of the description replacing the sample data and output with the actual data and results. Ride quality shall not exceed the boundary defined by the specified ride quality requirements, and carbody excursions shall not exceed the clearance requirements specified in TS 2.2.3. [CDRL 02-016]

SEPTA’s approval of the final report shall be required prior to approval of the truck drawings.

### 2.2.15 Fire Loading

The total fire loading of the car shall be held to a minimum. All of the smoke and flammability requirements of TS 17.24 shall be met. The Contractor shall ensure that the car fully complies with the fire safety requirements of the FRA as identified in 49 CFR Part 238. The Contractor shall also prepare for the Engineer’s approval all analysis and submittals required by the FRA as outlined in this Section. [CDRL 02-017]

### 2.3 NOISE AND VIBRATION

#### 2.3.1 Noise Criteria

Vehicle noise and vibration characteristics shall comply with FRA regulations, APTA Standards and Recommended Practices, and the Contract requirements. The noise environment created by the car shall be in compliance with the standards presented in 40 CFR 201 and the compliance regulations of 49 CFR 210. Where conflicts exist between the requirements of the Regulations and the Specification, the most restrictive shall apply. Tests shall be required to demonstrate compliance.

Unless otherwise indicated, noise level is defined by the latest version of ANSI S1.4 as weighted sound pressure level measured by the use of a metering characteristic and weighting A, B, or C as defined in ANSI S1.4. The unit of the noise level is decibels (dB), and the reference pressure is 20 micropascals.

Overall noise levels shall be measured in dB on the A scale with slow meter response setting for stationary car measurements and fast meter response for moving car measurements. A Type 2 sound level meter in accordance with the latest version of ANSI S1.4 shall be used. For octave and 1/3 octave band measurements, filters in accordance with the latest version of ANSI S1.11 shall be used.

For measurements under steady state operating conditions, the period of observation shall be five (5) seconds.
All measurements of exterior noise levels shall be performed on level ground at a distance of 50 feet or as otherwise specified from the centerline of the track five (5) feet above the top of the rail in an essentially free field environment such as outdoors away from reflecting surfaces other than ballast, ties, track, and the adjacent ground.

Measurements of interior noise levels shall be performed in a fully equipped car with no personnel on board other than the Operator, the crew (for dynamic tests), the person performing the measurements, and an observer. The noise level shall be measured at locations approved by the Engineer [CDRL 02-018] inside the car as follows:

- Not less than one (1) foot from finished surface of ceilings, end walls, or side walls on each vehicle level
- At the approximate height of a seated passenger's ears at representative locations throughout the car including one (1) at the height of the seated Operator in the cab
- At the approximate height of a standing passenger's ears at representative locations throughout the car
- One (1) foot from the geometric center of and perpendicular to each return air grille
- At all door locations 24 inches from the finished surface and 63 inches above the top of the finished floor

Measurements, methods, locations, and instrumentation used shall be the same for static and dynamic tests.

Specified noise limits shall be for continuously operating equipment and for equipment which operates occasionally such as a circuit breaker or pneumatic pressure relief device. The allowable noise level shall be reduced by at least three (3) dB if significant pure tones in the range from 250 Hz to 4,000 Hz are present in the noise. Pure tone noise shall be considered significant in this context if any one-third octave band sound pressure level is 5 dB or more higher than the arithmetic average of the two (2) adjacent bands containing no pure tones. For octave and one-third octave band measurements, filters in accordance with the latest version of ANSI S1.11 shall be used.

### 2.3.2 Interior Noise Levels

#### 2.3.2.1 Cab

The sound level in the cab during normal operation shall average less than or equal to 85 dBA, with an upper 99% confidence limit of 87 dBA per 49 CFR 229.121. Noise measurements shall be made using a sound level meter and measurement technique conforming, as a minimum, to the requirements of Subparagraph (a)(3) of 49 CFR 229.121.
A badge plate permanently affixed to the rear cab wall with stainless steel hardware shall also contain wording stating the successful compliance with both the cab level noise requirements of 49 CFR 229.121 as well as the requirements of 49 CFR 210.29. A sample of the badge plate shall be submitted to the Engineer for review and approval during the Pilot Testing program. [CDRL 02-019]

### 2.3.2.2 Passenger Area

When a single completely assembled and operating car moving at any speed up to 79 mph on bolted rail and 100 mph on welded rail with tangent at grade, ballast, and tie (either concrete or wood) track with all auxiliaries operating simultaneously at normal conditions and with the vehicle operating in any specified mode of acceleration, deceleration, or coasting, the noise level in the car’s interior without passenger load (AW0) measured at all locations shall not exceed:

- a. Upper level 70 dBA
- b. Lower level 75 dBA
- c. Intermediate level 75 dBA
- d. Door vestibules 76 dBA

With the same car at rest immediately following the preceding test and with only the lights, air conditioning, and ventilating equipment operating, the noise level in the car’s interior measured at all locations shall not exceed 70 dBA.

### 2.3.2.3 Wayside Noise

Car or train produced noise levels shall not exceed the following with all auxiliary equipment operating simultaneously at a distance of 50 feet from each side of the car and measured at the height of the axles in an open area with no fences, sound barriers, or other wayside obstruction or sound reflecting surfaces within 100 feet of the test location:

- a. Car stationary empty with all subsystems operating 67 dBA
- b. Empty car on tangent track in full service friction braking at 40 mph 75 dBA

In all cases, the allowable noise level shall be reduced by at least three (3) dB if any pure tones in the range from 250 Hertz to 4,000 Hertz with a one-third octave band sound pressure level five (5) dB or more greater than the arithmetic average of the two (2) adjacent bands containing no pure tones are present. Sound level measurement shall be made in accordance with ANSI S1.4 requirements for a Type II instrument set to an A weighted fast response with filters in accordance with ANSI S1.11 used for one-third octave measurements.
2.3.2.4 Vibration Criteria

Equipment and auxiliaries mounted anywhere on the car, carbody, or trucks when the car is stationary with all subsystems operating shall not cause vertical or horizontal vibrations anywhere on the car floor, walls, ceiling panels, and seat frames in excess of 0.10 inch peak to peak amplitude between 0 and 1.4 Hz, in excess of 0.01 g peak acceleration between 1.4 Hz and 14 Hz, and in excess of 0.045 inches per second peak vibration velocity for the frequency range above 14 Hz. Car equipment and auxiliary component structure and mounting shall be designed to prevent amplification through component resonance beyond a level twice that of the attachment point. The vibration force output of any rotating component shall not exceed the vibration environment specified for the component.

All vehicle equipment shall be designed to operate without damage, degradation of performance, noise, vibration, rattling, and audible resonance when subjected to vibration and shocks encountered during normal service at all speeds up to ten (10) percent above maximum operating speed. Carbody mounted components shall be designed to withstand continuous vibrations of not less than 0.2 g at frequencies up to 100 Hz in all directions as well randomly oriented shock loads of five (5) g’s longitudinally, three (3) g’s vertically, and three (3) g’s laterally. Truck components located above the primary suspension shall be designed to withstand continuous vibrations of at least six (6) g’s at frequencies up to 100 Hertz in all directions as well as randomly oriented shock loads of eight (8) g’s. For truck components carried on the axles, the Contractor shall in conjunction with their subcontractors jointly determine the most severe shock and vibration levels arising from the combination of the proposed equipment and operation on the SEPTA Regional Rail System so that apparatus suitable for the service intended shall be provided. Tests shall be conducted in accordance with IEC 61373, 1999, Railway Application, Rolling Stock Equipment, Shock, and Vibration Tests.

2.3.2.5 Noise and Vibration Attenuation

Particular attention shall be given to the design of the equipment to ensure minimum generation of noise and vibration and to the attenuation of airborne and solid borne noise and vibration along the path from source to passengers and crew. Vibration isolators, enclosures, baffles, seals, acoustic absorbing materials, mass, bracing of panels with adequate sound transmission loss or panels with adequate transition, or other appropriate methods shall be incorporated into the car’s design to attenuate noise and vibration generated by the operation of the car and all other equipment to ensure that the noise and vibration parameters are not exceeded.

Noise levels from equipment installed on the car shall be controlled by the Contractor to ensure noise and vibration requirements are achieved.
2.4 SAFETY

2.4.1 System Safety Program

The Contractor shall develop, implement, and maintain a comprehensive system safety program (SSP) conforming to the guidelines and requirements of 49 CFR 238 - Subpart B, 49 CFR 229, 49 CFR 226, and the APTA Manual for the Development of System Safety Program Plans for Commuter Railroads. SEPTA shall use the implementation guidelines of 49 CFR 238.105 as the basis for determining the acceptability of the Contractor's SSP.

The SSP shall develop the method to identify all hazards related to the cars and impose design requirements and management controls which prevent mishaps by eliminating hazards or reducing risks to levels acceptable to SEPTA. The analysis defined in the SSP shall be quantitative and show the severity and probability of each hazard and the mean time between hazardous events (MTBHE) for each hazard and the entire vehicle. Car system software shall be treated as a safety critical item and shall be included in the development of the SSP to ensure reliable fail-safe system software. [CDRL 02-020]

Safety requirements defined in this Section and elsewhere in this Specification shall be incorporated into the SSP and the Contractor's designs.

2.4.2 Applicability of 49 CFR 238.105

Specific portions of 49 CFR 238.105 are referenced herein. These references shall not be construed as limiting the applicability of any portions of 49 CFR 238.105. Requirements may be waived only where approved by SEPTA.

Formats for reports, listings, analyses, and other required documents shall be submitted to the Engineer for review and approval. All documents shall be submitted on approved forms. Where necessary, the Contractor’s methods and analyses shall be amended to provide all the information required by the approved forms.

2.4.3 General Design Requirements

Hazards shall be resolved according to the precedence rules listed in paragraph 49 CFR 238.105 with the restriction that hazards with a Category I and II all levels of probabilities and hazards of Category III with a level A probability (as defined in 49 CFR 238.105) shall be resolved only by the methods contained therein unless approved by SEPTA. The Contractor shall develop a quantitative fault tree analysis (FTA) for all Category I and II severity hazards.

The general safety design requirements of 49 CFR 238.105 and the guidelines listed below shall be incorporated into the design of the car systems affecting safety:

a. Only components with high reliability and which have been proven in conditions similar to the projected service shall be utilized.
b. All items identified as SAFETY CRITICAL shall be automatically monitored for performance.

c. All devices not guaranteed to be fail safe shall be assumed capable of failing in permissive modes.

d. All electronic circuits shall be assumed to be capable of failing in permissive modes.

e. Software shall be considered unsafe unless verified in an approved program while operating in the proposed hardware.

f. Systems shall be based on closed circuit principles in which energized circuits result in permissive conditions while interrupted or de-energized circuits result in restrictive conditions.

g. All vital circuits not wholly within the system apparatus enclosure shall be double-wire with the exception of connections to non-vital circuits which may be single-wire single break.

h. Any component or wire becoming grounded shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that shall permit a flow of current equal to or in excess of 75 percent of the release value of any safety device in the circuit.

i. Circuit impedances, signal encoding, shielding, layout, and isolation shall be selected to minimize the effects of interference to the extent that safety is maintained under all conditions.

j. Commands that result in permissive conditions shall be propagated by no less than two (2) independent signals both of which must be present before the permissive condition can occur. The lack of either signal shall be interpreted as a restrictive command.

k. Systems controlled by variable level signals shall be arranged such that a zero (0) level signal results in the most restrictive condition. At least one (1) enabling signal independent from the variable control signal shall be present before the control signal can modulate the system to a more permissive level.

l. Circuit breakers (which should be double pole with positive/negative breaks) shall be guaranteed by the manufacturer to successfully interrupt rated currents. Circuit breakers and fuses shall be applied such that the maximum circuit fault currents cannot exceed the manufacturer's guaranteed operating ranges.

m. Systems that rely on structural integrity for safety shall have sufficient safety factors such that failures do not occur within the life of the vehicle under all foreseeable conditions.

n. Systems subject to wear shall not wear to permissive states within a period no less than three (3) times the overhaul period under the worst case combination of duty cycle, environment, and other influences. Such devices shall be clearly indicated as SAFETY CRITICAL in the maintenance manuals.

o. Mechanical systems, which apply force to achieve safe states, shall not depend upon the application of fluid pressure or electrical energy unless specifically approved.
p. All locks, catches, and similar devices affecting safety shall be either self-engaging without the application of power or if engaged by the application of power shall remain fully engaged in the absence of power. They shall not be operable by use of common tools such as screwdrivers, pliers, etc.

q. All systems shall function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation, and the SEPTA environment.

r. All safety related systems and devices within those systems shall be clearly identified as SAFETY CRITICAL in all operation and maintenance manuals, procedures, and training materials.

### 2.4.4 Failure Induced Hazards

Car equipment and systems shall be designed and constructed to revert to safe modes under failure conditions. The Contractor shall employ high quality components, proven systems, redundancy, checking devices, and other techniques to accomplish this goal.

Car systems whose failure could result in hazards of Category I or II of all probability levels or a Category III hazard with a level A probability shall conform to both of the following design principles:

a. The failure of a single device shall not result in a permissive condition.

b. An undetected failure of any device shall not permit a subsequent device failure to result in a permissive state.

The term "failure" includes both the initial device failure and all consequential device failures caused by the initial failure.

The term "device" includes any component, subsystem, or system whether electrical or mechanical.

The terms "restrictive" and "permissive" relate to potential system responses, which result in either a safer or less safe condition respectively, such as: stop versus proceed, a lower speed versus a higher speed, deceleration versus acceleration, etc.

Systems shall conform to the safety design principles by one or both of the following methods:

a. The utilization of fail-safe devices, that is, devices with known guaranteed by the manufacturer failure modes such as signal grade relays

b. Independent channels with independent checking of each. All channels shall indicate a permissive state in order that the controlled system achieves a permissive state. Failure in any channel shall not affect any other channel or force the system to a permissive state. Lack of correspondence between channels shall be alarmed and shall force a restrictive state upon the system. Checking equipment invariably requires devices conforming to the previous method.
Failures in equipment, which result in an indication of danger whether or not actual danger exists, shall be considered to have occurred in a safe manner. Conversely, a failure which results in an indication of safety when a dangerous condition may exist shall not be considered safe.

2.4.5 Friction Brake System

An independent failure detection system shall compare the brake commands with the friction outputs to determine if a failure has occurred and indicate any failure to the car monitoring system.

2.4.6 Fire and Life Safety

All car components, subsystems, and systems shall be designed for the prevention of fire and for the protection of the public, employees, and emergency response personnel from injury due to fire, smoke, explosion, or panic due to fire and for the protection of the system elements from damage by fire or explosion.

Design shall provide for equipment to be located outside of the cab and passenger areas whenever practical to isolate potential ignition sources from combustible materials. The floor shall be designed to prevent propagation of an underfloor fire to the car. Fire stops shall be provided at floor and roof penetrations. Enclosures for control and other critical equipment shall be located to provide protection against environmental contamination and mechanical damage.

2.4.7 Safety Under Normal Operating Conditions

The car shall present a safe hazard free environment to SEPTA's personnel and passengers.

Individuals shall not be exposed to tripping hazards, sharp points, edges, lethal or injurious voltages, toxic materials, abrupt or unexpected accelerations, or similar hazards. Location, illumination levels, colors, graphics, and surface finishes shall be selected to maximize visibility of step edges, controls, and other objects with which the personnel and passengers must interface.

Normal and emergency equipment and controls which the personnel may operate shall be clearly identified, and operating procedures shall be presented in both printed and graphic formats.

The Contractor shall provide material safety data sheets for all hazardous materials. The data sheets shall be provided during the design review phase of the project. The data sheets shall include all materials used to produce the locomotive as well as all materials provided with the locomotive. [CDRL 02-021]

Maintenance manuals, procedures, and training shall indicate the proper handling, storage, and disposal of hazardous materials. Exposure of maintenance personnel to lethal or injurious voltages shall be minimized through compartments, interlocks, and similar measures. All equipment shall be free from sharp points and edges. All equipment containing hazardous materials, lethal, or injurious voltages, or other risks shall be clearly labeled on both the outside and the inside of the equipment enclosure.
Maintenance, operating, training, and other manuals shall clearly identify all hazardous materials and equipment. All maintenance procedures involving hazards shall contain clear identification of the hazard and instructions to minimize or eliminate the hazards during the procedure.

### 2.4.8 Human Error and Other External Influences

All systems shall minimize unsafe conditions resulting from human error. No sequence of operations or the simultaneous activation of controls shall result in unsafe conditions. Where conflicting commands such as simultaneous power and brake are requested, the more restrictive condition shall result.

Maintenance of safety related equipment shall be arranged such that the effects of errors are minimized. Methods such as limitation of adjustment ranges, unalterable software, non-interchangeable parts, and visible wear indicators shall be employed.

### 2.4.9 Hazard Identification

The Contractor shall identify all failure induced and normal operating (non-failure condition) hazards. Hazards shall be compiled into lists and submitted to the Engineer for review and approval during the design review.

The hazard lists shall be organized into a preliminary hazard list. [CDRL 02-022]

In addition to those hazards identified by the Contractor, the following hazards shall be included in the listings and shall be considered hazards of Category I or II severity:

- a. Emergency brake fails to apply when requested
- b. Service brakes fail to apply when requested
- c. Propulsion fails to cease when requested
- d. An axle speed varies significantly from train speed
- e. No motion detection system indicates no motion when the train is moving
- f. Door open spontaneously when not commanded by crew
- g. Doors open spontaneously when not commanded
- h. Door opens on wrong side of car
- i. Door closes on person’s limb and indicates door closed and locked to the control system
- j. Door interlocks erroneously indicate door is closed and locked
- k. Cab car operation responds in a permissive manner to a restrictive cab signal aspect
I. Excessive currents or overheated equipment cause a fire hazard

m. Indication of uncoupled when not uncoupled

n. Train moves in the wrong direction

o. Train speed and track curvature combine in such a manner as to cause a train to derail or a vehicle to overturn

2.4.10 Hazard Analyses

The Contractor shall perform a preliminary hazard analysis (PHA) on all hazards identified in the hazard lists developed above. This analysis shall demonstrate that the car conforms to the requirements of this Specification and that all identified hazards are either eliminated or reduced to levels of risk acceptable to SEPTA. [CDRL 02-023]

During the analysis process, the Contractor shall be responsible for the correction of those software hazards identified under TS 2.4.9.

All hazard analyses shall be adjusted or amended as required during the car design and construction.

The PHA shall be the basis of the hazard tracking log (HTL) which shall show the final severity and probability of each hazard at the vehicle level and the document, test, or analysis that shows that the mitigation justifies the final severity and probability. This would include FMECA, FTA, subsystem hazard analysis, or other analysis as approved by the Engineer. The HTL shall be updated and submitted every 90 days after CDP for review. [CDRL 02-024]

Analyses shall identify all maintenance errors that could result in unsafe conditions such as incorrect adjustment of sensors. Analyses shall also include design errors that could produce unsafe conditions such as an improper circuit breaker type or rating and temperature or environment dependent device selections.

2.4.11 Safety Certification

The Contractor shall provide a safety certification for the vehicle prior to the vehicle being delivered to SEPTA for testing and prior to being placed in revenue service. [CDRL 02-025] This safety certification shall include a list of any open items from the HTL and any restrictions in operation. The safety certification shall be updated as any open item is closed until all items are closed at which time a full safety certification package shall be submitted including all supporting documents (i.e. FMECA, FTA, etc.) for SEPTA’s records. [CDRL 02-026]
2.4.12 Software Safety

The system safety program shall include a software safety section which applies to any embedded or external software or firmware which controls or monitors safety critical functions. The requirements for software safety, which shall be in addition to the requirements of TS 17, shall meet or exceed the requirements of the SEPTA Software Safety Plan in accordance with 49 CFR 238.105, 49 CFR 228 Subpart E, and CENELEC Standard EN50128, Railway Applications: Software for Railway Control and Protection Systems especially Sections 8 through 17.

Software safety requirements shall treat software as an integral part of a hardware/software system. Functions accomplished through the use of software shall be considered safety critical unless an independent redundant hardware means is also provided to accomplish the same function.

Features of the software safety program shall include a description of how the following shall be accomplished: definition, implementation and oversight of the software design and verification process, integrity of the documentation, software hazard analysis, software safety reviews, software hazard monitoring, reporting and tracking, and software integration with hardware at each stage of the design and testing process for components, subsystems, systems, cars, consists, and trains incorporating software for safety critical functions.

2.4.13 Electronics Safety Requirements

The Contractor shall develop safety analyses (SA) per 49 CFR 229 Subpart E - Locomotive Electronics. These reports shall be submitted to the Engineer for review and approval [CDRL 02-027], and the Contractor shall support SEPTA throughout the FRA review of the SA. The Contractor shall provide documentation, training, and support as required by the approved safety analysis, FRA, and 49 CFR 229 Subpart E including:

a. Product testing results and record
b. Operations and maintenance manuals
c. Training and qualification program
d. Operating personnel training

2.4.14 Potentially Hazardous EM Fields

The car shall not produce any health hazard to the public, passengers, guide animals, train crew, or maintenance personnel. In this regard, the Contractor shall develop an EMF Hazard Control Plan which shall define all efforts from the initial car design phase to control/mitigate any potentially adverse EMF health hazard effects. [CDRL 02-028] The methodology used shall be based on sound systems engineering principles, and shall include analysis and measurements as necessary. It shall define acceptable worst-case exposure levels and applicable frequency ranges of interest, including both ELF and RF based on the car design and application. Analysis and measurement data from similar applications shall be utilized to the maximum extent possible. Recommendations and guidelines of applicable reports, and standard test procedures/limits shall be referenced including those of the EPA, FRA, and IEEE.
2.5 FAILURE MODE EFFECTS ANALYSIS

The Contractor shall perform a failure mode effects analysis (FMEA) to identify weaknesses in system hardware and software design and to analyze the modes and effects of failures whenever these details are not established by historical records of equipment operation. The FMEA shall provide input to system designs and to the safety analyses for theoretical circuit behavior, random component failures, electrical interference, systematic component failures, and software errors in software based logic. The FMEA and reliability and maintainability analyses shall be updated throughout the car design development. The Contractor shall identify all failure induced and normal operating (non-failure condition) hazards falling into severity Categories I, II, and III (as defined in MIL-STD-882). Hazards shall be compiled into a preliminary hazard list (PHL), subsystem hazard list (SSHL), and system hazard list (SHL) and submitted for approval to the Engineer. [CDRL 02-029] The following hazards shall be included in the listings and shall be considered hazards of Category I or II severity:

a. Emergency brakes fail to apply when requested
b. Service brakes fail to apply when requested
c. Propulsion fails to cease when requested
d. No motion detection system indicates no motion when train is moving
e. Door opens spontaneously when not commanded
f. Door opens on wrong side of car
g. Door closes on person's limb and indicates door closed and locked to the control system
h. Door interlocks erroneously indicate door is closed and locked
i. Excessive currents or overheated equipment cause fire hazard
j. Indication of uncoupled when not uncoupled
k. Train moves in wrong direction
l. Slide control does not reapply brakes after slide correction
m. Cars in train separate when not commanded
n. Train regenerates into dead section of catenary

The Contractor shall perform a hazard analysis on all hazards identified in the hazard lists. Analyses shall demonstrate that the car conforms to the requirements of this Specification and that all identified hazards are either eliminated or reduced to levels of risk acceptable to the Engineer. All hazard analyses shall be adjusted or amended as required during car design and construction.
The analysis methods shall be selected by the Contractor as appropriate for the system under evaluation and the category of hazard severity. Hazards of Category I and II severity shall receive analyses sufficiently rigorous to demonstrate that the hazard cannot occur under any reasonable conditions. The Contractor shall be prepared to demonstrate by test the validity of any portion of all analyses of Category I or II severity hazards.

Standard failure and safety analysis methods and published failure rates for components shall be utilized wherever possible. All electrical circuit failure mode analyses shall include a sneak circuit and dry contact analysis. All methods shall be submitted to the Engineer for review and approval. [CDRL 02-030]

Existing hazard analyses of subsystems may be submitted provided the analyzed subsystem is identical in all respects to that proposed including the operating environment, and the analysis method is sufficiently rigorous. Analyses or tests required by other Sections of this Specification such as structural analyses or fire penetration tests may also be submitted for consideration by the Engineer where appropriate. Analyses shall examine the car in the single car and train consist configurations and shall include circuit faults within the electrical circuits and also when coupled to other cars in SEPTA’s fleet.

Analyses shall identify all maintenance errors that could result in unsafe conditions such examples being, but not limited to, incorrect adjustment of sensors and incorrect adjustments of the door obstruction sensing system. Analyses shall also include design errors that could produce unsafe conditions such as an improper circuit breaker type or rating and temperature or environmental dependence on proper operation for use in checking designs.

### 2.6 ELECTROMAGNETIC COMPATIBILITY

The Contractor shall develop an EMC control plan for review and approval by SEPTA. [CDRL 02-031] This plan shall include all design techniques, features, laboratory testing, and field testing used by the Contractor to ensure EMC.

The Contractor shall develop an EMI safety analysis that evaluates and mitigates the hazards presented by the EMI to all onboard systems and all wayside systems. Special attention shall be given to the cab signal system and wayside signaling systems. [CDRL 02-032]

Except as otherwise noted herein, the car shall conform to EN50121-3-1 and all relevant components shall conform to EN50121-3-2.

#### 2.6.1 General EMC Testing

This testing consists of two (2) levels:

- a. Laboratory testing of each electronic subsystem on the car as a standalone test to verify emissions and susceptibility

- b. Field testing of the complete car to verify emissions and susceptibility
The purpose of the laboratory testing is to qualify each subsystem before it is installed in the vehicle. This is done at an early stage to allow time for design modifications if required. The field testing is used to qualify the entire car and ensure EMC with its operating environment.

### 2.6.2 Laboratory Testing of Each Subsystem

Each subsystem on the car capable of producing or being susceptible to EMI shall be subjected to the following tests:

- a. FCC Part 15.109 Radiated Emissions: this test shall cover 30 MHz to 6 GHz
- b. FCC Part 15.107 Conducted Emissions: this test shall cover from 0.15 MHz to 30 MHz
- c. IEC 61000-4-2 Electro-Static Discharge (ESD): performance criteria B shall apply
- d. IEC 61000-4-3 Immunity to Radiated Fields: this test shall cover from 80 MHz to 6 GHz. The test shall be done at 20 V/m and performance criteria A shall apply.
- e. IEC 61000-4-4 Immunity to Electrical Fast Transients (EFT): performance criteria A shall apply
- f. IEC 61000-4-5 Immunity to Surges: performance criteria B shall apply
- g. IEC 61000-4-6 Immunity to Conducted RF: performance criteria A shall apply

The Contractor shall generate detailed test procedures for each of the above tests and submit them for approval by SEPTA. [CDRL 02-033]

### 2.6.3 Field Tests of Car

The car shall be subjected to the following field tests to verify EMC with its environment. These tests must be performed at SEPTA and shall not be waived.

#### 2.6.3.1 Radiated Emissions

The Contractor shall generate a detailed test procedure and submit it to the Engineer for review and approval. [CDRL 02-034] This test procedure should use APTA-PR-E-S-010-98 as a guideline.

The following limits shall apply:

- a. 109 dBµV/m/MHz at 0.15 MHz, linear on log frequency plot to 85 dBµV/m/MHz at 30 MHz
- b. 58 dBµV/m/MHz from 30 MHz to 90 MHz
- c. 68 dBµV/m/MHz from 90 MHz to 6 GHz
- d. Measured at 50 feet from center line of rails
2.6.3.2 Inductive Emissions

The Contractor shall generate a detailed test procedure and submit it to the Engineer for review and approval. This test procedure should use APTA-PR-E-S-010-98 as a guideline. [CDRL 02-035]

The following limits shall apply: 100 millivolts RMS from 0 to 500 Hz and 20 millivolts RMS from 500 Hz to 20 kHz.

2.6.3.3 Cab Signal Interference (CSI)

The Contractor shall generate a detailed test procedure and submit it to the Engineer for review and approval. [CDRL 02-036]

The following limits shall apply: the maximum CSI measured at the output of the track receiver coils shall be a minimum of six (6) dB lower than the susceptibility level of the cab signal system as determined and verified by laboratory testing. In no cases shall it be higher than the following:

a. 90 Hz thru 103 Hz 300 milliamps maximum
b. 245 Hz thru 255 Hz 150 milliamps maximum
c. A minimum of six (6) dB lower than the susceptibility level of the cab signal system as determined and verified by on track testing with rail loop (axle) currents as follows:
   1) 90 Hz thru 103 Hz 500 milliamps maximum
   2) 245 Hz thru 255 Hz 250 milliamps maximum

2.6.3.4 Compliance to IEEE 519

The Contractor shall perform testing to verify that the car complies with IEEE 519 under all modes of operation including any permitted degraded modes.

2.6.3.5 Critical Frequency Zones

With respect to Amtrak drawing A-60-7659, Revision B, please note the following:

a. 90-103 Hz, 150-162 Hz, and 195-205 Hz not to exceed 0.6 A
b. 245-255 Hz not to exceed 0.3 A

These are very critical limits for the cab signal system and track circuits in the signal system and must be limited to the values shown.

In addition, the third and fifth harmonics of the above 300, 468, 500, 600, 750, 780, 1000, and 1250 Hz must be avoided to ensure the above levels are not exceeded anywhere in the critical ranges specified above.
In addition, note the requirement for levels not to exceed 0.03 A (30 mA) in the range 500-7000 Hz. This requirement includes the not to exceed levels for the third and fifth harmonics listed above as well as a host of longer range audio track circuits with frequencies interspersed between the specific harmonics listed.

Finally, >7KHz (7000 Hz) there are shorter range overlay track circuits where levels must not exceed 0.004 A (4 mA).

### 2.6.4 Test Procedures
All test procedures must be submitted to the Engineer for review and approval prior to any formal EMI testing. [CDRL 02-037]

All test procedures must contain, as a minimum, the following items:

a. Complete listing of all test equipment and instrumentation used in the testing

b. Block diagrams, schematics to illustrate the interconnections between the unit under test to the test equipment and instrumentation

c. A step by step instruction of the test set up and conditions for each test

d. Pass/fail criteria

### 2.7 RELIABILITY
The Contractor shall prepare and maintain a reliability program plan. The plan shall require that a reliability analysis be performed for each component, system, and the complete car type. The reliability analysis shall list each component’s generic type and base failure rate using handbook data or operating experience.

The reliability program plan and a preliminary reliability analysis shall be submitted within 90 days from the Notice to Proceed. The reliability analysis shall be updated during the vehicle design process to correspond to design changes that affect reliability. [CDRL 02-038]

The Contractor shall establish a database to monitor the reliability of the cars, measured as Mean Distance Between Failures (MDBF) or Mean Time Between Failures (MTBF), the latter as measured by the car’s elapsed time meter.

a. The overall fleet average MDBF shall be no less than 10,000 car miles.

b. The ATC/PTC system shall have a MDBF of 100,000 miles.

c. The auxiliary power system (all voltages) shall have a MDBF of no less than 100,000 car miles.

d. The heating and air conditioning system shall have a MDBF of no less than 50,000 car miles.
e. The door system and controls shall have a MDBF of no less than 60,000 car miles.

f. The compressed air supply and friction brake system shall have a MDBF of no less than 60,000 car miles.

For each of the equipment categories described above, the stated reliability requirements shall be met by only those components necessary to produce normal car operation. Components whose sole function is an auxiliary one, such as data logging, fault annunciation, etc., shall not have their failures counted against the basic system performance. An average operating speed of 27.5 mph may be used for design calculations.

For the above, a chargeable failure shall be defined as any equipment related occurrence considered by SEPTA’s Railroad Division as rendering the car unfit for service; or as any maintenance action requiring repair or replacement of any subsystem or whole-vehicle component which is not an approved consumable item (or which is approved as being a consumable item but is not achieving its design service life) and which failure has not either been due to a failure occurrence in equipment of another subsystem, or due to failure of SEPTA to perform the recommended preventive maintenance actions, vandalism or physical mistreatment at a human interface, operating or weather conditions of unusual aspect or severity beyond those noted in TS 2.2.5, or due to accident. The term “unusual aspect or severity” shall be understood to mean a conditions that does not occur on the SEPTA Railroad Division at less than 10 year intervals. The time, place or type of service operated by the car at the time of a failure shall not be of any consequence.

### 2.8 Availability

Six (6) months after acceptance of the first car, vehicle reliability and vehicle maintenance requirements shall be such that fleet availability shall exceed 90 percent at 5 a.m. daily where availability is defined as:

\[
\text{Availability} = \frac{\text{Available cars}}{\text{Total number of cars in the fleet}}
\]

Available cars are all cars which are not removed from service for unscheduled maintenance or repairs.

### 2.9 Maintainability

The cars shall be designed and constructed to meet specified maintenance requirements.

The use of modules, self-diagnostics, quick disconnects, and similar devices shall be maximized to facilitate component exchange and off vehicle repair of defective components.

Equipment layout and access points shall be coordinated to provide ready access for maintenance and inspection purposes.
The Contractor shall show during design reviews the layout and ease of maintainability of each item on the car to ensure Specification compliance. The areas of high failure probability (high stress voltages, current or mechanical devices, etc.) shall be designed to limit the failure damage to a confined area and not to affect other equipment or devices. SEPTA reserves the right to witness the installation and removal of equipment. An equipment accessibility review shall specifically be included in the FAI (first article inspection). Access to major components and items such as the transformer shall be designed for ease of replacement.

The Contractor shall submit a maintainability program plan which defines the design efforts that shall be made to accomplish the manufacture of a car with reduced maintenance time for major systems, subsystems, or critical components. The maintainability program plan shall be submitted within 90 days from Notice to Proceed. [CDRL 02-039]

### 2.10 CONTRACT DELIVERABLE REQUIREMENTS LIST

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3 CARBODY EXTERIOR

3.1 GENERAL

3.1.1 Scope
This Section describes the carbody structural functions and design requirements including, but not limited to, finish, strength, construction, materials, and fastening. Car sides shall be flat; the roof shall be corrugated. The design and construction of the cars shall comply with the applicable requirements of FRA Regulations and APTA Standards and Recommended Practices. Where there is a conflict, the most restrictive shall apply. With regards to APTA-PR-CS-S-034-99 Revision 2, Section 5.5.2.3, the torsional capacity of the coupler installation could be equal to or greater than that of the existing SEPTA cars with a similar type coupler arrangement.

The cars shall be easy to clean and maintain using SEPTA’s existing equipment, procedures, and practices, and shall include considerations for the safety of the car occupants including the crew and maintenance personnel. The design shall provide for the maximum possible ease and safety of passage from car to car through the end doors. The design of the car shall facilitate cleaning and maintenance tasks. Crevices, pockets, and hidden areas, where dirt and debris can accumulate, shall not be allowed in the design. Exposed corners shall be rounded and all edges shall be de-burred. Details of the design arrangement and installation of the carbody equipment and apparatus shall be submitted to the Engineer for review and approval. [CDRL 03-001]

3.1.2 Arrangement
Apparatus requiring frequent inspection or attention shall be readily accessible and replaceable. Apparatus requiring attention more frequently than every 180 days, or in emergencies, shall be accessible from the side of the car or in a location approved by the Engineer. All other apparatus shall be arranged to provide ready access from maintenance pits and/or from the side of the car and/or from access panels in interior locations approved by the Engineer. Large apparatus shall be capable of convenient replacement by a forklift truck from the side of the car or by overhead crane through appropriately sized roof access panels. The Contractor shall supply, at no additional cost, all special material handling equipment required for car mounted apparatus, such as lifting and storage frames for HVAC units and lifting rigs for air reservoirs. The frequency of required service shall determine the degree of accessibility.

Apparatus supports and housings shall be incorporated into the underframe structure, equipment compartments, and equipment lockers so that the maximum usefulness of metal is obtained, and that the apparatus, as supplied by the manufacturers, may be mounted interchangeably. Apparatus supports shall comply with APTA-PR-CS-S-034-99 Revision 2, Standard for the Design and Construction of Passenger Railroad Rolling Stock, Section 5.7, Equipment Attachment.
All protective devices on the car that are not specifically required to be located inside the carbody, or to have provisions for resetting from within the carbody, shall be located undercar at the side or in the overhead equipment compartments. Provision shall be made for access to such devices without encroaching upon the clearance limit outline. For purposes of this paragraph, protective devices shall include air brake cut outs, circuit breakers, fuses, latching protective relays, and other devices requiring replacement or resetting to move the car or cause auxiliaries to function. Locations for all protective devices shall be identified on arrangement and installation design drawings. [CDRL 03-001]

3.1.3 Finished Edges

The Contractor shall ensure that all surfaces are free from surface defects, sharp edges, corners, and protrusions at any place where passengers, crew, or maintenance personnel may come in contact. All corners shall be rounded and edges shall be qualified in accordance with the Underwriters Laboratory Standard UL 1439, Standard for Test for Sharpness of Edges on Equipment. This requirement shall apply to equipment or components furnished by suppliers as well as to the Contractor’s own manufacture. Alternatively, workmanship samples, identifying edge sharpness criteria for specific applications, may be proposed for approval by the Engineer.

All metal used in the fabrication of the carbody structure and its associated parts shall comply with the requirements of TS 17.

3.1.4 Operating Position

The F-end of each cab car shall be equipped with a full width Operator’s cab, having the control console located on the right side. The cab shall be separated from the passenger compartment by a wall with a hinged lockable door. Controls for operating the train and all doors shall be located within the cab as described in TS 7 and shall be accessible by standard SEPTA keys.

The cab and associated apparatus shall be designed to meet, as a minimum, the noise requirements of TS 2.3.

The cab shall be air conditioned and completely sealed to present an area completely free from the outside environment.

3.2 STRUCTURE - MATERIALS

3.2.1 General

The carbody, except for the underframe, shall be constructed of stainless steel. All welding shall conform to the requirements of TS 17. All material used in the car shall conform to the requirements of TS 17 as appropriate to the design and materials used.

All stainless steel elements of the carbody, which are connected to other members by welding, shall be constructed of AISI type 301L stainless steel with carbon content not exceeding 0.03 percent, as specified in TS 17.3. Stainless steel parts, attached to other parts by mechanical fasteners, may be constructed of AISI types 201, 202, 301, 302, 304, 316, or 430 stainless steel.
Low alloy high tensile steel (LAHT) shall be used for the end underframe assembly as described in TS 3.3.2. The use of LAHT steel shall comply with all of the requirements of TS 17.4.

Each production shell shall be serialized with a serial number at the forward most jacking pad, visible from the side of the car.

### 3.2.2 Exterior Finish

All exterior surfaces of the carbody shall be unpainted stainless steel with a grit finish unless otherwise specified in this Specification. The Contractor shall provide and apply the exterior graphics package to the carbody per TS 1.5. The exterior graphics package shall include all FRA and APTA required and recommended signage. SEPTA and the Contractor shall jointly develop the configuration of the exterior graphics.

On each end of each car adjacent to the intercar jumper receptacle, the Contractor shall provide a permanently mounted instruction diagram showing the correct interconnection of all trainline jumpers. The Contractor shall submit details of the graphics package and its installation to the Engineer for review and approval. [CDRL 03-002]

Cosmetic aspects of the carbody are of great importance to SEPTA. The Contractor shall be responsible for manufacturing techniques to fabricate flat carbody surfaces. All sheet metal exposed to view (side, end, and roof sheathing) shall be as smooth as possible on the outside with a maximum variation from a straight line on flat surfaces, measured in any direction, of 0.0984 inch (2.5 mm) gradual discontinuity over 36 inches and 0.0625 inch (1.5 mm) within a distance of 12 inches on the sides of the car. For the roof, deviations of 0.1875 inch (4.7 mm) over a 36 inch span and 0.125 inch (3.2 mm) over a distance of 12 inches will be allowable provided the area involved cannot be seen from the platform level. For conditions where discontinuities within the flatness form have wave or rippling effects, acceptance criteria shall be based on not exceeding 0.0625 inches (1.5 mm) within the patterned area under any distance. The Contractor shall also control and properly support large assemblies during repositioning, lifting, storing, or moving such assemblies so as not to cause flexing that will enable or cause distortions or unflat conditions of the assembly to occur. These requirements apply from production through to when the vehicle is in the ready to run condition. Dents, gashes, or other surface imperfections shall not be permitted.

The required appearance of exposed welds shall be as described in TS 3.3.1.3. Three (3) samples of all exterior finishes shall be submitted to the Engineer for approval; this includes samples of 2B (bright cold rolled) and 120 grit scratch finishes and samples of all exposed resistance welding conditions illustrating the various metal build ups and configurations. [CDRL 03-003] If proposed, samples of exposed butt joints and finished arc welds shall be included. These samples shall be used throughout the program to maintain quality.

Resistance weld samples shall include a minimum of six (6) welds and shall be 8 1/2 inches by 11 inches in size. [CDRL 03-004]
All samples approved by the Engineer shall be permanently marked as to application, date of approval, and Specification requirements and be kept by the Contractor in a sample file for reference throughout the Contract as required.

Patented lockbolts may be substituted for rivets, if approved by the Engineer, provided it can be shown that they are applicable in each situation, and they have the required strength. All rivets and lockbolts shall be set with power tools; no hand riveting is permitted. Patented lockbolts must be set with power setting tools recommended by the manufacturer of the lockbolt.

Where riveting is proposed, samples of each type and size of joint shall be submitted to the Engineer before work commences. These sample joints shall be made from representative construction materials. Countersinking and dimpling samples shall be made with the same tools proposed for construction. Rivets and riveting tools shall be the same as proposed for construction.

Finish appearance is of great importance. Prior to the release of the manufacturing drawings, finish samples of every gauge combination and of every rivet style, type, and size shall be submitted to the Engineer for approval. [CDRL 03-005] These samples shall be used throughout the program to maintain quality.

Where welding and riveting are used in combination, the Contractor shall show that the strength of the joint has not been compromised by the combination of fastening methods. In general, rivets or bolts in combination with welds shall not be considered as sharing the stress, and the welds shall carry the entire stress for which the connection is designed (reference AWS D1.1, Section 2.6.7).

### 3.3 CARBODY STRUCTURE ARRANGEMENT AND DETAILS

#### 3.3.1 General

Materials used in carbody construction shall be in accordance with the provisions of TS 3.2 and TS 17.

The car structure shall be designed as a modified girder, using the roof and the floors as the chord members, connected by the sides, which shall carry the shear. The car shall be designed and constructed so that, for the life of the car, the camber between bolsters will be positive, but not in excess of 1/2 inch under AW1 load, and shall not be less than zero under AW3 load. Refer to TS 2.2 for the definition of passenger loads.

Carbody camber shall be defined as its vertical curved shape as viewed in side elevation. Carbody camber shall be a smooth arc from end to end of the carbody, and shall be measured from a datum line drawn between the intersection of the arc with the centerline of the body bolsters to a line tangent to the arc midway between bolsters. The maximum difference between the camber of each side sill measured at the location of maximum deflection shall not exceed 0.125 inch.
A sufficient number of jigs, fixtures, and templates shall be used to assure interchangeability of components and uniformity of structure throughout the fleet. Such parts of the bodies, as underframes, side frames, end frames, and roofs, shall be built on jigs. All weld and bolt patterns shall be identical on all cars. All equipment hangers shall be interchangeable on all cars without the use of shims or elongated holes.

The design load requirements of this section shall be analyzed and included in the stress analysis as required by TS 3.8.5. The analyses submitted shall not be limited to only those where specific reference to the analysis is provided.

### 3.3.1.1 Structural Connections

All connections between structural members shall be capable of developing the full strength of the weaker member. The anchor rod bracket specified in TS 3.3.13 is a permitted deviation.

All overload requirements (loads over normal operating conditions) shall be analyzed as specified and then reanalyzed with the load magnitude increased until calculations show that structural member crushing has commenced. It shall be shown that the connections of the primary structural members have not failed. The specified overload conditions shall include the end sill, coupler, collision posts, corner posts, truck to carbody connection, and bolster anchor bracket loads.

Rivets or bolts, used in combination with welds in a structural connection, shall not be considered as sharing the load with the welds. When used in a structural connection, welds shall be designed to carry the entire load across the connection as required by AWS D1.1, Section 2.6.7.

All mechanically fastened connections shall be designed using a factor of safety of two (2) based on the proof load of the fastener. Clamping force friction shall be ignored in the design and analysis of mechanically fastened connections.

There shall be no attachment to the primary carbody structure by welding subsequent to completion of primary carbody structure manufacturing procedures. An exception shall be made for hangers’ resistance spot welded for attachment to the web of a beam. Welding to the end of such hangers, at a distance 0.8 inch (20 mm) or more from primary structure, shall be permitted.

Intermittent fillet welds on tension members shall be prohibited. Plug or slot welds on tension members and intermittent groove welds shall be prohibited. Stud welding to the carbody structure shall not be permitted. Stud welding to non-load carrying stiffeners and secondary structure shall be permitted when approved by the Engineer.

Self-tapping screws shall not be used for structural connections. With the exception of the attachment points for floor panels, interior panels, and trim, there shall be no tapped holes in the car structure. Tapping plates may be used, and if used shall be attached to the car structure with mechanical fasteners unless consideration of reduced material properties and stress concentrations have been considered in the original design and analysis.
Structure with tapped holes shall meet the following requirements for tapping plates. The tapping plate shall be equal to or greater in thickness than the diameter of the bolt for which the tapping plate is intended, and a clearance hole shall be drilled in the structure for the bolt. Tapping plates shall be designed to the same strength standards as the equivalent nut.

Rivets, blind rivets, and lockbolts shall be set with power tools. All holes for mechanical fasteners shall be clean and free of burrs. The Contractor shall devise a method for removing the burrs on the far (blind) side of a blind rivet hole and a method for its inspection.

3.3.1.2 Exposed Rivets and Lockbolts

Exposed exterior rivets or lockbolts shall have flush heads in dimpled or countersunk holes. Any rivets exposed to the exterior shall be self-sealing. The head of the fastener shall be flush on the outside surface. The rivets or lockbolts shall be arranged in regularly spaced patterns. Rivets and lockbolts shall be stainless steel. When used in contact with aluminum, stainless steel rivets or lockbolts shall be coated with zinc chromate, or approved equal, before installation. Where possible, only the head and the shank of the rivet or bolt shall be in contact with the aluminum part when secured in place. Suitable bushings may be used in lieu of the zinc chromate paste. Structural calculations shall include the reduced cross section in areas that are drilled and countersunk.

3.3.1.3 Exposed Welds

Exposed exterior spot welds, located in the unpainted surfaces on the sides and ends of the cars, shall be arranged in regularly spaced patterns. All other exposed welds shall be sufficiently finished to be unnoticeable except by close visual inspection.

3.3.1.4 Floor Level

The difference in height of the four (4) corners of the finished car shall not exceed 3/8 inch measured at the end sills with the suspension air springs both inflated and deflated. The measurement shall be made on the completely assembled and equipped car mounted on its completed trucks. The measurement may be made from any suitable structural member of the underframe.

3.3.1.5 Carbody Strength


In the selection of the type and thickness of material to be used, the Contractor shall be guided by the need to attain the maximum strength and reliability with the minimum weight obtainable at reasonable cost.

The framing and sheathing of the carbody shall form an integrated structure capable of resisting, without permanent deformation or fatigue failure, the buffing and other stresses inherent in the type of service for which the cars are intended.
The carbody strength shall be sufficient to permit operation with up to AW3 loading for the design life of the car without structural damage including fatigue cracks. The carbody shell shall meet the static and dynamic strength requirements stated in this section.

The carbody structure shall be designed to absorb the kinetic energy of the collision impact to minimize passenger accelerations. The carbody shall be designed for a controlled crush starting at the ends of the car.

The Contractor shall base its structural design on the specific loads, deflections, and properties of structural sections called for in this Specification. For structures not specifically covered by this Specification, the Contractor shall base its design on its experience, subject to successful stress analysis and structural testing, and the approval of the Engineer. The structure and equipment supplied shall resist the specified loads with load factors consistent with those which have been shown to be successful for railway passenger equipment.

The stress analysis shall show that in no case shall the stress be greater than the following with the appropriate load factors applied:

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<td>1) Allowable fatigue stress range at the appropriate vertical load variation with seated passenger load (see Item c, Notes 1 and 2):</td>
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<td>2) Ultimate load carrying capacity of the member’s stress (see Item c, Note 5):</td>
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<td>b) Asymmetrical jacking (see Item c, Note 3):</td>
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<td>b. Allowable shear panel stresses shall be the ultimate load carrying capacity of the members (see Item c, Note 5):</td>
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<td>1) Normal maximum vertical carbody loading: (See Item c, Note 1):</td>
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<tr>
<td>2) Symmetrical jacking at jack pads and at coupler carriers (see Item c, Note 2):</td>
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</tr>
<tr>
<td>3) Asymmetrical jacking (see Item c, Note 3):</td>
<td>1.0</td>
</tr>
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c. Notes:

1) At 10,000,000 cycles for ferrous materials.

2) All jacking conditions shall be based on an empty carbody with trucks attached.

3) Asymmetrical jacking conditions shall be based on the most outboard diagonally opposite jack pads with trucks attached.

4) Allowable fatigue stress of welded elements shall be determined from AWS D1.1. Where insufficient information is available due to the lack of published data on this subject, the allowable fatigue stress shall be determined experimentally by the Contractor.

5) Stability calculations of stainless steel elements shall include consideration of the effects of the anisotropic behavior of stainless steel, and of reductions in elastic moduli with increasing stress. Calculations shall follow the methods described in Lincoln and Watter's Strength of Stainless Steel Structural Members as Function of Design, or the AISI Stainless Steel Cold Formed Structural Design Manual, or the ASCE Specification for the Design of Cold-Formed Stainless Steel Structural Members (with safety factors modified as noted above), or another method acceptable to the Engineer.

The completely equipped carbody shall be designed to carry its AW0 carbody weight (not including truck weight) plus a uniformly distributed passenger load equal to the passenger portion of AW3. The stresses in the carbody under an applied AW3 load less the truck weight load shall not exceed the lesser of 50 percent of the guaranteed minimum material yield strength or the buckling strength.

Notwithstanding the previous paragraph, for each joint design, the static stress at the AW3 carbody load shall be less than the stress that determines the allowable fatigue stress range.

The allowable fatigue stress range shall be computed by multiplying the static stress at the AW3 load by the dynamic factor (fatigue load range). This stress range shall be within the design fatigue stress range (fatigue limit) obtained from AAR C-II, Section 7.2, or AWS D1.1 for non-redundant or redundant structures as applicable and as approved by the Engineer. [CDRL 03-006] The bolster, its connections to the carbody and truck, the side frame local to the bolster, and the coupler support and its connections shall be considered non-redundant.

The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for joint designs not covered by AAR C-II, Section 7.2, or AWS D1.1.

The dynamic factor shall be determined by the Contractor and shall not be less than ±20 percent. The fatigue design shall be based on applied and allowable fatigue stress ranges at 10 million cycles.

The natural frequency of the carbody under AW3 load supported at the secondary suspension points and modeled as a free-free beam shall be not less than 2.5 times the natural frequency of the car’s secondary suspension system. An analysis of the natural frequency of the car shall be submitted as required. [CDRL 03-007]
3.3.2 Underframe Structure

3.3.2.1 Underframe

The underframe assembly shall be composed of the center sill (if used) end underframes, floor beams, sub-floor, cross bearers, and body sills. All parts of the underframe shall be constructed of stainless steel or low alloy high tensile steel except the end underframes which, in all cases, shall be constructed of low alloy high tensile steel.

Alterations to the underframe, such as drilling, cutting, welding, heating, burning, etc., during fabrication assembly not previously incorporated on the drawings, is expressly forbidden without the written approval of the Engineer.

With an evenly distributed AW3 load, no cross bearer shall deflect more than 0.125 inch between the center and side sill, and the floor panels shall not deflect more than 1/250 of their span between floor beams.

The underframe shall also include supports for seat and floor installations for both the lower and intermediate levels of the car. Floor panel arrangements shall be longitudinal end-to-end applications consisting of a stainless steel “hat section” configuration member acting as a seat pedestal support member and framing for floor panel installations. Placement shall be based on the standard pedestal location requirements based on a 3x2 arrangement as defined in TS 4.2.2.

Where seats are to be mounted, within the “hat” of the hat section, a full length tapping plate capable of meeting the minimum strength requirements of ASTM F594, Grade 5 nuts shall be permanently affixed to the support’s surface for engaging seat pedestal mount bolts.

The tapping rails shall be equidistant from the car’s longitudinal centerline to allow for the application of diverse seat types. The tapping rail hat section side profile prior to the surface of the flange shall be the thickness of the floor panels as outlined in TS 4.5.1 in addition to a single strip of elastomeric tape at the panel’s mounting surface after being fully secured by a countersunk screw fastener.

The hat section shall be attached to the top of the floor beams and designed to support as well as fasten the ledges of the center and side floor panels. The hat section shall be of a gauge as to provide a rigid, tap-able surface capable of supporting the floor panel and securing fasteners.

Where hat sections span across floor beams, and potentially along the side structures supports, a shim of the same thickness of the hat section flange shall be installed to create a level surface for floor panel installations. No step-downs due to flange thicknesses shall be allowed.

Additional floor panel supports shall be added as necessary to assure that no open span of more than 23 inches is unsupported. Any supports shall be directly grounded to the structure and not bridged.
3.3.2.1.1 End Sill Compression Load

Under an end compression load equal to a minimum of 500,000 pounds applied longitudinally over an area no larger than 6 inches high by 24 inches wide and centered vertically and horizontally on the end sills of a carbody loaded to AW0, the following conditions shall be met:

a. There shall be no permanent deformation in any structural member, including sheathing, the anti-climber, and its fasteners.

b. The maximum stress in any material outboard of the bolster attachment shall not exceed the lesser of yield or critical buckling stress. The maximum stress in any material inboard of the bolster shall not exceed 80 percent of the lesser of yield or critical buckling stress.

c. The Margins of Safety shall progressively increase from the ends of the carbody to the center. At no point inboard of the coupler anchor shall the Margin of Safety be less than the lowest Margin of Safety (greater than or equal to one (1)) of outboard of the coupler anchor. The maximum stress outboard of the bolster attachment shall not exceed yield stress. The maximum stress inboard of the bolster shall not exceed 80 percent of the yield stress.

d. The vertical deflection of each side of the shell, with respect to the body bolsters as measured by test, shall not differ from the analytically determined value by more than \(\pm 10\) percent. The points to be measured shall be at the outer bottom edge of the side sill.

3.3.2.1.2 Coupler Compression Load

The carbody shall meet the standard for carbody end compressive strength of APTA-PR-CS-S-034-99 Revision 2.

Under an end compression load equal to 800,000 pounds applied longitudinally to the line of draft of a carbody loaded to AW0, there shall be no permanent deformation in any structural member including sheathing. In addition, the following criteria shall be met:

a. There shall be no permanent deformation in any structural member including sheathing, the anti-climber, and its fasteners.

b. The maximum stress in any material shall not exceed the lesser of the yield or critical buckling stress.

c. The Margins of Safety shall progressively increase from the ends of the carbody to the center. At no point inboard of the coupler anchor shall the Margin of Safety be less than the lowest Margin of Safety (greater than or equal to one (1)) of outboard of the coupler anchor. The maximum stress outboard of the bolster attachment shall not exceed yield stress. The maximum stress inboard of the bolster shall not exceed 80 percent of the yield stress.

d. The vertical deflection of each side of the shell, with respect to the body bolsters, shall not differ from the analytically determined value by more than \(\pm 10\) percent. The points to be measured shall be at the outer bottom edge of the side sill.
3.3.2.2 End Underframe

An end underframe unit, including but not limited to the body bolster, draft sill, end sill, draft gear pocket, coupler support structure, and collision post stubs (see also TS 3.3.6.1), shall be provided at each end of each car and shall be fabricated of low alloy high tensile steel conforming to the requirements of TS 17.4. The end underframe shall be assembled by arc welding in accordance with TS 17.22 using complete penetration groove welded joints. The use of prequalified welding procedures, per AWS D1.1, is permissible.

The end underframe assembly shall be heat treated after welding if required for stress relief or to attain the required strength level.

Approved drainage shall be provided for all cavities to preclude the retention of water. All cavities shall be painted after welding and heat treating.

The end underframe weldment shall provide for continuity of flanges and webs at any place where load-bearing members intersect. The end underframes shall be designed so that in case of excessive impact, failure shall be by the buckling or crushing of structural elements rather than by the shearing of structural elements or by failure of connections between elements.

The end underframe shall be constructed of LAHT, assembled by arc welding in accordance with TS 17.22 and AWS Structural Welding Code D1.1, using AWS prequalified complete joint penetration groove welded joints, as defined by the AWS Structural Welding Code D1.1, wherever primary loads are carried across the joint in tension or compression. The AWS prequalified partial joint penetration groove welded joints may be used where primary loads are carried in shear along the length of the weld. Fillet welds may be used in joints which do not carry primary loads.

If heat treatment is required for stress relief, the assemblies shall be heat treated after welding in accordance with AWS D1.1 Section 5.8.

In order to avoid difficulties in attaching the light gauge floor pans to heavy underframe members, brackets or clips may be provided on the underframe for subsequent attachment of floor pans.

3.3.2.2.1 End Sill

The end sill shall include the buffer beams, the anti-climbing arrangement, and the collision post stubs and shall be securely attached to the collision posts, side sills, and the draft sill. The collision post stubs shall extend down to the bottom plate of the end sill and shall be securely welded to both the top and the bottom plates.

The end sill shall be designed to transmit the required anti-climber, end sill, and coupler loadings into the collision posts and draft sill without exceeding the yield strength of the end sill structure. It shall also be capable of transmitting into the draft sill, without failure of the end sill structure, the loading and bending moments which can be applied by the collision posts when they are loaded at 18 inches above the floor to their ultimate bending strength, and when they are loaded just above the floor to the ultimate shear capacity of the collision post/stub post combination.
The coupler, support structure, buffer beam above the coupler, and its attachment of the end underframe shall withstand a 100,000 pound vertical load in either direction for any horizontal position of the coupler, without permanent deformation of the coupler and support structure and supporting structure in the end underframe or otherwise without ultimate failure.

### 3.3.2.2 Anti-Climbing Mechanism

An anti-climbing arrangement shall be provided at each end of each car designed so that coupled cars under full compression shall mate in a manner so as to cause each car to resist climbing the other. The cab end and the non-cab end anti-climbing arrangements shall be in conformity with 49 CFR 238.205. If the coupler is to provide any part of anti-climbing resistance, it shall also meet the load required in 49 CFR 238.205.

An analysis of the anti-climbing arrangement(s) shall be included in the stress analysis required by TS 3.8. The analysis of the anti-climbing mechanism shall include an analysis of the attachment of the coupler/draft gear and draft gear carrier plate to the underframe.

### 3.3.2.3 Coupler Carrier

A coupler carrier shall be provided as part of each end underframe assembly and shall be designed in accordance with the applicable FRA requirements as specified in TS 3.3.1 and shall meet the requirements of 49 CFR 238.207. In addition, the coupler carrier, and those portions of the carbody to which it is attached, shall be designed to withstand the loads caused by supporting one end of the car on the coupler carrier with the truck attached such as might occur during emergency jacking or lifting with a crane in the event of a derailment. Under this coupler carrier load, the allowable design stress of the coupler carrier, or any part of the carbody structure to which it is attached, shall be the yield, critical buckling stress, or 80 percent of the ultimate, whichever is lower.

The coupler carrier element on which the coupler shank slides shall have a non-metallic wear plate, manufactured of Nylatron or Gatke material or approved equivalent. This part and its supporting springs shall be interchangeable among cars.

Provision shall be made for safely lifting the extreme ends of the cars with a crane in the event of a derailment. The carbody structure shall be designed to permit lifting both ends of an empty car simultaneously with trucks attached without damage or yielding on any part of the car. Lifting eyebolts shall be able to be attached to the buffer sill for this purpose in a manner similar to that used on SEPTA cars. Lugs for lifting the car shall also be provided at the top of the collision posts at each end of the car. The Contractor shall demonstrate this lifting procedure during the pilot car inspection. The procedure and design shall be submitted to the Engineer during the design review of the car for his approval. 

[CDRL 03-008] Four (4) car sets of eyebolts and fitting hardware shall be provided as part of the Contract.
3.3.2.2.4  Collision Post Shear Reinforcement

If reinforcement is used to provide the specified collision post shear strength at the floor, it shall be designed to transmit the specified shear and other loads into the end underframe. The cab end reinforcement shall be continuous from the bottom of the end sill up to at least 30 inches above the top of the underframe, then gradually taper to a point not less than 42 inches above the top of the end sill. The non-cab end reinforcement shall be continuous from the bottom of the end sill up to at least 18 inches and then taper to a point at 30 inches.

If shear reinforcement is not used, the stainless steel post shall be arranged to penetrate the end underframe unit and weld to the top and bottom plates of the end underframe unit.

The connections and supporting structure at the tops of the collision posts shall be designed to develop sufficient horizontal, vertical, and bending strength, so that if one or both posts, whichever is more critical, is overloaded in bending to ultimate strength, the post top connections and supporting structure, if stressed beyond their yield strengths by the resulting horizontal, vertical, and bending loadings, shall deform plastically by buckling and bending the members to accommodate the post plastic bending failure. The ultimate strength of the connection fasteners and welds shall be sufficient to prevent their failure, even with severe plastic deformation of the collision posts and the top connecting and supporting structural elements.

Overload of the collision post bottom connections shall result in the buckling and crushing of the underframe structural members to which the collision posts and any collision post reinforcements are attached, rather than by shearing or fracturing of the posts.

3.3.2.2.5  Body Bolster

The body bolster shall be designed to transmit loads between the truck and the carbody and between the draft sill and the body and side sills. The design shall provide clearance for the truck in all positions and accessibility for truck maintenance and detrucking. Positive stops shall be provided on the carbody and truck bolsters to limit the vertical and transverse movement of suspended trucks when the carbody is lifted. The stops shall meet the recommended practice of APTA-PR-CS-S-034-99 Revision 2.

The design and construction of the bolster shall consider the high fatigue environment in which it will be operating. If backing strips are used in one sided full penetration arc welds in members subjected to tension fatigue, the backing strips shall be removed after welding. A fatigue resistant design shall be a prime requirement of the body bolster structure.

3.3.2.2.6  Draft Sill

The draft sill shall extend longitudinally from the end sill to the body bolster and shall include the coupler support structure. It shall be designed to transmit the specified longitudinal loadings from the anti-climber and coupler into the body bolster.
3.3.2.3 Corner Post

A structural post shall be installed at each corner of the car. The corner posts shall meet the requirements of APTA-PR-CS-S-034-99 Revision 2, and 49 CFR 238.213. The posts shall be continuous from the bottom plate of the end sill to the roof. The posts shall be connected to the top and bottom plate of the end sill, side frame, roof structure, and intervening structural shelves. The attachment of each corner post at the bottom shall be sufficient to develop its full shear value. If reinforcement is used to provide the shear value, such reinforcement shall have full value from the bottom of the end sill for the cab end corner posts to 30 inches above the top of the end sill, then taper to a point not less than 42 inches above the top of the end sill connection. For the non-cab end corner posts, the reinforcement shall have full value from the bottom of the end sill to 18 inches above the top of the end sill, then taper to a point not less than 30 inches above the top of the end sill connection. The overloading of the corner posts, at the level of the top of the end sill, shall result in the buckling and crushing of the underframe members to which the posts are connected rather than the shearing off of the posts themselves. The trap door may be considered in its lowered position to reinforce the corner structure as listed in TS 3.4.2. If designed to do so, the design shall be approved by the Engineer.

The corner post shall be connected to the side frame, end frame, and roof structures such that the yield strength of the connections and the supporting structure will not be exceeded when the corner posts are loaded to their yield strengths as described above. In addition, the roof and roof connections shall resist without failure the top load of the corner post, when the corner post load is increased to the ultimate bending strength of the post.

The corner posts shall be continuous closed sections, from the bottom of the end sill to the roof, unless shear reinforcement is used. If shear reinforcements are used, the corner posts shall be welded to the shear reinforcement at the floor, to the intermediate side frame rails and sheathing, and to the roof rails to develop the full strength of the posts.

3.3.2.3.1 Corner Post Load 18 Inches Above Floor

Each cab end corner post shall resist, without yielding or exceeding the critical buckling stress, an inward load of 100,000 pounds applied in any direction from longitudinal to transverse, at the level 18 inches above the end sill connection. Each non-cab end corner post shall resist a load of 30,000 pounds applied in the same manner.

The connections of the posts to the supporting structure and the supporting structure itself shall develop the ultimate load carrying capacity of the posts. If the posts are designed to support more than the specified capacity, the supporting structure shall be strong enough to support the increased capacity of the posts; the posts shall fail before the supporting structure.

3.3.2.3.2 Corner Post Shear Load at Floor

Each cab end corner post shall have an ultimate shear value of not less than 300,000 pounds at a point even with the top of the end sill to which it is attached. The load application shall be inward in any direction from longitudinal to transverse in a horizontal plane. Each non-cab end corner post shall have an ultimate shear value of not less than 150,000 pounds applied in the same manner.
The shear value shall be based on the depth of the web in the direction of the applied load, which is the depth of the member times the web thickness. In cases where the load application is not in the direction of the web, the load shall be divided into vector components parallel to web elements, and the shear value calculated for each element.

3.3.2.3 Corner Post Strength Along Its Length

The load carrying capacity of the corner post, when loaded anywhere from the top of the underframe to the roof in a horizontal plane any direction from longitudinal to transverse, shall be a minimum of 45,000 pounds for cab end corner posts and 20,000 pounds for non-cab end corner posts with no permanent deformation in the carbody.

3.3.2.3.4 Corner Post Strength at the Point of Attachment

The load carrying capacity of the corner post, when loaded at the point of attachment to the roof, shall be a minimum of 30,000 pounds for cab end corner posts applied longitudinally and 30,000 pounds for non-cab end corner posts applied in any direction from longitudinal to transverse with no permanent deformation in the carbody.

3.3.2.4 Side Sills and Body Sills

Side sills, extending between car ends, shall be provided on both sides of the car. They shall be fastened to:

   a. Floor beams
   b. Cross bearers
   c. Carbody bolsters
   d. End sills
   e. Sub-floor panels (underframe shear panels)
   f. Transition members

Side sills shall have a fine grit scratch finish with grain horizontal as described in TS 3.2.2. The side sills shall form a structurally continuous bottom chord for the side frame. The side sills shall be designed to resist the combined vertical and longitudinal loads resulting from the specified design loads. Longitudinal or body sills, located inboard of the side sills, may be used, if necessary, to carry longitudinal loads through the underframe. The side and body sills shall be designed so that any failure of the carbody will begin in the draft sill outboard of the coupler support structures, rather than in the region between the coupler support structures, when longitudinal loadings exceed the specified values.

Center sills, if used, shall be of one piece members extending between body bolsters. If provided, the center sill shall be welded to transverse floor members and bolsters and shall be braced by cross bearers. The center sill and body bolster shall provide for continuity of flanges and webs where the members intersect.
3.3.2.5 **Cross Bearers and Floor Beams**

Cross bearers shall be provided to transfer the applied vertical loading from the center sill (if used) to the side framing. Floor beams shall be provided to transfer the vertical floor loads to the side sill, center sill if used, and side framing. The cross bearers and floor beams shall be fastened to the center sill, if used, so that they stabilize the center sill against column failure both vertically and laterally.

The spacing and sizing of the floor beams shall limit floor panel (described in TS 4.5) deflection to a maximum of 1/8 inch under an evenly distributed vertical crush load.

With the vehicle floor loaded to simulate a uniformly distributed AW3 passenger load plus loads of all interior equipment such as seats, interior liners, and equipment boxes, the floor beams shall not deflect more than 1/250 of the span between supports, and the maximum stress in the floor beams shall be less than the critical buckling stress or 50 percent of the yield strength of the material, whichever is less.

3.3.2.6 **Sub-Floor, Intermediate, and Lower Levels**

A stainless steel sub-floor shall be provided throughout the length and width of the car. At the intermediate level, the sub-floor shall not be less than 0.020 inch thick, and the sub-floor and its attachments to adjacent structural members shall be capable of resisting the shear resulting from the specified compression loading without permanent deformation. The lower level sub-floor pan shall be at least 0.090 inches thick. The sub-floor pans shall be securely fastened to the bottom flanges of the floor beams and to the center sill, if used, draft sills, and side sills. The sub-floor shall be sealed to close off air leaks for car pressurization. Between the carbody bolsters, the sub-floor shall be attached to the above mentioned members in a manner to allow for easy replacement of damaged panels and yet provide the attachment and sealing required to meet the structural, car pressurization, and flammability requirements. Spacing and sizing of the transverse floor members shall limit floor panel deflection to a maximum of 0.125 inch under evenly distributed crush loading. The attachment design shall be as approved by the Engineer. [*CDRL 03-009*]

The sub-floor pan shall contain the underfloor thermal and acoustic insulation. The pans shall be suitably stiffened to prevent resonant noise and vibration and “oil canning” under any operating condition.

If the floor pans are separate sheets, they shall be securely fastened to the car structure. A weather-proofing sealant shall be applied to the edges of the sheets immediately before installation. The fastening and sealing system shall prevent moisture, dirt, dust, and debris entry into the sub-floor for the life of the vehicle.

3.3.2.7 **Upper Level Floor**

The upper level floor shall be supported by a suitable system of longitudinal and cross members. The allowable deflection of the upper level floor under its dead weight plus the maximum passenger load shall not exceed 1/8 inch. Additional support for the upper level floor system shall be provided by the permanent partitions available in the lower level floor area. The stresses in any member of the upper level floor or its support structure under maximum passenger loading (AW3) shall not exceed half of the yield strength of the material.
All members of the upper level floor shall permit the fastening of equipment and the installation of the air conditioning system, wiring, lighting fixtures, and other equipment for the lower level ceiling appurtenances in a secure manner. The framing shall be arranged so that lower level equipment can be replaced and maintained through removable panels without disturbing carbody structural members. Ducting for circulation of conditioned air for the lower level shall be fastened to the upper level floor framing arrangement consistent with the air distribution requirements of the HVAC system.

### 3.3.3 Roof

The car roof framing shall consist of carlines (transverse) and purlins (longitudinal), all suitably fastened to the side and end framing to provide a strong, rigid, integrated structure adequate for the service intended and the requirements of this Specification. The roof shall meet APTA-PR-CS-RP-001-98, APTA-PR-CS-S-034-99 Revision 2, and 49 CFR 238.123. All members of the roof framing shall be designed and arranged to permit the installation and fastening of the air conditioning system, roof wiring, lighting fixtures, equipment, ventilation ducts, and other required apparatus in a secure manner. The roof framing shall be arranged to allow the replacement and maintenance of overhead mounted equipment through removable interior ceiling panels without disturbing the carbody structural members. Ducting for the circulation of conditioned air shall be coordinated with the roof framing arrangement and configured to be consistent with the air distribution requirements of the heating and air conditioning systems described in TS 8. The roof shall be properly reinforced and braced with the structural members to carry the weight, stress, and vibration due to roof mounted apparatus.

Roof framing shall permit the degree of interchangeability of equipment specified in TS 2.1.7. The roof shall be framed and reinforced around openings. All reinforcements shall be welded stainless steel. Reinforcements on the roof shall be made watertight by welding or soldering. No through roof mechanical fastening is permitted. The roof sheathing and structure shall be designed to support the specified roof loads. Both ends of the roof shall be designed to support the tops of collision posts and distribute the specified collision and corner post loads.

All parts of the roof structure, sheets, equipment covers, roof walkway, screens, and other guards shall have sufficient strength to withstand, without exceeding the yield strength, 80 percent of the ultimate strength and critical buckling stress under any of the following conditions:

1. The loads imposed by a mechanical car washer consisting of a pressure of 60 per square foot over a 12 inch wide band extending transversely across the carbody,
2. Concentrated loads of 250 pounds applied anywhere over a 3 inch square, and
3. Uniform load of 15 pounds per square foot.

Roof sheets may be corrugated in the area above the sight line on a smooth sided car.

The roof shall also support without yielding the loads imposed by normal operating conditions, including loads imposed by roof mounted equipment, stanchions, handholds, and specified collision and jacking loads.
Equipment mounted under the roof, suspended from the roof structure, shall be bolted to the framing members. The framing members shall be reinforced in the subassembly to accept the equipment load.

The design loads for equipment and apparatus attached or mounted to the roof, including gutters, air scoops, antennae, lights, air horns, equipment supports, and supporting roof framing, shall be 8 g's longitudinal, 4 g's vertical and 4 g's lateral. Such loading may develop the ultimate load carrying capacity of the member being investigated.

Shrouds or other approved aesthetic treatment shall be erected to conceal roof mounted equipment, as proposed by the Industrial Designer and approved by the Engineer. Shrouds shall be made of the same material as roof sheets, designed to harmonize with the car design, and not interfere with any ventilation requirements of roof mounted equipment or air intakes. All side and end openings in the shrouds shall be screened as required for ventilation. Perforated stainless steel screening or equivalent as approved by the Engineer may be used. All roof arrangements shall prevent accumulation of leaves, water, car wash cleaner, snow, ice or excessive dirt.

Deflecting plates shall be installed at the ends of the roof to prevent water from cascading between cars. The design arrangement and installation of roof equipment shall not permit accumulation of water. Drainage provisions shall be subject to approval by the Engineer. [CDRL 3-010]

Alternate designs that meet the Specification requirements shall require approval of the Engineer.

### 3.3.4 Structural Side Frame Posts

Side frames shall consist of vertical members such as window posts and door posts and longitudinal members such as roof rails, side sills, window top rails, and belt rails. They shall include sheathing and internal skin stiffening members. Structural posts shall be located at the sides of door and window openings and elsewhere as required to limit deflection and fatigue stresses. Structural posts shall be continuous between the side sill and roof rail if the upper level floor support side rail is not designed to be a primary load carrying member. If the upper level floor support side rail is designed to be a primary load carrying member, the side posts shall be continuous from the lower side sill to the upper side sill and continuous from the upper side sill to the roof rail. At the upper side sill, gussets shall be used to reinforce connections to effectively make the posts continuous between the lower side sill and the roof rail. Where longitudinal rails are interrupted by posts, gussets shall be used to reinforce connections to effectively make the rails continuous. All gussets shall be full height. The side frame posts or stub posts (between the side sills and belt rails) shall transmit applied vertical loadings from the body bolster ends, cross bearer ends, and jack pads into the side frame sheathing. The belt rail and its supports shall be designed to resist the specified side load in accordance with APTA-PR-CS-S-034-99 Revision 2. All posts shall be formed sections.

Intermediate structural elements between the side frames shall transfer all seat and floor loads to the side frame posts. Passenger seats shall be supported by continuous structural members fastened to the side frame posts. The carbody side and side frame posts shall be capable of supporting the full seating loads with a minimum safety factor of 2.0, based on yield strength without permanent deformation at a deflection not to exceed 0.125 inches. The side frame shall conform to APTA-PR-CS-S-034-99 Revision 2.
The carbody structure shall be designed to resist an inward transverse load of 40,000 pounds applied anywhere along the side sill and 10,000 pounds applied anywhere along the belt rail (the horizontal rail member at the bottom of the window openings in the side frame). These loads shall be applied separately over the full height of the member for a distance of 8 feet (2.4 m) along its length. The allowable stress shall be the lesser of yield or the critical buckling stress except that, for the purposes of the calculation of stress to show compliance with this requirement, local yielding of the side skin adjacent to the side sill and belt rail shall be allowed.

Alternate designs that meet the Specification requirements shall require approval of the Engineer.

Planning and provisions shall be made to allow harness routing for passenger convenience outlets through or around structural elements. The position of the harness shall be below the window opening and horizontal belt line structure while avoiding any routing in spaces appropriated for floor heating elements.

### 3.3.5 Side Sheets

Smooth metal side sheets shall be structurally fastened to the outside of the side frame posts. Smooth side sheets may be stiffened by corrugations or similar sections fastened to the side sheet hidden face. The finish and flatness shall be as defined in TS 3.2.2. Dents, gashes, or other surface imperfections shall not be permitted.

Side sheathing shall be resistance spot welded to the outside of the side frame posts between the side sill and the roof. Side sheets may be stiffened by corrugations or similar sections resistance welded to the inside face of the side sheet. Flat side sheathing shall be a minimum of 0.059 inch (1.5 mm) thick.

Approved weather strips shall be applied at the door openings. Alternate designs that meet the Specification requirements shall require approval of the Engineer.

### 3.3.6 End Frame

The car end frames shall consist of two (2) corner posts, one (1) each at the juncture of the front end and side frames, two (2) collision posts located at the approximate third points of the end frame width, but in any case not more than 40 inches apart, a body end door, a structural shelf, framing posts, and sheet metal sheathing connected to the structural framing members as necessary. It shall be designed to resist the specified vertical, transverse, and torsional loads as required by APTA-PR-CS-S-034-99 Revision 2. The door posts and header shall be designed to carry the body end door while maintaining weather tightness.

The end sheets shall be of the same material as the side sheets and securely framed to the car structure. The sheets shall be smooth and flat such that waves and ripples shall not exceed 5/16 inch (peak to valley) in three (3) feet measured in any direction.

A diaphragm shall be provided at the end of all cars in accordance with TS 3.10.3.
3.3.6.1 Collision Posts

Collision posts shall meet the requirements of APTA-PR-CS-S-034-99 Revision 2 and 49 CFR 238.211. The car end structures shall be provided with vertical collision posts at both sides of the end openings fastened securely into the roof structure at the top and welded to the top and bottom plates of the end underframe. The collision posts shall be constructed of stainless steel or LAHT.

The collision posts shall be continuous closed sections from the bottom of the end sill to the top of the roof, unless shear reinforcement is used. If shear reinforcement (stub posts) are used, the posts shall be welded to the shear reinforcement at the floor, to stub posts, and to the roof to develop the full strength of the posts. The cab car F-end carbody doors shall be mounted on the collision posts.

The cab end collision post and the non-cab end collision post shall meet all applicable requirements as specified in TS 3.3.1 and in APTA-PR-CS-034-99 Revision 2 if shear reinforcement (stub posts) are used. Reinforcement, to provide the specified shear strength, shall meet all applicable requirements of the APTA Standards and Recommended Practices and FRA regulations as specified.

The connections and supporting structure at the tops of the collision posts shall be designed to develop the necessary level of horizontal, vertical, and bending strength to ensure that if either one or both collision posts, whichever is more critical, is overloaded in bending to its ultimate strength, the post top connections and supporting structure shall deform plastically by the buckling and bending of the members to accommodate the collision post plastic bending failure. The ultimate shear and tensile strength of the connection fasteners and welds shall exceed that required by this deformation to ensure that failure of the fasteners and welds shall not occur, even with severe plastic deformation of the collision posts and of the top connecting and supporting structural elements. Overloading of the collision post bottom connections shall result in the buckling and crushing of the underframe structural members, to which the collision posts and collision post reinforcements are attached, rather than the shearing or fracturing of the posts.

For the stress analysis for bending in the plastic range of the material, the reduction in the modulus of elasticity and its effect on the stability of the post compression flange shall be considered and included in the strength calculations. The calculation method outlined in the AAR Manual of Standards and Recommended Practices, Section C, Part II, Paragraph 4.2.2.16, or another method approved by the Engineer, shall be used. The calculations shall be based on extended stress strain curves determined experimentally by the Contractor if these data are not otherwise available, at the midpoint of the shelf, assuming the shelf to be a beam simply supported at its ends. The shelf may be integrated with the control console on the cab side.

Lifting eyes shall be installed at the extreme top edge of each collision post of both ends of all cars to allow the lifting of the car with overhead cranes or a boom. Procedures and designs shall be submitted to the Engineer for approval during the design review of the car. [CDRL 03-008] The lifting eyes shall be arranged such that they are readily accessible without removal of cover plates. The top of the collision posts, including lifting eyes, shall not extend above the surface of the roof. It shall be possible to lift the car at AW0 load with an overhead crane or boom at only one end with trucks attached and supported by the opposite end truck without exceeding 50 percent of the yield strength of the material.
Preliminary layout drawings and supporting calculations of the cab end frame members shall be submitted for approval before the end frame design is finalized. [CDRL 03-011] The drawings shall be clearly marked to indicate conformity to the requirements of this Section.

The stress analysis, required by TS 3.8, shall include an analysis of the collision posts and corner posts together with their connections and supporting structure.

### 3.3.6.1.1 Collision Post Load 18 Inches and 30 Inches Above Floor

The load carrying capacity of each cab end collision post, when loaded in a horizontal plane +15 degrees of the longitudinal axis of the vehicle, shall be a minimum of 200,000 pounds at a point 30 inches above the top of the underframe without exceeding the ultimate strength of the material. The post shall be capable of inelastically absorbing a minimum of 130,000 ft. lbs. while continuing to support the 200,000 pound load.

Each non-cab end collision post shall resist, without exceeding the ultimate strength of the carbody, a horizontal load of 300,000 pounds applied anywhere between the floor and a point on the collision post 18 feet above the top of the underframe and in any direction within 15 degrees of the longitudinal axis of the car.

### 3.3.6.1.2 Collision Post Shear Load at Floor

The ultimate horizontal shear strength of the cab end collision stub post shall be 500,000 pounds and the non-cab end shall be 300,000 pounds when the load is applied in any direction within 15 degrees of the longitudinal axis of the car at a point even with the top of the underframe to which the posts are attached. The shear strength of the collision posts shall be based on the area of the web, which is the depth of the member, in the direction parallel to the applied load times the web thickness. This shear strength shall be carried to the bottom of the end underframe.

### 3.3.6.1.3 Collision Post Strength Along Its Length

The load carrying capacity of the collision post, when loaded at any point from the top of the underframe to the roof in a horizontal plane within 15 degrees either side of the longitudinal axis of the vehicle, shall be a minimum of 60,000 pounds for the cab end collision posts and 50,000 pounds for the non-cab end collision posts with no permanent deformation in the carbody.

### 3.3.6.2 Structural Shelf

A structural shelf shall be provided just below the cab end windows connected securely to the corner post and the collision post. The structural shelf and its connections to the collision and corner posts shall resist without yielding, buckling, or tearing a load of not less than 15,000 pounds applied anywhere along its span. The shelf may be integrated with the control console on the cab side.

All secondary structural connections for framing, bracketry, and/or equipment mounts shall be made plum relative to the car structure by appropriate fixturing and shall be permanently attached by welding or huck bolts. No slots, oversized holes, and/or bolted fastener arrangements shall be allowed.
3.3.7 Equipment Boxes and Mounting Supports

All equipment boxes and mounting supports shall meet the requirements of APTA-PR-CS-S-034-99 Revision 2.

Equipment shall be installed in compartments on the intermediate level over the trucks or at other approved locations inside the car. Brackets and other means of support for the equipment shall be designed and installed to facilitate access for maintenance and servicing and for removal and reapplication. Fasteners shall be conveniently accessible.

There shall be no underfloor equipment other than piping, conduit, electrical boxes and wiring, and accessories associated therewith unless approved by the Engineer.

Exterior compartments shall be provided with hinged doors for access from inside or outside of the car. Exterior doors shall be gasketed to be water and dust tight.

Equipment access panels shall be provided for each compartment to permit removal and replacement of all components. In addition, it shall be possible to perform such service functions as battery removal, watering, and flushing from the exterior of the car.

The car side equipment compartment access panels and doors shall be constructed so as to harmonize structurally and esthetically with the car sides. The equipment access panels shall be removable. When closed, they shall be held fast with structural bolts so as to comprise an effective structural segment of the side. The side access doors shall swing outward and have appropriate latching operable from both sides.

When closed, the access doors shall have a positive seal effected by a dog, wedge, or similar device. A lock operable by the standard SEPTA key shall be provided.

Side access panel and door construction shall be of stainless steel to match with the carbody. The panels shall be of a rigidity and strength comparable to the adjacent car side areas. All joints and edges shall be thoroughly sealed and drain holes provided to permit the drainage of entrapped moisture. Doors shall not rattle or vibrate during operation.

The openings with close off panels shall be reinforced by an additional side frame structure surrounding the opening. The panel to close off the opening is to be structural and bolted to the basic side frame structure with stainless steel structural bolts so as to become an integral load bearing component of the side frame. The entire installation shall be watertight.

The battery box shall be constructed of stainless steel and shall be properly vented to prevent accumulation of gases. The vents shall be covered with screens and deflectors to preclude entry of dirt and water. Large drain holes with deflectors shall be installed in the bottom.

Supports for equipment boxes and apparatus shall be stainless steel. Where possible, supports for heavy apparatus shall rest on the horizontal flanges of the side sills, roof rails, or body sills. Attachment of these supports to structural members shall be by mechanical fasteners, not by welding, and shall be subject to the approval of the Engineer. [CDRL 03-012]
Internal structure and sub-plates shall be provided within the compartments to support the equipment, and the equipment shall be bolted to the substructure. No equipment shall be bolted directly to the walls.

Equipment box structures, mounting brackets, hinges, lids, covers, access doors, vents, and interior panels shall be designed to withstand the loadings received in the intended railroad service. The design loads for all equipment, any part of the equipment, equipment boxes, equipment hangers, standby supports, safety hangers, and carbody supporting structure shall be not less than eight (8) g’s in the longitudinal direction, four (4) g’s vertical, and four (4) g’s lateral. The loadings shall be applied separately; and such loading may develop the ultimate load carrying capacity of the member being investigated.

Equipment within an equipment box need not meet the above criteria provided it can be shown that the equipment will not penetrate the walls of the equipment box when exposed to these g levels. The equipment box shall conform to these load criteria with the rearranged equipment in addition to its normal arrangement.

In no case shall the strength of a fastener or the shearing of the fastener through the base material be the limit of the carrying capacity of a member.

Covers on the exterior of the car shall fit tightly and be gasketed to prevent the entrance of water (including both driving rain and high pressure car wash spray), dust, sleet, and snow. Seals on covers shall be of a material that shall ensure watertightness, remain resilient, and remain intact for a period of at least ten (10) years.

All boxes with cover access from the exterior of the car shall contain a drainage hole that will allow drainage to the undercar. If the hole leads directly to the atmosphere, a stainless steel cotter key shall be installed.

All equipment boxes, which are required to be watertight, shall be given a water test. For the purposes of this test, adjustable cover latches shall be adjusted to compress the cover seals no more than 50 percent of the compressible height of the seal for covers so equipped.

The cover/door seal shall be hollow vented neoprene rubber bulb type permitting at least 1/4 inch compression using the latches and edge design proposed for each door. The edge of the cover shall not deflect (bow) more than 1/16 inch between latches when the latches compress the seal 1/4 inch. No permanent deformation of the door shall be possible with any combination of latch settings. The seal shall be mounted on a lip on the box, and the cover shall seal against it. Foam seals shall not be allowed.

The seal shall be a clamp on type which shall fit over a lip on the box and be mechanically clamped to remain in place without adjustment throughout the life of the seal. The installation shall provide easy replacement of damaged seals and secure the attachment until replacement is required. Adhesive bonding of seals to the box or cover shall not be permitted. Samples shall be submitted to the Engineer for approval. [CDRL 03-013]

Equipment covers and appendages, that require a flat plate bolted sealing arrangement, shall use die cut neoprene rubber designed with a thickness to allow a full even sealing without distortion.
Undercar equipment, with a direct line of sight to a wheel for any possible truck orientation, shall be protected from water splash and flying rock ballast or other missiles thrown by the wheel. If separately mounted solid metal shields are used to provide such protection, they shall not hinder the flow of air to a degree which might cause heat damage to wiring or apparatus.

No apparatus over 25 pounds shall be supported by bolts in tension. The Contractor may submit to the Engineer for specific approval an alternative apparatus support design utilizing bolts in tension provided that such design includes an adequate stand by support arrangement. The design of the stand by support arrangements shall include the effect of the equipment dropping from its mount. Apparatus requiring removal and replacement for other than accident damage shall be supported so that both the bolts and nuts are accessible. Bolts used to mount or support underfloor equipment shall not be less than 3/8 inch diameter and shall meet the requirements of TS 17.2. Dissimilar metals shall not be used at connections requiring disassembly for removal and replacement of equipment. Equipment supported on resilient mounts shall have safety straps or other devices which will support it in case of a failure of the resilient mounts. The design of the safety straps shall include the effect of the equipment dropping from its mounts. No equipment shall be supported by bolts in holes tapped into the underframe.

Boxes required by TS 3.1.2 to be accessible from the side of the car shall be as flush as possible with the side of the car consistent with the car clearance diagram and shall be provided with top hinged access covers on the outboard side and, if required, the inboard side. Outboard covers shall raise a minimum 90 degrees for quick examination of the interior without removing the covers. Inboard covers shall open to the maximum extent possible but in no case less than 60 degrees. All hinged covers shall also be readily removable without more than a 12 inch swing out and without the use of tools. Openings provided upon removal of covers shall be of sufficient size to permit removal and replacement of any component in the box with easy access to equipment in the box for inspection and maintenance. All group covers shall have a "hold open" feature built into the hinge configuration. The "hold open" feature shall in no way interfere with or impede the easy removal or replacement of the cover.

All access covers shall be provided with quick release latches which operate with a toggle type action. The latches and keepers shall be arranged so that they do not protrude beyond the bottom of the box or cover in the latched position. The latches shall be adjustable to compensate for seal relaxation. The latch and all its components shall be fabricated from an austenitic stainless steel and shall be similar to existing SEPTA cars or approved equal.

A spring loaded safety catch shall be provided at the center of each underfloor box cover. The safety catch shall be designed to engage and retain the cover at all operating speeds without the cover latches engaged.

Conduit shall be connected to equipment groups using watertight connectors as manufactured by Universal, Erickson, or approved equal. The entrance of conduit into the top or bottom of equipment boxes shall not be permitted.

Materials, used in underfloor equipment box assemblies and the workmanship involved in the assembly and finish of underfloor equipment boxes, shall conform to the applicable requirements of TS 17.

Final dimensions and arrangement of all equipment compartment access shall be subject to approval by the Engineer. [CDRL 03-014]
3.3.8 Buffer Walkway Plate and Face Plate

The construction of the walkway plates, buffer, and side stems shall be such that there shall be no metal to metal contact between moving parts in order to prevent noise, minimize wear between all parts, and require no lubrication.

The walkway plates, buffer, and side stems shall be so arranged to permit coupled cars to negotiate minimum radius curves and crossovers, as described in TS 2.2 without any binding of the total mechanism.

3.3.8.1 Buffer Walkway Plates

Hinged stainless steel walkway plates, having a safety tread surface, shall be provided at each end of the car to provide a continuous flat and level walkway between coupled cars. The design of the walkway plate shall be coordinated with the body end door threshold on the ends of the cab cars and trailer cars and the buffer specified herein. The walkway plate shall rest upon the buffer and be readily removable to allow access to the emergency lift holes in the end sill. The walkway plate should be similar to existing SEPTA cars and a fixed walkway plate is not acceptable.

3.3.8.2 Buffer

A buffer, as further described in TS 3.10, shall be provided at each end of the car. The buffer shall be designed to accept the diaphragm specified in TS 3.10.3. The buffer shall be free to move in a direction parallel to the length of the car to the extent required to maintain contact with a coupled car buffer for the track curvature and crossover conditions listed in TS 2.2. The buffer face plate shall be guided and held against the buffer face plate of a mating car by a tubular side stem and compression spring arrangement. The face plate shall be a minimum six (6) inches high to prevent pass over of two (2) adjacent buffers with maximum vertical movement of two (2) coupled cars. The face plate shall be as specified in TS 3.10.1. The guiding means for the tubular side stem rods shall be provided with non-metallic material with both sound deadening and low friction non-lubricated capabilities.

3.3.9 Gutters

Water deflecting gutters shall be installed over all side doors. They shall prevent water from dripping into or in front of the side door opening when the car is stopped. Gutters shall also protect the entire end of the car. Deflecting plates shall be installed on both ends of the roof to prevent water from cascading between cars or down in front of the operating cab. Gutters, deflecting plates, and air scoops shall be designed to withstand the loads, as stated in TS 3.3, and also those imposed by a brush type car wash without permanent deformation. Gutters shall be made from the same material as the shell, roof, and side sheets. Deflection air scoops on the A-end of the cab car shall be made of stainless steel and designed to withstand loads and the brush whipping action of car washes from either direction.
3.3.10 Jack Pads and Lifting Eyes

The carbody structure shall be designed so that jacks or cradles may be used for lifting the car at the jacking pads. Eight (8) 2 1/2 inch by 6 inch jacking pads, with the longer dimension parallel to the longitudinal centerline of the car, shall be installed on the side sill in approved locations to prevent damage to the carbody structure when lifting a car. The design of the jacking pad shall only be used in approved jacking pad locations. The car shall be so designed to permit jacking of either of the car end for truck removal or rerailing with the opposite end of the car resting on its truck without damage to the truck attachment, underframe, or any of the underfloor apparatus. It shall be permissible on the cab car to remove the pilot to fulfill this requirement. The design vertical load for each jacking pad shall not be less than one half the empty weight of a ready to run (AW0) car. The design horizontal load shall be 10 percent of the design vertical load. The horizontal load shall be applied simultaneously with the vertical load in any direction to produce the worst stress condition. The allowable design stress shall be yield or 80 percent of ultimate, whichever is lower, or the critical buckling stress of any part of the jack pad or the structure to which it is attached. Jacking pads shall extend one half (1/2) to one (1) inch below the bottom of the side sill. There shall be no permanent deformation when the car is symmetrically jacked from any combination of pads with the car at AW0 with the trucks attached.

The empty carbody with trucks attached (AW0) shall be capable of being lifted on the outboard most diagonally opposite jack pads without resultant permanent deformation on any element of the carbody structure. An analysis of the carbody structure, under torsional loading of the diagonal jacking, all symmetric jacking, and all lifting conditions defined in TS 3.3, shall be included in the stress analysis required by TS 3.8.

The stress analysis required by TS 3.8 shall include an analysis of both the collision post lifting hooks and buffer eye hooks under all torsional loading showing all stresses on the carbody and all attachments during lifting of the car from both ends when ready to run in the following conditions:

a. Car upright
b. Car lying on left side
c. Car lying on right side

For lifting from either the left or right side, the car will be analyzed with an equal lifting load applied to one (1) collision post lifting hook on each end of the car. Stresses will not exceed yield with a load factor of 1.1 with the addition that highly localized yielding of the hook and associated region, which does not otherwise compromise the ability of the affected structure to meet the requirements of the specification, will be permitted on a case by case basis.

3.3.11 Snowplow Pilot

A snowplow pilot, which meets the requirements of 49 CFR 229.123, shall be provided at each cab end. It shall be similar to the pilot installed on the existing SEPTA cars or approved equivalent. A complete approved package, consisting of all detail drawings for each part of the snowplow together with an FEA on the structure and its attachment to the car, shall be submitted to the Engineer for approval. This package shall be submitted at least 180 days in advance of delivery of the first car. [CDRL 03-015]
The snowplow pilot shall be constructed of stainless steel or low alloy high tensile steel properly coated for corrosion resistance in accordance with TS 17.23. It shall be as large and as low as possible to prevent objects from being rolled under the car. The pilot shall not hit the running rail under worst case conditions of carbody vertical displacement, including completely deflated air springs and wheels worn to the condemning limit. Pilots shall be interchangeable among cars.

The snowplow pilot shall be strong enough to perform its intended functions but, as a minimum, shall be designed to resist loadings not less than the following:

a. Longitudinal load at rail location at bottom of pilot: 50,000 pounds on each side applied simultaneously
b. Longitudinal load at centerline of car at bottom of pilot: 20,000 pounds, applied separately
c. Transverse load on lower edge transverse member: 30,000 pounds, applied separately

The allowable design stress shall be yield or 80 percent of ultimate, whichever is lower, or critical buckling stress.

The portions of the carbody to which the snowplow pilot is attached shall be substantially stronger than the pilot, so that if the pilot is overloaded, damage to the portions of the car to which it is attached will be minimized. Longitudinal struts shall be provided to carry the longitudinal loads at rail location into the carbody, and their inboard ends shall be attached to the bottom of the draft sill in the region of the draft gear installation. Snowplow pilots shall be attached to the carbody by mechanical fasteners; the connection shall be designed and constructed to facilitate installation and removal and to permit interchangeability among cars. The pilot shall incorporate a bolted, readily replaceable, sacrificial blade at the bottom of the pilot to prevent damage to the pilot in case of rail contact. The blade shall extend 2 inches below the pilot structure.

The design shall provide for easy removal of the pilot when required for jacking of the car from one end as described in TS 3.3.1.

### 3.3.12 Truck to Carbody Connection

An approved truck safety mechanism shall be provided in accordance with 49 CFR 229.141, 49 CFR 238.219, and APTA-PR-CS-S-034-99 Revision 2. The truck to carbody connection shall have strength of not less than the equivalent of an ultimate shear value of 250,000 pounds. This force shall be applied horizontally in any direction parallel to the plane of the car floor. This horizontal loading resistance shall be designed to cause the truck to function as an anti-telescoping device in the event of derailment and shall be carried down to the wheel horizontal centerline. The connection shall also be designed to resist the vertical component of that force when such horizontal force is applied to the center of the leading axle with the truck in its most adverse position.
The construction shall also provide a connection between the carbody and trucks so that the trucks are raised with the carbody unless intentionally detached therefrom. A vertical load factor of 2.0 shall be applied in the design of the connecting elements, and the allowable design stress shall be yield or 80 percent of ultimate, whichever is lower, or the critical buckling stress. The truck safety mechanism shall not interfere with normal suspension elements for any possible condition of shimming for wheel wear.

An analysis of the strength of the connection of the trucks to the carbody, calculated for all vertical and horizontal loads, shall be included in the stress analysis required by TS 3.8.

### 3.3.13 Bolster Anchor Brackets

Bolster anchor rods and brackets shall be provided to transmit the longitudinal loads between the carbody and the truck. They shall be positioned to minimize longitudinal vibration to the carbody. Two (2) bolster anchor rods and brackets shall be provided on each truck. The bolster anchor rods each shall resist a longitudinal load in either direction of not less than two (2) times the complete truck weight without exceeding the yield of the materials used or the critical buckling stress. Loads used for the design of the anchor rod bracket shall, as a minimum, be three (3) times the complete truck weight. In addition, the strength of the anchor brackets and attachments to the carbody shall exceed that of the radius rods such that under conditions of extreme loading, the rods will fail without causing permanent deformation to the anchor brackets, their attachments to the carbody, or the carbody structure.

The anchor rod bracket shall be frangible, i.e. the anchor rod bracket shall fail and fall away under load before the carbody structure is damaged. Any horizontal load, which develops the ultimate load carrying capacity of the anchor rod bracket, shall not develop a stress greater than yield, 80 percent of ultimate yield, or the critical buckling stress in the side sill or other car structure. The load shall be applied in any direction in the horizontal plane of any part of the anchor rod bracket below the side sill. A specially designed joint, which breaks at a predetermined load, shall be permitted.

The attachment of the anchor bracket to the carbody shall be by mechanical fasteners, designed and constructed to permit interchangeability among cars, and arranged to permit removal of the bracket from outside of the carbody without interference from the car structure. The bolster anchor rods are described in TS 11.10.

### 3.3.14 Vestibule Steps

The Contractor shall submit an analysis of the vestibule steps and associated structure. The loads used for the design of the vestibule steps shall be based on the maximum standing load assuming the 95 percentile male with a factor of safety not less than 2.0. The design shall ensure that the design load stress of the vestibule steps does not exceed the yield strength of the material. [CDRL 03-016]
3.4 VESTIBULE

3.4.1 General

Each cab car shall have three (3) vestibules and each trailer car shall have four (4) vestibules. The end vestibules for corner post doorways shall have a full length sliding door on each side. The door shall extend from just below the roof rail to a threshold built into the lowest step. The end vestibule door opening shall provide a clear opening 6 feet 4 inches high and 32 inches to 36 inches wide with the trap door in the down position. The floors in the corner vestibule shall have a non-skid material applied to easily replaceable stainless steel panels. The design of the vestibule steps and vestibule shall use similar materials compatible with operating and maintenance practices. Details of the design, material, arrangement, and installation shall be submitted to the Engineer for review and approval. [CDRL 03-017]

The quarter point vestibules shall contain single door panels on each side of the car which open into door pockets. The quarter point vestibule side doors shall be used only at high level platforms and handicap ramp facilities. The floor in the quarter point vestibules shall have a non-skid surface. The color and pattern of the floor shall be aesthetically compatible with the floor covering provided throughout the interior of the car. Details of the design, material, arrangement, and installation shall be submitted to the Engineer for review and approval. [CDRL 03-018]

3.4.2 End Vestibule

A vestibule shall be provided at each end of the trailer car and the B-end of a cab car. It is defined as the area between the end frame and the end vestibule partition wall. The structure of the end vestibule shall be designed so that the critical buckling stress is less than the critical buckling stress of the structure of the remaining car with loads applied to the buffer; i.e. when a collision occurs at the sill, the end vestibules shall collapse before the center of the car distorts. Failure shall be by buckling and bending; no shear failure shall occur. All material, which is normally part of the car, shall be considered as resisting an end collision whether or not designated as structure.

3.4.2.1 Vestibule Partition

A transverse partition shall be located just inboard of each end side doorway. This partition shall be designated as part of the car’s structure and shall assist in resisting vertical and torsional loading and in stabilizing the side framing. Shear resistant partition sheets shall be securely connected to the body end door posts, draft sill, floor panel members, top transverse door header member, and end-side door framing construction.

3.4.2.2 Side Door Framing

Carbody framing at the end side door opened area shall be designed to transmit vertical shear from the vestibule partition to the side framing under the torsional loadings. This area of the car structure shall be intended on each side of the car to provide space for the outside sliding end vestibule side doors in the open position. The side framing in the end side door open area shall extend below the side sill to the level of the lowest step. This lower framing shall support the bottom door track and assist in transmitting loads between the end sill and corner post.
The structure shall accommodate vertical handholds on the low platform doors. The clear door opening at this door shall be 31-34 inches.

### 3.4.2.3 Floor Plates and Trap Doors

End vestibule floors shall be provided with a Darkar or approved equivalent anti-skid surface. The Contractor shall submit samples and material specifications to the Engineer for approval. [CDRL 03-019]

The material quality shall be limited to those having the highest level of anti-skid properties.

Safety is a prime consideration in the selection of anti-skid material for the vestibule floor. End side door traps, constructed of stainless steel plate having a Darkar or approved equivalent non-skid surface, shall be provided. Side door traps shall be located at both sides of both ends of all trailer cars and at B-ends of the cab cars. The side door traps shall be designed for manual operation with the end vestibule side doors closed. The trap door shall have a coil spring and hinge arrangement which shall allow the trap door to open (lift) 15 to 20 degrees when the trap door down latch is released. The spring shall also assist in lifting the trap door to the open latched position. Once installed and after initial adjustment, the trap door spring shall require no further adjustments. The trap door arrangement shall include a “pull rod” to allow the crew to release the trap in the down position from the outside of the car with the door opened. The pull rod shall be concealed during normal operation and shall not interfere with use of the steps. The trap door and side door shall provide for the minimum increase in gap between a high level platform and the trap door edge and comply with the requirements of 49 CFR 27, 37, and 38. The Contractor’s design must comply with the requirements of 49 CFR 238 and APTA-PR-CS-S-034-99 Revision 2.

A SEPTA approved mechanism shall be provided to unlatch the trap door from the exterior of the vehicle when the end side door is in the open position. The mechanism shall use a rigid stainless steel linkage arrangement suitability supported and guided for the application to eliminate rattles and vibration with minimum wear points. The use of cables in the latch and release mechanisms shall not be permitted. The mechanism shall be located on the corner post side of the doorway and shall not affect loading and unloading of passengers. When the mechanism is engaged, the trap door down latch shall be released. The mechanism shall automatically return to the neutral non-engaged position when released.

### 3.4.2.4 Passenger Steps

Stainless steel step wells, consisting of three (3) steps with Darkar or approved equivalent anti-skid surfaces, shall be located at the end vestibule entrances equipped for high level and low level platform stations. The top surface of the lowest step tread shall be 17 inches (nominal) above the top of the rail. The tread depth shall be a minimum of 10 inches; riser heights shall be equal. All step edges shall have a permanent band of color(s) running the full width of the step which contrast from the step tread and riser or adjacent floor by 70 percent as determined by the formula:

\[
\text{Contrast} = \left(\frac{(B1-B2)}{B1}\right) \times 100.
\]

Where  \( B1 \) = Light Reflectance Value (LRV) of the brighter areas, and

\( B2 \) = Light Reflectance Value (LRV) of the darker area.

Samples shall be submitted to the Engineer for approval. [CDRL 03-020]
3.4.2.5 Threshold and Door Track

The lowest step shall contain a threshold designed to guide the bottom edge of the end vestibule side door during door operation and mate with the door bottom edge when the door is in the closed position so as to exclude water, snow, and drafts from the vestibule. The threshold door track shall be heated with track heaters to prevent snow and ice accumulation in the track. The threshold heater shall not be lower than 16 inches above the top of the rail. The threshold and door track shall be provided with adequate drainage to prevent the buildup of water and debris in the track. The door track shall extend the full length of the end vestibule side door travel.

In board of the vestibule steps, the door track shall be enclosed in the lower door panel pocket and supported by the extension of the end side door framing below the side sill. An easily removed panel shall be provided on the car exterior to allow access to the door pocket and lower door hardware for maintenance and repair. Also, an easily accessible door shall be installed on the outside of the lower door pocket to allow access to the bottom door track for clearing obstructions and removal of debris.

3.4.3 Quarter Point Vestibule

The quarter point side door opening shall be reinforced in the roof, sides, and floor as required to meet the strength requirements of TS 3.3. The required stress analysis shall include an analysis of this area. The clear door opening shall be 32 to 36 inches wide, 6 feet 4 inches high and provided with a single sliding door constructed per TS 4.6.1 and controlled per TS 6.4. The interior of the car shall contain a vestibule formed by nonstructural partitions constructed of plymetal or approved equal panels per TS 4.4. The ceiling in the quarter point door vestibule area shall be flat at the same height as the intermediate level ceilings and constructed per TS 4.4. The ceiling shall contain LED light fixtures per TS 9.5 and emergency lighting per TS 9.7. The ceiling shall also have two (2) air diffusers connected to the overhead duct, which shall continue above the area as described in TS 8.7, and a PA speaker and grill per TS 13.2. Each of the partition walls shall have advertising sign frames on both sides. The floor covering shall be the same as the aisles per TS 4.5.3.

The aisle width, at the center car partitions into the passenger seating area, shall be 34 inches for all configurations. The vestibule and adjacent intermediate level shall comply with the requirements of 49 CFR 27, 37, and 38.

3.5 NOT USED
3.6 INSULATION

3.6.1 General
The entire carbody, including exterior doors and stepwells, shall be acoustically and thermally insulated. All materials used shall meet the flammability and smoke emission requirements of TS 17.24, shall not support vermin or insects, be resistant to fungus, and not absorb water or odors. All fiberglass insulation used shall be manufactured from long, textile-type or rotary-type glass fibers which are drawn from a calcium borosilicate mixture to an average diameter of nine (9) microns. The fibers shall be bonded together with a thermosetting phenolic resin which shall not exceed six (6) percent by weight. All insulation used shall not mold or rot, not have any odor nor corrode any metals, and be capable of performing to an upper temperature limit of 450°F. The use of urethane foam insulation is prohibited.

Thermal breaks shall be provided between the main conditioned air supply duct and roof structural members, between interior finish panels and any metal primary or secondary structural members which are thermally grounded to the outside surface of the carbody sheathing, and at any other location where it is necessary to interrupt an all-metal path between the interior of the carbody and the outside of the carbody sheathing.

3.6.2 Thermal
The thermal insulation system shall limit heat transfer of the completed car to as low a value as possible, but in any case shall not exceed a maximum of 1100 BTU’s/hour/degree F, or other Engineer approved value, under conditions of 70°F interior temperature and 0°F exterior ambient. The following insulation thickness listings are a minimum requirement. Glass or mineral fiber insulation shall be used, and it shall be installed so that it will not shake down in long service under vibrating conditions.

The roof, side walls, and ends of the car, including the inside of posts and structural members where accessible, shall be insulated with minimum 2.5 inch thickness glass fiber, or an equivalent mineral fiber, with reduced thickness permitted for the side walls where necessary. The roof insulation shall be retained by stainless steel spears or wires. Side and end wall insulation shall be retained by spears or any other approved method. On the inside of the door pockets additional insulation shall be applied to the fender lining. All areas around structural members shall be filled with insulation. The retainer system used shall not have sharp pointed ends following installation so that it will not be a hazard to maintenance personnel.

Where there is an interface of floor heating to the car walls, stainless steel or metal foil faced 2.0 inch thickness glass fiber with a minimum density of 2 pounds/cubic foot, or an equivalent mineral fiber, shall be applied to any heater guard area of the walls. The stainless steel or metal foil surface shall be exposed toward the inside of the car.
The floor shall be insulated with 3 inches of glass fiber insulation, consisting of a 1.5 inch thick layer of 1 pound/cubic foot density long fiber glass fiber, a lead septum and a 1.5 inch thick layer of 1 pound/cubic foot density short fiber glass fiber, or approved equal. The insulation shall be placed in the structural floor between the cross bearers (or beams) and retained by stainless steel subfloor shear panels forming the bottom of the car in an approved manner. All insulation shall be compatible with the material used at the affected locations in the car structure. The exterior doors shall be insulated wherever possible.

### 3.6.3 Acoustic

A vibration and sound damping material shall be applied to the inner surfaces of all areas of the structural shell including sub-floor pans, ends, roof, and side frames. Thermal and acoustical fiberglass insulation shall be applied to the internal surfaces of the air ducts if required to meet the requirements of TS 8.6 and TS 2.3. The thickness of the damping material shall be such that it will provide ten (10) percent of critical damping for the treated surface. The damping material shall have a vibration decay rate of not less than 45 decibels per second (at a temperature of 75°F) as measured by the Geiger plate method. It shall be resistant to dilute acids, alkalis, greases, gasolines, aliphatic oils, and vermin and shall meet the flammability guidelines listed in TS 17.24. It shall be unaffected by sunlight or ozone and shall not become brittle with age. It shall be Daubert Chemical Co. No. 368 sound deadening compound, Aquaplas No. DL-10, or approved equal.

Application of this damping compound and preparation of the surfaces to which it is applied shall be in accordance with the supplier’s recommendations. The compound shall be applied wet to the supplier’s recommended thickness. The alternative acoustic insulation system shall be service proved for commuter rail application and shall demonstrate compliance with the design and performance requirements specified.

A protective primer shall be applied as required by the manufacturer’s recommendation prior to the application of the sound deadening compound.

### 3.7 WINDOWS

#### 3.7.1 General

All exterior windows of the car shall be certified as meeting the requirements of 49 CFR 238.221 and 49 CFR 223. The certifications shall indicate that all end facing window assemblies meet the requirements of Type I testing, and that all side facing window assemblies meet the requirements of Type II testing.

All edges and radii of glass and plastic lights shall be ground smooth. Windows shall fit the carbody without binding to prevent cracks from developing in the window after the cars are in service. All windows shall meet the requirements of TS 17.8. Details of the design, arrangement, and installation of the window assemblies shall be submitted to the Engineer for review and approval. [CDRL 03-021]
Glazing in windows and doors shall be of the following types and thicknesses:

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum Thickness</th>
<th>Transmission</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side coach</td>
<td>.460</td>
<td>Tinted</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Side entrance doors</td>
<td>.460</td>
<td>Tinted</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Cab end windshields</td>
<td>.562</td>
<td>Clear</td>
<td>Laminated Sheet</td>
</tr>
<tr>
<td>Non-cab vestibule end doors</td>
<td>.460</td>
<td>Clear</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Collision post door</td>
<td>.562</td>
<td>Clear</td>
<td>Laminated Sheet</td>
</tr>
<tr>
<td>Dedicated cab door</td>
<td>.250</td>
<td>Tinted</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Cab drop sash</td>
<td>.460</td>
<td>Tinted</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Cab vestibule end doors</td>
<td>.460</td>
<td>Clear</td>
<td>Polycarbonate</td>
</tr>
</tbody>
</table>

All exterior windows shall be mounted to the carbody in endless neoprene gaskets. The neoprene gaskets shall be designed to form a watertight seal without the need for sealing compound between glazing and gasket. All neoprene gaskets shall be designed for use with polycarbonate and shall be designed to compensate for the expansion rate of the polycarbonate material. The neoprene gaskets shall have rounded corners both inside and outside the car to facilitate cleaning.

All other exterior miscellaneous glazing, such as marker light windows, exterior destination sign windows, etc., shall use tempered glass.

All neoprene gaskets shall be made in one endless piece by vulcanizing the ends together and shall conform to the requirements of TS 17.7.

### 3.7.2 Passenger Side Windows

Passenger side windows shall be fixed single glazed units supported directly in the car structure with endless neoprene glazing strips. Except for the emergency windows, the glazing strips shall be laced from the inside of the car. Emergency windows' glazing strips shall include a provision to be laced from inside and outside of the car.

Side window glazing material shall be single thickness, mar resistant coated polycarbonate mounted in the carbody deadlight window opening. The window size shall be maximized for optimal passenger view and comply with applicable FRA Regulations and APTA Standards and Recommended Practices. The polycarbonate thickness shall be sufficient to conform to the requirements of the Type II test specified in TS 3.7.1 and shall meet the requirements of TS 17.8.2.

The polycarbonate shall be uniformly tinted to produce a visual light transmission of 15 percent +/- 4 percent throughout the entire window area. The polycarbonate shall have a solid tint of neutral gray color to match PPG-Graylite 31 or approved equal.
The design of the installation shall allow for the expansion of polycarbonate material and shall withstand external and internal pressure differentials caused by head on pressures, passing trains, and prevailing winds experienced during normal service.

### 3.7.3 Passenger Emergency/Rescue Access Windows

Eight (8) passenger side windows, as designated by the Engineer, shall be arranged to function as emergency exit/access windows. Two (2) emergency windows shall be located in each of the vehicle’s three (3) sections on opposite sides of the vehicle. These windows shall be identified and marked as emergency windows both on the inside and outside of the car and shall comply with the requirements of 49 CFR Parts 223.9, 238.113 and 238.114 and APTA-PR-E-RP-002-98. Each passenger emergency window shall be a flat piece of FRA Type II nominal 0.46 inch thickness tinted polycarbonate. The design and location shall be approved by the Engineer. [CDRL 3-022]

Generally, these windows shall operate in the same fashion as those on the SEPTA Silverliner IV cars for both exit and access and shall be marked in a similar fashion. The passenger emergency windows shall conform to the requirements of the standard passenger windows in all respects except that each emergency window shall have a modified edge bevel as required and be glazed in a neoprene glazing strip which has a removable locking strip on both the inside and outside of the car. This glazing strip shall provide a watertight seal. A red metallic handle, as approved by the Engineer, shall have a reinforced attachment to the interior removable zipper strip portion of the glazing strip at the upper left corner of the window. The gasket shall be easily removable by pulling the handle requiring a force not to exceed 40 pounds. The handle shall be imprinted with 0.25 inch high phosphorescent paint letters reading “PULL FOR EMERGENCY EXIT”. Beneath the red metallic handle, a red bail style pull handle shall be mechanically fastened to the glazing to facilitate removal of the window. Adhesive bonding is prohibited. The location and size of this handle shall be fully covered by the metallic pull handle. “PULL TO REMOVE” shall be imprinted in phosphorescent paint on the handle in 0.25 inch high letters. This lettering shall normally be hidden from view when the gasket is installed. The window shall be removable by the current U.S. adult human scale 2.5th percentile female. Sufficient seat clearance shall be provided to allow for emergency window removal.

The windows shall be identified and marked as emergency windows in accordance with requirements of 49 CFR 238 and APTA-PR-E-RP-002-98.

### 3.7.4 Windshield Cab Car

The Operator’s windshield and the end facing window opposite the Operator’s area shall be single glazed fixed and mounted directly in the end frame panel. The window assemblies shall be designed to meet the FRA Type I impact requirements listed and shall meet the requirements of TS 17.8. The windshield shall be electrically heated complying with AAR Recommended Practice RP-500, Appendix A. The terminal board for connecting the two leads shall be mechanically mounted on the carbody (not on the window surface) and have the wires secured to prevent damage from installation or during car cleaning. The window frame shall be of a metal frame configuration, and glazing shall be designed so that the window cannot be pushed into the cab. The windows on both sides of the cab and, if possible, the collision post door shall be the same size and interchangeable.
The construction of the cab windshield shall use FRA Type I, triple laminated, clear glass as manufactured by NASG or approved equal.

The Operator’s windshield shall be electrically heated using 110 volts 60 Hertz AC single phase power. Heating control shall be as specified in TS 8.5.2. The electrical wiring connections shall be on the inside of the glazing, preferably at the top. The terminal board for connecting the two leads shall be mechanically mounted on the carbody (not on the window surface) and have the wires secured to prevent damage from installation or during car cleaning. The windshield used on the passenger (left) side of the cab end of the car shall not have provisions for heating.

The inside surface of each windshield and collision post door window shall have DuPont-type 307 spall shield.

End windows shall not be provided at the B-end of the cab car or on either end of the trailer cars.

3.7.5 Cab Drop Sash Window

Each Operator’s cab shall have a vertical sliding window assembly installed consisting of a tracked anodized aluminum sash, a sliding window insert, and a lower pocket assembly to accommodate the window in the lowered position and also allow for drainage of any accumulated water that may leak past the seals.

The sash shall be designed to permit an Operator of the dimensions listed in Human Engineering factors as required in TS 1.5.1 and 1.5.2 to easily lean out, when either seated or standing, and be able to view a station platform or the wayside in either direction. The minimum clear side-to-side opening shall be thirteen (13) inches wide. The height of the cab viewable portion of the cab window shall be equal to the height of the windshield and allow the maximum allowable opening when the glazing panel is down in the storage position. Locks and keepers shall not encroach into this opening. A drawing of the proposed arrangement shall be submitted to the Engineer for review and approval. [CDRL 03-023] The sliding window assembly shall be included in the cab car mock ups where it will be reviewed and assessed for operation, ergonomics and general configuration.

The sliding window panel shall consist of framed glazing material of a single thickness of 0.460 inch and be sufficient to conform to the requirements of the Type II glazing, mar resistant coated polycarbonate and comply with applicable FRA regulations and APTA Standards and Recommended Practices. The polycarbonate shall be uniformly tinted to produce a visual light transmission of 15 percent +/- 4 percent throughout the entire window area. The polycarbonate shall have a solid tint of neutral gray color to match PPG-Graylite 31 or approved equal. The glazing shall be marked as required by FRA regulations on the inside facing surface.

The sash frame shall be constructed of extruded aluminum alloy of type 6061-T6 or T4. Strength and quality requirements shall conform to AIA specifications. All elements of the drop sash frame assembly shall contain adequate seals to both the carbody and the sliding window panel when in the up and locked position.
To prevent the accumulation of snow and ice, the sliding section shall have its surfaces mounted inboard. The windows shall be effectively weather stripped, free of rattles and drafts, reinforced for hard usage and designed to eliminate rattles. A back up drainage feature shall be included where any moisture that may ingress from compromised seals will be drained directly to the exterior of the car either by a pocketed section with drain feature as a portion of the drop sash assembly or the interface of a built in drainable pocket incorporated into the carbody structure.

The sliding portion of the sash shall be designed to slide freely in either direction. The sash shall be secured by a rugged latch assembly of an approved design, easily reached by a seated Operator. The sash design shall be such to allow the sliding portion to maintain any derived opening during normal operating conditions. Positive latching in the closed position is required as well as positive retention in any of the designated open positions.

The handle shall be designed and positioned to provide the best ergonomic condition for closing, locking, latching, and opening movements. No more than fifteen (15) pounds of force shall be needed to initiate opening of the sash and no more than ten (10) pounds of force shall be needed to move the sash from any other point. The lock shall be of a highly durable design which is resistant to being picked or forced open from the exterior. The lock assembly shall contain a key lock feature that will allow the Operator to lock or unlock the window when desired. However, it shall not lock automatically, thus allowing the window to latch open or closed at any time with the key lock in the open position. The key lock shall be designed to use the standard coach key. The forces shall be demonstrated and measured during the FAI of the first assembly units.

If the drop sash assembly is mounted from the interior side of the car and the installation results in gaps between the assembly and the car’s side sheet, a reverse bezel frame shall be incorporated to interface with the design of the drop sash assembly. The reverse bezel shall mount and seal against the full perimeter of the exterior opening of the side sheet, interface with the sliding window assembly, and seal against the interface point of drop sash assembly itself. Each of the seal applications for the reverse bezel to the exterior window opening and to the drop sash assembly shall be designed to be die cut, elastomeric material and not be dependent upon tube-type, curable seal products.

### 3.7.6 Side Door Windows

Side entrance door windows shall be fixed single glazed units supported directly in the side door with endless neoprene glazing strips. The glazing strips shall be laced from the inside of the car. The glazing strips shall be designed to be watertight without the use of sealants.

The window glazing material shall be single thickness, clear or tinted as required, mar resistant, coated polycarbonate of sufficient thickness to conform to the requirements of the Type II test specified in TS 3.7.1 and shall meet the requirements of TS 17.8.

### 3.7.7 Collision Post Door Windows

The window, mounted in the collision post door, shall be fixed type mounted directly to the door. The window assembly shall be designed to meet the FRA Type I impact requirements listed in TS 3.7.1.
The construction of the collision post door window shall require the use of 9/16 inch minimum thickness, triple laminated, clear glass as manufactured by Sierracin or Triplex, or approved equal, with a DuPont 307 spall shield.

3.7.8 Powered Vestibule End Door Window

Windows mounted in the vestibule end doors shall be constructed of clear, single thickness, mar resistant coated, clear polycarbonate of sufficient thickness to conform to the requirements of the Type II test specified in TS 3.7.1 and shall meet the requirements of TS 17.8.2.

The window shall be secured directly to the vestibule end door with an endless neoprene glazing strip laced from the outside of the door.

3.8 STRESS ANALYSES

3.8.1 General

Prior to carbody and truck testing, the Contractor shall prepare and submit for review and approval stress analyses of the carbody and truck structure and equipment supports for any element of equipment weighing over 150 pounds. Stress analyses for supports for items weighing less than 150 pounds may be requested for review at the discretion of the Engineer.

The Contractor shall use the stress analysis as an engineering tool to aid in the design of the lightest weight car and truck in compliance with the requirements of the Specification. Structural tests shall be conducted in accordance with the requirements of TS 18.2 to confirm the accuracy of the analyses as required by TS 3.8.

The approved stress analyses shall be a prerequisite for approval of the structural test procedures and structural drawings required by this Specification and shall be used as an aid in determining strain gauge locations during the tests. [CDRL 03-024]

The stress analyses shall indicate the calculated and allowable stresses and Margins of Safety for all elements for all specified load conditions. The stress analyses shall, as a minimum, include finite element analyses (FEA) using recognized computer programs such as NASTRAN, ANSYS, STRUDL, ALGOR, or approved equal, supplemented as necessary by manual or computer calculations of stresses at joints.

The initial stress analyses shall require assumptions as to configurations, weights, and the method of manufacture all of which may require reevaluation and change as the designs are developed. As changes are made to the original assumptions, the stress analyses shall be revised and submitted for review. The final submitted and approved stress analyses shall be for the car and truck in the as built configuration.

All stress analysis reports shall conform to the requirements in TS 3.8.6.

The following meanings shall apply in performing the analyses:

a. Permanent Deformation
A member shall be considered as having developed permanent deformation if any one of the following conditions is met:

1) The minimum yield strength as published by ASTM for the specified material and grade is exceeded. For materials or grades not covered by an ASTM specification, the minimum yield strength as guaranteed by the manufacturer is exceeded. For materials without a specific yield point, the 0.2 percent offset method shall be used to determine yield strength.

2) The material has buckled or deformed and does not return to its original shape or position after the load is released.

b. Ultimate Load Carrying Capacity

The ultimate load carrying capacity of a member is the maximum load that the member can support before it separates at its ultimate strength or completely fails as a column.

c. Margin of Safety

Margin of Safety (MS) is:

\[ MS = \frac{\text{Allowable Stress}}{\text{Calculated Stress}} - 1 \]

The calculated stress shall include the applicable load factors. MS shall be a minimum value but a positive number.

d. Load Factor

Load factor is a number by which the actual or specified load is multiplied in computing the calculated stress. The load factor shall include all applicable safety factors.

3.8.2 Stress Analyses and Test Plans

Carbody and truck stress analyses and test plans shall be submitted for approval no later than 120 days after NTP. It shall be discussed during the first design review meeting. The plan shall be a working document and updated as the design develops. When the plan for the analyses and testing is revised, it shall be updated and resubmitted no more frequently than monthly. Each revision shall include revision level indications. [CDRL 03-025]

The stress analyses and test plans shall include an outline of the procedure the car builder shall use to analyze and test the design of the carbody and truck. It shall also include the following:

a. A listing of all load conditions to be used during analysis and test including load magnitudes and points of application with Specification references.
b. A description of the analysis to be used for each load condition.

c. Acceptance criteria for each load condition.

d. Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each analysis.

e. Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each test.

f. A table of material properties showing the engineering properties of each grade and temper of each material used in the car and truck structures. This table shall include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension, compression, and shear elastic moduli. For all material properties, an acceptable source for those properties shall be cited. In each case, minimum guaranteed values from the specifications for the corresponding grade and heat treatment of the material shall be used. Materials, grades, and tempers not used in the carbody construction shall not be included in the tables. The table shall list the properties of the fasteners and the welds.

g. A description of the major assumptions used in the stress analyses.

h. A description of how analyses results shall be correlated with test results.

i. A list of all connections deemed “potentially critical”, e.g. all corner and collision post connections, all connections of the end underframe to the carbody, and the underframe.

j. A list of all structural tests to be conducted on the carbody and truck along with acceptance criteria.

The stress analyses and test plans shall be approved prior to submittal of the stress analysis report required by TS 3.8. The plan shall be made a volume of the stress analysis report. The plan shall follow the general requirements of the report in TS 3.8.6.

### 3.8.3 Finite Element Model Report

The Contractor shall submit the carbody and truck elastic finite element analysis (FEA) model for review and approval prior to performing the analyses. [CDRL 03-026] The element grid, all assumptions, and all input data such as loads, constraints, section properties, and material properties shall be included as part of the preliminary submittal and again as part of the complete analyses. Solid elements shall be used for major structural areas of the truck frame and bolster.
If requested, the Contractor shall submit the complete electronic FEA input data files and output result files (for carbody and trucks) in a format readable by analysis software, such as ANSYS or FEMAP or approved equal. If a solid model was used to develop the FEM, the parameters of the model shall be supplied as electronic input on CD ROM. The first model report shall be submitted not later than 180 days after NTP. The Engineer shall specify the selected program prior to submittal. If requested, submittal of the input data files and output results files shall be part of the review and approval of the stress analyses. Submittal of the model may be required with the FEM report and at any time thereafter that the file is revised and changed but no more frequently than monthly. All resubmittals shall include a list of changes to the model.

The element mesh, all assumptions, loads, boundary conditions summed totals of reactions forces and moments, area properties and material properties, and units used shall be included as part of the preliminary submittal and again as part of the complete report. A key to all symbols and colors shall be included. Boundary reaction forces of the carbody and truck at AW0 shall be included. Each load condition submittal thereafter shall also include diagrams of areas of mesh refinement.

The FEM report shall include a structural diagram (layout) of the carbody (including sheathing) and truck showing the locations of all members and shapes and indicating the material and dimensions of each. Methods of joining shall be completely defined. As a minimum, the following views shall be included on the carbody structural sketch: side elevation, top view of the roof and the underframe, and typical cross-sections of the carbody at a window, side doors, and full-height side frame posts. For the truck, the following views shall be included in the structural sketch: side elevation, top and bottom views, and typical cross sections at key changes of geometry and weld types. Cross sections of the structural members with shape, dimensions, material, and thickness shall be shown.

The FEM report shall include a list of drawings with revision levels used to develop the model. As drawings are revised, the model shall be updated to reflect the changes, or there shall be documentation to indicate that the drawing changes do not affect the FEA results to be included with the next FEM submittal.

### 3.8.4  Carbody and Truck Stress Analysis Report

#### 3.8.4.1 General

The stress analysis report shall be prepared and submitted for review and approval no later than 60 calendar days prior to the scheduled commencing of manufacture of any carbody and truck structural parts. [CDRL 03-027]

The stress analysis shall show the calculated and allowable stresses and Margins of Safety for all elements for all specified load conditions.

The stress analysis shall include calculations of stresses in joints, joint elements, and other important elements. It shall include FEA results, connection, buckling, natural frequency, and fatigue analyses.
In computing the shear strength of a beam, only that portion of the beam which is in line with the force vector shall be considered as resisting the force. If the force is skewed to the web of the beam, the force vector shall be divided into components, one in line with the web and the other in line with the flange. The shear resistance shall then be computed separately for each component. There shall be a table showing geometric properties such as area and section moduli.

The report shall demonstrate that all structural members satisfy the requirements of this Specification in compliance with each design load and condition and of good practice in the rail transit industry. The report shall be organized and in sufficient detail so that the Engineer can readily follow the theory and its application to the car. The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted to the Engineer.

A summary of the results of calculations of stresses in all structural framing members and shear panels shall also be included. The locations, where calculated stress levels equal or exceed 80 percent of the allowable stress criteria specified in TS 3.3 and TS 11.1, shall be shown in a separate table along with the design and operating conditions (loads) which precipitate them.

The report shall include detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing. There shall be a summary table listing the Margins of Safety of all major members and any other member where the Margin of Safety is less than 0.20 together with the affected joints under all specified loads. The table shall include:

a. The identity of the member
b. Its location
c. The load condition
d. The Margin of Safety
e. The page on which the analysis can be found
f. The material of that member
g. The allowable stress of the members

3.8.4.2 Finite Element Analysis

As part of the stress analysis, a linear-static finite element analysis (FEA) of the complete carbody and truck shall be performed. The FEA shall be a recognized computer program such as NASTRAN, ANSYS, Algor, STRUDL, or approved equal. The purpose of the carbody and truck FEA, along with other analyses types, shall be to show that the design meets the requirements of the Specification. In the event that stresses measured during structural load tests do not agree with the results of the FEA, the measured stresses shall be considered correct and the FE model revised and the analysis rerun (see TS 3.8.5, Validation of Stress Analysis).

The submittal input and output shall have each page numbered and columns of data shall be clearly labeled on each page using terms, symbols, abbreviations, and units defined in the analysis report.

At the discretion of the Engineer, finite element models (FEM) and results shall be reviewed during the conferences conducted within three (3) weeks after each submittal. At these conferences, SEPTA shall have full access to the FEM input, output, and use of the software on the computer used for the analysis.
Color plots shall be prepared showing the following:

a. Deflections in all three (3) axes
b. von Mises or other approved combination stresses
c. Maximum and minimum principal stresses
d. Direction of maximum and minimum principal stresses
e. Meshing accuracy index
f. Maximum shear stress

All plots shall show the maximum and minimum values and all values which are greater than 80 percent of the specified maximum value. Each drawing shall include a triad showing the direction of the global axes. Plots at high magnification shall be keyed to a plot showing the structure to an extent sufficient to orient the high magnification plots.

The report shall include all reaction forces, summed totals of reaction forces and moments, and a table to show static equilibrium for each load case.

If requested, the FEA input and output data shall also be submitted on electronic media as approved by the Engineer. The electronic files shall be in a format readable by SEPTA software, such as ANSYS or FEMAP, the specific format to be determined by the Engineer prior to submittal. Submittal of the electronic data files is required with the report and at any time the file is changed but no more frequently than monthly. Criteria for final approval of the stress analysis shall include the Contractor’s submittal of the fully configured input and output data files as required by this paragraph. This can be combined with the requirements of TS 3.8.3.

Upon completion and approval of the final design, the FEA model and analysis report shall be updated to represent the final configuration of the structure.

3.8.4.3 Connections

The report shall include analyses of all critical connections of major structural elements under all specified load conditions.

Critical connections, which cannot be adequately analyzed, shall be prototyped and tested to demonstrate compliance with the requirements of the design and the Specification.

The report shall include analyses of all critical and highly loaded connections showing that the joint is stronger than the weakest member being joined as required by TS 3.3.

The FEA shall be supplemented, as necessary, by manual or computer calculations of stresses at joints.

3.8.4.4 Buckling

The inelastic buckling strength of structural members subjected to any combination of compression and shear shall be calculated. The variation in the stainless steel compression modulus with stress shall be considered in calculating compressive stability of stainless steel members.
The buckling values shall be used as the basis for the allowable stress values for the specified load cases. Any member in any of the elastic static analyses with a calculated compressive stress equal to or greater than 35 percent of its material’s yield strength shall be included.

3.8.4.5 Natural Frequency

The natural frequency of the carbody under AW3 load and rigidly supported at the bolsters shall be calculated. Also refer to TS 3.3.1.

3.8.4.6 Fatigue

An analysis of the fatigue life of the car and truck shall be included in the stress analysis report as required by TS 3.3 and TS 11.4. It shall include a tabulation of the Contractor’s selection of allowable fatigue stresses with data sources and assumed fatigue stress ranges for structural members which are critical in fatigue.

The minimum allowable fatigue stress range for the carbody is computed by multiplying the static stress at the AW3 load by the dynamic factor. The dynamic factor shall be determined by the Contractor but shall not be less than +20 percent. The allowable fatigue stress range shall be based on a calculated car shell lifetime of 10 million cycles. This stress range must be within the design fatigue stress range obtained from one of the following sources as approved by the Engineer:

a. For carbon and low alloy steel members, the stress range shall be obtained from AAR C-II, Chapter VII, or AWS D1.1, latest edition.

b. For spot welded structures, the Contractor shall conduct a sufficient number of fatigue tests to determine the fatigue properties of the welded structure. The Contractor shall consider the effect of multiple spot welds and different spot weld arrays when planning the test program.

c. The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for materials or joint designs not covered by the above requirements.

The fatigue stress range and acceptance criteria for the truck is detailed in TS 11.4.1 and TS 18.2.1.10. The fatigue analysis section of the stress analysis report shall include table(s) showing the minimum static and fatigue strengths of single and multiple spot welds. Values shall be given for each material, temper, weld size, and thickness combination used in the carbody. The source of the data shall be provided.

3.8.4.7 Crashworthiness

The Contractor shall include an analysis showing that collision failure (collapse) will begin at the ends of the car.
3.8.4.8 Manual Analysis

A manual analysis shall be conducted to closely examine details of the carbody and truck (weld connections, welded and/or bolted joints, fatigue conditions) that are not readily handled by the FEA. The manual analysis format shall consist of a title, sketch of item to be analyzed with dimensions and applied forces, drawing reference, material properties, allowable stress, detailed stress analysis, and conclusions.

As a minimum, a manual analysis shall be performed on the following items:

   a. An analysis of the critical connections of the major structural elements and the critical loading conditions
   b. An analysis of the strength of the connections of the trucks to the carbody including calculated vertical and horizontal connection load limits
   c. An analysis of the truck equalizer beams
   d. An analysis of the axles
   e. An analysis of the coil springs
   f. An analysis of equipment hangers

3.8.5 Validation of Stress Analysis

Validation of the FEM shall be accomplished by comparing the carbody and truck structural test results for each test required by TS 18.2 with the corresponding stress analysis results or other method approved by the Engineer. This information shall be tabulated and submitted with the carbody and truck structural test reports for each test.

In the test procedure for each test to be used for validation, there shall be a preselected list of strain gauges to be used for the comparison which shall not be less than half of the total number of strain gauges used during the test. This table shall include a gauge number, element number, location, stress analysis strain value in the direction of the gauge, direction of the gauge on the carbody and truck, a column for the strain gauge value, and a column for notes. The test report shall include tables that compare stresses calculated from the test strain gauge readings with analytical stresses from the FEA and shall include the test stress value, the analytical stress value, the percent difference between the two values, and a space for annotation. The report shall include a graph, plotted in MS Excel, comparing the stresses calculated from the test strain gauge readings with analytical stresses from the FEA.

The percent difference between the two values shall be within 15 percent for 75 percent of the compared values of the test results and analytical results.
If the analyses results do not agree with the test results within the above specified tolerance, the Contractor shall revise the stress analyses, update the FEM, and rerun all FEA. All manual analyses using data from the FEA shall be recalculated using the corrected values. This process shall be repeated until agreement of results is within the specified tolerance. The stress analysis report shall be revised and re-submitted. All results from re-analysis shall meet Specification requirements. The design shall be corrected if such requirements are not met.

For any of the remaining 25 percent of the compared values, if the analytical values disagree with the test value by more than 15 percent and the test value is equal to or greater than 35 percent of the yield strength of the material, a detailed explanation of the reasons for the excessive variance shall be included in the carbody and truck test report. This explanation may include supporting manual calculations.

Approval of the carbody and truck test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.

### 3.8.6 Reports

The Contractor shall submit the required stress analysis report in compliance with the format and content specified herein. If a cited reference is not readily available to SEPTA, the Contractor shall provide the reference or copies of the pertinent pages. All references shall be in English. If an English reference cannot be found, an English translation shall be provided, and both the original and the translation shall be included in the report.

In addition to the body of the analysis, the stress analysis report shall include, at a minimum, the following:

a. A table of contents

b. The algebraic statement of all formulas and equations before the related calculations are performed along with the definitions of all terms and the values and units to be applied to these terms. In addition, the pages that show the development and interpretation of the formulas or data shall be included.

c. Units with all quantities

d. References for all formulas, calculation procedures, buckling coefficients, material strengths, fatigue strengths, and other physical and mechanical properties where these items appear in the stress analysis.

e. Each page, including all stress analysis sheets, shall be numbered, dated, and initialed by the author or analyst and checker, and in the event of a revision, the revision letter, date, and initials of the analyst and checker.

f. Particular reference to, but not limited to, the following:

   1) Side sill
2) Body sills (if used)
3) End sill
4) Anti-climber
5) Draft sills
6) Coupler supports
7) Side frame rails
8) Side frame posts
9) Transverse and longitudinal sections at doorways
10) Body bolster
11) Floor and floor beams
12) Collision posts
13) Corner posts
14) Structural shelf
15) Roof structure
16) Equipment supports
17) Connections between structural elements
18) Truck frame

If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall show the test procedure, raw data as well as reduced data, and summary with detailed discussion of the results.

A table, listing and defining all symbols and abbreviations used in any analysis, shall be included.

g. A table providing the physical properties of each material (grade and temper) used for the carbody and truck. This table shall include yield strength, ultimate strength, elongation, tension, compression, and shear moduli. Minimum acceptable values shall be used and shall be selected from the ASTM (or equal) material specification.

h. A tabulation of the Contractor’s selection of allowable fatigue stresses for the carbody and truck material and each type of weld joint and assumed applied fatigue stress ranges for members and weld joints which are either highly or critically loaded.

### 3.9 SAFETY APPLIANCES

All safety appliances shall conform to the requirements of 49 CFR 231.14 and 231.12. Handholds and safety appliances shall be kept within the car construction outline.

All safety appliances shall be polished stainless steel with stainless steel fasteners for installation. Exterior and interior handholds shall be forged of a one piece 5/8 inch stainless steel rod with the exception of item i. below. As a minimum, the handholds shall be located as follows:

a. Each collision post (4)
b. Each body end door post (4)
c. Each vestibule side door interior post (8)
d. Two (2) horizontal each car end (4)

e. One (1) diagonal on each side of passenger entrance steps (one (1) on the underside of the trap door) (8)

f. Above end vestibule side doors horizontal (4)

g. Each corner post above the Trainman’s foot step (4). These should be horizontal, if possible, but must provide for stable positioning of the Trainman when in use with the foot step.

h. One (1) vertical at each quarter point door vestibule bulkhead at the aisleway (4)

i. One (1) horizontal at each quarter point door bulkhead, 36 inches above the finished floor (8)

j. One (1) vertical at each end side door exterior vestibule post

A loop step shall be provided at each F-end corner of the cab car as required by 49 CFR 231.14.

Critical fasteners shall be used to apply safety appliances. Refer to TS 17.2.2.

60 days prior to commencing manufacturing of the first carshell (for instance cutting, burning, forming plate or receiving structural sections, etc.), the Contractor shall prepare detailed layout(s) for review with the FRA of all safety appliance locations and methods of mounting, major equipment mounting and supports, seat mounting arrangement, smoke and flame compliance, emergency egress locations for emergency windows and roof access points, and supplemental power arrangements for emergency lighting and public announcement communication equipment. [CDRL 03-028]

At least 30 days prior to the shipment of the fully assembled pilot car, the Contractor in coordination with SEPTA shall notify the FRA’s Office of Safety Assurance and Compliance that the car is ready for inspection. The Contractor shall then coordinate a sample car inspection with the FRA’s designated representative(s). The Contractor shall address all deficiencies found during this inspection to ensure that the car complies with all CFR requirements. [CDRL 03-029]

### 3.10 BUFFER, SAFETY BARRIERS, AND DIAPHRAGMS

#### 3.10.1 Buffer Assembly

All cars shall have a buffer foot plate and face plate at each end sill.

The face plate shall accept the diaphragm and be free to move in a direction parallel to the length of the car to the extent required for track curvature and car dynamics. It shall be guided and held against the face plate of a mating car by a tubular side stem and compression spring arrangement. A sound deadening material, UHMW-PE UV or approval equal, shall provide both deadening and low friction non-lubricating capabilities to the tubular side stem rod guides. The front face shall be covered with the UHMW-PE UV material.
The buffers shall not bind during normal train operation.

### 3.10.2 Safety Barriers

A stainless steel safety bar shall be provided at each end of each car. It shall be used to form a transverse barrier between collision posts. It shall be secured to one post on a pivot pin and shall latch securely in both the horizontal and stored (vertical down) positions. The latches shall not protrude into the clear opening of the doorway.

### 3.10.3 Diaphragms

Tubular non-metallic modular maintainable diaphragms shall be provided at both ends of all cars. For the trailer cars, the diaphragm shall be similar to SEPTA’s three (3) piece wrap-around style. The F-end of cab cars shall consist of a five (5) piece design with radius elements vulcanized into the diaphragm’s assembly to preclude noise generation from headwind exposure during operation. Diaphragms shall provide a tight seal and exclude water ingress and drafts under all normal operating conditions.

Diaphragms shall be made of cloth reinforced molded neoprene tubes which shall be clamped to the structure by an easily removable rectangular bar. Diaphragms shall be constructed of the following parts made in neoprene rubber as covered in Federal Specification HH-P-151F, Class 2, or approved equal, but in all cases shall comply with the smoke, flame, and toxicity requirements of 49 CFR 238, Appendix B. The supplier shall submit designs for applying an exterior coating to the neoprene tubes that will allow them to slide easily on each other and will also extend their life. The diaphragm size, arrangement, and installation shall be compatible with existing SEPTA commuter rail vehicles and approved by the Engineer. [CDRL 03-030]

### 3.11 INTER-CAR BARRIER

Both ends and both sides of each car shall be equipped with pantograph type hinged gate assemblies or approved equal, four (4) per car. The gate shall comply with the requirements of 49 CFR 38.109 and shall be designed to prevent individuals from inadvertently falling between cars from level (high) boarding platforms. The gate assembly shall be stainless steel and shall maintain constant contact with the gate of the adjoining cars under all conditions and requirements. A mechanical keeper latch shall be provided for each gate to retract and secure the gate against the end of the carbody when required. The latch shall be constructed of stainless steel and shall not require a key for operation. The gates shall function in a safe and satisfactory manner under all operating conditions encountered throughout the SEPTA system. Wear plates shall be replaceable and made with phenolic laminated Gatke material. Details of the design, arrangement, and installation of the barrier shall be submitted to the Engineer for review and approval. [CDRL 03-031]
3.12 SANDING SYSTEM

Two (2) stainless steel sand boxes, with a capacity of at least five (5) cubic feet of sand each and sanding apparatus, shall be provided on each cab car. Controls, piping, and hoses shall be arranged to permit sand to be deposited on the rail ahead of the leading wheels, when the cab car is at the head end of a train, automatically when a locomotive wheelslip or emergency brake application occurs and manually as requested by the Operator. Sand boxes shall be designed with appropriately sloped sides to allow efficient gravity feed of sand to the traps. Method of adding sand and sealing the box after each sand addition shall be subject to approval by the Engineer.

Solenoid control valves shall be Salem 500-BS or approved equal. Sand traps shall be Salem 277-2, or approved equal, with integral rotary sand shutoffs and quick disconnects. Sand boxes and sand traps shall be located under the car just forward of the truck. They shall be inside of the side sill on each side of the car.

Control of sand from the cab car shall be by means of two (2) spring return lever, "wobble" type toggle switches. One (1) switch shall control forward and reverse sanding on the locomotive, and the other switch shall control sanding on the cab car only. The switches shall be connected to illuminate the "sand on" light when either switch is actuated. Details of the design, arrangement, and installation of the sanding system shall be submitted to the Engineer for review and approval. [CDRL 3-032]

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4 CARBODY INTERIOR

4.1 INTERIOR FINISH

4.1.1 General

The design and attachment of all interior fittings shall comply with the requirements of 49 CFR Part 238.233 and APTA-PR-CS-S-006-98, Standard for Attachment Strength of Interior Fittings for Passenger Railroad Equipment. The car interior shall be pleasing in appearance, modular in design, and free of sharp corners or edges to eliminate the possibility of injury to passengers, train crew, and maintenance personnel in either normal usage or emergencies. Design emphasis shall be placed on integration of components, maintainability, passenger safety, aesthetics, and cleanability. All interior materials shall comply with the requirements of TS 17. Surfaces requiring paint are not permitted. Access covers and panels shall, wherever possible, be flush when closed. All corners shall be rounded, and all joints, corners, etc., shall be designed to minimize collection of dust and avoid passenger injury by pinch points, projections, sharp edges, or other hazards. Flat horizontal surfaces shall be avoided on linings and appliances to prevent dust collection. If the interior lining has a pattern, all doors and access covers shall be made out of the parent lining in order to maintain the pattern match. Thermal breaks or barriers shall be provided to prevent seated passengers from contacting cold surfaces on the side wall exclusive of the window glazing.

All materials provided for the interior of the car including the cab shall be selected for a high level of strength, rigidity, durability, and resistance to scratching and marking in addition to the other specified requirements. No material shall suffer any loss of performance when exposed to temperatures ranging from -20 degrees F to 160 degrees F or exhibit degradation of properties (including color) under long term exposure to ultraviolet light. No material shall produce any odor that would be noticeable or irritating to the passengers, Operator, or train crew. No material shall degrade or stain when exposed to food, drink, graffiti, or any cleaners used by the SEPTA Railroad Division. Metal castings used on the interior of the car that are visible to passengers shall be an investment casting or equal. Sand castings shall not be used.

The interior design including lining materials, attachment methods, colors, and finishes shall be as proposed by the industrial designer and approved by the Engineer. [CDRL 04-001] Special attention shall be given in the design regarding human factors and ergonomics for the train crew and passengers in accordance with the requirements of TS 1.5. High contrast colors shall be used as visual clues as an aid to visually impaired passengers especially for the interior entranceways, wheelchair areas, handholds, and steps. The selection of the type of materials to be used, colors, and surface finishes shall be approved by the Engineer prior to any material purchase. The sources for all interior components shall be selected from those suppliers having manufacturing facilities within the continental United States of America for ease of replacement. Exceptions to this requirement may be authorized by the Engineer if there are suitable reasons for the variance.
Wherever specific lining materials are called for in this Specification, it is for the purpose of establishing a level of strength, rigidity, cleanability, durability, and resistance to scratching and marking and does not necessarily imply that these materials will meet the test standards defined in TS 17. Other lining materials with at least equal durability which comply with these requirements may be proposed for approval. It is intended that all interior materials have durability sufficient for a minimum service life of 20 years without replacement with the desired service life being in accordance with TS 2.1.4. The finish color shall extend through all lining materials except melamine and fiberglass reinforced plastic (FRP). All exposed stainless steel shall be given a grit finish as required in TS 17.3.2. Grain direction shall be arranged to suit the decorative scheme.

Fiberglass reinforced plastic or approved equal coated with DuPont Tedlar composite material shall be used to the extent practical to provide large radius corners, smooth transitions, and minimize molding while providing a graffiti resistant surface. Non-directional patterns and colors shall be used on the Tedlar composite and colored to minimize the appearance of dirt and graffiti as well as coordinated with the interior color schemes proposed for the cars.

Access to apparatus mounted within the carbody shall be afforded by the use of access panels or doors. It shall not be necessary to remove any linings or partitions to inspect or clean any part of the HVAC equipment, door operating equipment, or any other equipment requiring periodic inspection or maintenance. Removal of moldings shall not be required to gain access to equipment areas or for maintenance or cleaning.

4.1.2 Installation

The car interior shall be designed to minimize the time and cost required for future repair work by using, for example common components wherever possible. While joints on side linings shall be appropriate to the window placement, they should also be located to require the minimum number of seats to be removed for future panel replacement. All linings shall be designed for easy removal and installation. For ease of accident repair, all linings shall be individually removable without the need to remove adjacent linings. The use of “keyed” linings, which must be installed or removed in sequence starting at one end of the car and working to the other end, is prohibited.

The interior linings shall be designed and mounted to avoid vibration when the car is in operation, and no panel shall sag, drum, buzz, or produce other sounds at any time. Expansion or other provisions shall be incorporated as needed to guard against potential cracking or crazing. All joints exposed to passenger view shall be covered by moldings or be trimmed or configured in a finished manner to result in a pleasing appearance and both designed and applied with a high level of workmanship and shall be free from gaps.

The mounting of interior lining components shall be designed to accommodate the dynamics of car movement without transmitting stress to the liners. All inside and outside corners shall have a one (1) inch or greater radius to both prevent accident injury and preclude dirt accumulation. There shall be no concealed areas, hidden corners, or cavities in the interior where contraband may be hidden. All interior covers and access doors unless specified otherwise shall require the use of the standard key to open. Interior linings shall be designed to have a liberal radius cove at intersecting adjacent surfaces specifically at all inside radii of the intersecting surfaces of the heater guard and floor to partitions, end bulkheads, cabs, seat enclosures, and doorway partitions. The transition between the heater guard and
side wall and the door pocket linings shall be designed to eliminate inside corners to enhance

cleanability.

"Anti-squeak" Neoprene (chloroprene) or cork elastomer tape shall be used between linings and any
structure to which they are attached or with which they come in contact. Where linings conceal any
apparatus requiring replacement or even infrequent maintenance, they shall be fastened with captive
tamperproof machine screws designed to allow ready access for removal and replacement of apparatus.
The interior linings and moldings shall be free of all undulations. The maximum allowable variation from
a designed contour on all interior surfaces shall be 0.125 inch over three (3) feet in any direction. Fluorescent lighting fixtures shall be supported from the car structure and not the linings.

The design and layout of the interior linings shall minimize the size and number of the seams and
moldings. Exposed fasteners shall be allowed only for specific approved applications, and the quantity of
fasteners per application shall be kept to a minimum. Items on which exposed fasteners will be
considered for use are access panels, cab console, heater guards, coat hooks, and door hardware.
Specific approval is required for the use of exposed fasteners on any other interior application. All screw
hardware used shall be Phillips head type made from stainless steel. It is desired that only one size
screwdriver shall be necessary to remove all lining attachments and trim.

All trim used to conceal joints and inside or outside corners shall be standardized sizes of satin finished
stainless steel or other materials proposed by the industrial designer and approved by the Engineer.

All joints and connections shall be tight and rattle-free. All holes in the linings or carbody
structure for mounting trim shall permit complete interchangeability of parts. All hinges shall be full
length stainless steel piano type, and any other interior mounting or latching trim shall be of stainless
steel.

4.1.3 Moldings

The interior lining design shall minimize the use of moldings. However where necessary, moldings shall
be used to cover all joints. Snap-on, H-type, plastic insert, or other approved types having no exposed
fasteners shall be used. Moldings shall be hard surfaced plastic, plastic coated aluminum or steel, or
aluminum or steel coated with polyester powder coat in a color and gloss matching the adjacent lining.
Moldings shall be mechanically attached to the interior linings. Extrusions shall be designed to prevent
trim inserts from shifting out of position and be tight, gapless, and rattle free. The attachment of all
interior appurtenances shall be designed to meet the requirements of APTA-PR-CS-S-006-98, Standard
for Attachment Strength of Interior Fittings for Passenger Railroad Equipment.

4.2 PASSENGER SEATS

4.2.1 General

Both the upper level and lower level main seating areas shall consist of seating units designed for two
passengers each placed in rows located on both sides of the center aisle (2x2 seating). Fixed single seats
shall also be used to take advantage of any available space where multiple passenger bench seats
cannot be installed and shall be used to enhance passenger flow aspects for approaching and exiting the
seating area.
Seating direction shall be split in half from the transverse centerline of the car and face the closest end of the car. Seats nearest bulkheads may face either the bulkhead or be turned to face the center of the car depending on which direction achieves maximum foot space and leg room.

The upper level seating area shall be designed in a way that the seating may be later modified to a 3x2 seating layout. In order to limit seat types, the pedestal placement for all seating shall be based on the pedestal placement on the seat frame that would be sized by the shorter width of a 2x2 designed for 3x2 seating layout.

All main seating area transverse seats shall follow the aisle and seat width minimums as required in TS 4.2.2.

Intermediate level seating shall consist of one (1), two (2), or three (3) passenger seats, whatever is appropriate for maximum seating while taking into consideration passenger flow, access to maintenance lockers, ADA wheelchair parking, bicycle restraint devices, and the ability to park luggage. All intermediate seating area seats shall be of a flip-up seat configuration to assist in accommodating these requirements.

Approval shall be required prior to placing a quantity order for any seat type. Details of the design, construction, installation, and arrangement of the passenger seats shall be submitted to the Engineer for review and approval. [CDRL 04-003]

4.2.2 Arrangement

The Contractor shall submit detailed drawings of the seats, seat installations (including pedestal placement dimensions and wall connections), with respect to the interior arrangement for each car configuration. [CDRL 04-004] A minimum seat pitch of 32 7/8 inches shall be maintained throughout the carbody based on seat assemblies with a seat back tilt of fifteen (15) degrees unless otherwise approved by the Engineer.

The Contractor shall design the interior arrangement to maximize seating capacity while providing a high degree of passenger comfort. The interior arrangement shall allow the smooth flow of passengers while entering, exiting, and moving through the vehicle.

When determining pedestal placement for the optional upper level 3x2 seating arrangement, it shall be based on a twenty (20) inch aisle. Individual seats within the 3x2 multi-seat assemblies shall be based on an eighteen (18) inch minimum width or larger as long as the aisle width is maintained.

Once the pedestal location is determined for the narrower two-seat unit in a 3x2 seating arrangement, it shall serve as the standard pedestal location for all seats.

Once the standard pedestal location has been determined, 2x2 seat units shall be sized for maximum width based on a 23.6 inch aisle. Passenger flip-up seats shall be installed in each intermediate level. The flip-up seats shall be designed to be mounted to the side wall of the intermediate level.
Each seat shall be provided with approved holders for tickets in use by SEPTA. The ticket holder shall be a Donovan Associates, Inc., Drawing Numbers 11492-2, or approved equal, and be affixed to the top of the seat back on the seat adjacent to the aisle. Seats in the intermediate area shall have ticket holders attached in the proximity of each seat and may be wall mounted provided they are not in the path of passengers so as not to become snagged on clothing or cause loss of ticket from contact with passengers passing by. The method and materials used to attach the ticket holders to the seat shall be approved by the Engineer. [CDRL 04-005]

4.2.3 Transverse and Flip-up Seat Construction

As much as possible, seat framing shall not be visible, but where visible it shall be satin finish stainless steel or approved alternative. Visible carbon steel seat structure powder coated in an approved color is permissible on the longitudinal seats. All non-visible seat structures shall be powder coated satin black or other approved color in accordance with a powder coat process approved by the Engineer. [CDRL 04-006] The underside of the bottom cushion of the flip up seat shall be considered visible.

All upper and lower level transverse seats shall be designed with a molded seat back shell using low toxicity Kydex 6200LTR material or approved equal. The color and finish shall be recommended by the industrial designer and approved by the Engineer. [CDRL 04-007] The seat back shell shall be recessed to provide the required knee room. One (1) seat back shell shall be designed for passenger placements for single and two (2) passenger seats.

All transverse seats shall be supported at the aisle side by a fully enclosed stainless steel pedestal and at the wall side by a bracket using bolted connections meeting the requirements of TS 17.2. Installation shall be applied to longitudinal secondary structure members designed into the car’s side structure and floor structure(s). The side bracket connection shall interface with the carbody's side secondary structural member and be designed to trap the head of the bolt for the installation of the seat's side plate, thus no two (2) sided tool access will be needed for bracket/seat frame installation or removal.

Flip up seat assemblies shall be securely wall mounted in conjunction with pedestal supports located toward the wall to allow open floor space for mobility devices, bicycles and luggage when the seat is in the flipped up position. The back and bottom cushions shall be similar in shape and contour to the transverse seat cushions. The design of the seat back shall consider the location and size of the passenger side windows and in no way limit emergency ingress/egress or passenger visibility out of any window unless otherwise approved by the Engineer.

The seat back shall be angled when the seat is in the down position but retract back to become flat to allow a compact folded unit when the bottom is in the stored up position. The entire assembly shall be designed to remain “up” (closed) or “down” (open) securely by means of springs and/or counterbalances without the need for a latch. The force required to operate the seat shall be minimized to the extent possible but in no case shall the operating force exceed ten (10) pounds throughout the full range of motion measured at the front edge of the seat.

All pedestal support seat installations to the floor shall be via secondary structural members designed for a blind bolt attachment configuration (bolt head exposed). The secondary structural member shall have a permanently affixed tapping plate attached to the bottom surface of sufficient thickness to meet the requirements of TS 3.3.2.1 and 17.2.2.1.
For transverse seating, floor seat mount member positions shall be based on the pedestal location of the narrowest two passenger transverse seat when installed to the side wall and become the standard pedestal location of all transverse seat frames as required in TS 4.2.1 and 4.2.2. Once determined, the seat members shall be installed equidistant from the car’s longitudinal center line. Due to the standardized pedestal location, the aisle end of the seat portions may be cantilevered as necessary. The same secondary structural member configurations shall be used for fixed transverse single seat floor mounting based on the dimensional characteristics of a single seat’s pedestal location.

The floor covering shall be counter-bored at each pedestal bolt location, and a special washer of a material approved by the Engineer and of the thickness of the rubber floor covering shall be inserted to ensure that the seat fasteners bear fully on the floor tapping rail and not on the floor covering. The attachment shall be sealed watertight with an approved caulk/sealant and in accordance with a procedure approved by the Engineer.

All seat attachment fasteners shall be stainless steel Grade 5 or higher. Nuts, if used, shall conform to ASTM F594, Grade 5, or higher. All tubing shall have ends plugged with stainless caps or other approved methods that provide an aesthetically pleasing appearance.

Approval of the seat securement methods, for each seat type, to the car shall be obtained from the Engineer before manufacturing. [CDRL 04-008]

4.2.4 Testing

All seat types including the longitudinal flip up seats shall be tested to demonstrate the capability to withstand the loads listed below and those defined in 49 CFR 238. Transverse seat frames shall be tested using the standardized pedestal location dimension.

Testing shall be performed using mocked up structural connection elements as found for each installation configuration found in the car. In the case where the car structure connection points differ, such as an upper level seating area support vs. a lower level seating area support, both connections shall be tested though the seat used would be the same.

Seat frame construction and attachments to the carbody and pedestal shall be sufficient to withstand without permanent deformation the stresses to be expected in commuter rail operation but not less than the loads listed below. It is emphasized that each type of seat (including flip up longitudinal), seat attachment, and seat to carbody support structure shall be designed to replicate that of the car and to comply with APTA-PR-CS-S-016-99 Revision 2 and tested per the following:

a. APTA-PR-CS-S-016-99 Revision 2, Section 5.1.1. The test shall be conducted in both horizontal directions from the back of the seat and from the front of the seat. A permanent set of 1/8 inch maximum will be permitted under these conditions.

b. The seat design and installation shall withstand a downward vertical load of 450 pounds applied once to an 8 x 10 inch area located at the middle of each seating area with no failure of the seat assembly and installation. Load shall be applied for a minimum of five (5) seconds.
c. APTA-PR-CS-S-016-99 Revision 2, Section 5.1.3. A permanent set of 1/8 inch will be permitted under these conditions.

d. Test 5.1.4 in APTA-PR-CS-S-016-99 Revision 2, Section 5.1.4. The test shall be conducted for two (2) horizontal conditions: toward the aisle and toward the wall side of the seat.

e. APTA-PR-CS-S-016-99 Revision 2, Section 5.1.2.

f. Two (2) rows of transverse seats shall be tested in accordance with APTA-PR-CS-S-016-99 Revision 2, Sections 5.2.1 and 5.2.2. Seats, seat components, and seat attachments shall be strong enough to prevent the seat and its parts from breaking loose. Seat distortion shall be allowed, however the seat shall not break loose from its fastenings.

g. Each type of seat shall be tested in accordance with APTA-PR-CS-S-016-99 Revision 2, Section 5.3.2.1, with the seat mounted in a simulated car structure. The seat may suffer permanent deformation but shall remain attached to the simulated carbody structure.

h. Each type of seat shall be tested in accordance with APTA-PR-CS-S-016-99 Revision 2, Section 5.3.2.2 with the seat mounted. The load shall be applied in both vertical directions separately. The seat may suffer permanent deformation but shall remain attached to the simulated carbody structure.

i. A human injury test shall be performed in accordance with APTA-PR-CS-S-016-99 Revision 2, Section 5.2.1.

The tests shall be observed and approved by the Engineer prior to seat production. [CDRL 04-009]

4.2.5 Armrests

A fixed armrest shall be provided only at the aisle side of each transverse seat. It shall be on an open stainless steel loop structure which will provide maximum aisle width. The armrest structure shall be designed to withstand the loadings specified in TS 4.2.4. Each armrest shall be formed and finished in a manner compatible with the seat design and consist of a grit finish as required in TS 17.3.2 and have a replaceable arm rest pad mounted on the top horizontal surface. The armrest pad shall be manufactured from textured energy absorbing rounded corner elastomer and shall meet the smoke and flammability requirements of TS 17.24. Each pad shall be removable and replaceable in a manner approved by the Engineer. [CDRL 04-010]
4.2.6 Handholds

Each seat shall have an energy absorbing handhold installed on the seat back functionally similar to the Silverliner V handhold design and shall not protrude into the aisle further than the armrest. The handhold shall be suitable to provide support and balance with proper ergonomics for a standing passenger without inconveniencing the seated passenger adjacent to it. The design shall be a steel frame covered with a textured energy absorbing rounded corner elastomer and shall meet the smoke and flammability requirements of TS 17.24. There shall be no sharp edges, gaps, dirt collecting crevices or seams, or exposed metal surfaces on the handhold or its interface with the seat back. The elastomer coating shall not crack in normal operation. All fasteners used to assemble the handholds to the seats shall be stainless steel flush mounted and not visible to passengers if possible. The material, design, and attachment shall be as approved by the Engineer. [CDRL 04-011]

4.2.7 Cushions

Seat cushions shall consist of a seat bottom cushion and a seat back cushion covered with vinyl seat upholstery. Each cushion shall be a one (1) piece assembly interchangeable with all other seat bottom or seat back cushions of the same type. They shall not rattle or make any noise during car operation and fit against each other and the seat frame when installed without visible gaps or misalignment. To delineate the seat area for each passenger, decorative treatment including contrasting upholstery coloring, upholstery seams, and extended headrests shall be used to support this effect. No bolstering of the bottom cushion or seat back cushion shall be provided. All upholstery material shall fit tightly with no visible wrinkles, sags, or other defects.

The seat bottom cushion shall be designed to be easily removed and replaced for maintenance as a single unit. The cushion assembly shall consist of a heavy duty aluminum pan with a Dutch roll lip on the perimeter which shall support a series of steel coil springs and edge wires manufactured of upholstery grade automatic coiling and knotting wire as supplied by Royersford Spring Company or approved equal. A minimum of 16 springs shall be provided for each passenger position each consisting of a minimum of four (4) rings with two (2) active coils. The springs shall be 10 gauge with 10.5 gauge for the middle of each seating position. All springs shall be 0 center coils with either double strands of 19 gauge lacing wire or a single strand of 17 gauge lacing wire. The use of knotted coils is prohibited. Edge wire shall be 8 gauge with open ends fastened with an 18 gauge ferrule 2.5 inches long. Stayrods or braces may be clipped to the edge wires as required for additional stability. Prior to assembly, all springs and edge wire shall be stress relieved at 560 degrees F for 15 minutes. All springs shall be secured by lace wires on all four (4) sides except for the perimeter units and secured to the edge wire with a minimum of one (1) clip. All lace wires shall be securely turned over the edge wire. The spring assembly shall be enclosed by a flame retardant canvas case. The top and four (4) sides of the spring assembly shall then be covered by a fabricated silicone foam assembly one (1) inch thick with an IFD firmness rating of approximately 75 consisting of Magnifoam Technology Inc. Model MF1-9575 foam or approved equal. The seat cushion assembly shall be mechanically secured to the seat frame with a 3M pressure sensitive adhesive Velcro or approved equal fastener system installed with 3M model 94 primer. Visible fasteners shall be avoided. Screws or other hardware if used shall be flush mounted stainless steel.
The seat back cushion shall be designed to be easily removed and replaced for maintenance as a single unit. It shall provide passenger comfort with the thinnest possible back and incorporate a headrest. The cushion assembly shall consist of a heavy duty aluminum pan with a Dutch roll lip on the perimeter and a one (1) piece molded or fabricated beveled back cushion of Chestnut Ridge Foam, Inc., CF Safeguard XL, or approved equal combination of chloroprene latex and polyurethane foam designed for long term transit service durability. The foam shall have an IFD firmness rating of 35 to 40 and be of an approved thickness with additional foam thickness in the upper corners or wherever required to improve appearance. The back cushion assembly shall be mechanically secured to the support frame. Visible fasteners shall be avoided. Any assembly hardware shall be flush mounted stainless steel.

The vinyl upholstery covering material shall be a non-expanded transportation grade vinyl seating material meeting the requirements of TS 4.2.9. Color, grain, and finish shall be as proposed by the industrial designer and approved by the Engineer. It shall be designed with a two (2) tone finish to hide dirt and must be resistant to all graffiti cleaning materials used at SEPTA without any deterioration. The vinyl upholstery shall be attached to the bottom and back cushion assemblies by a combination of a 0.75 inch wide polypropylene sewn on strip that locks into the Dutch roll lip of the pan along with fire retardant 3M pressure sensitive adhesive Velcro material (installed with 3M model 94 primer) or approved equal and arranged with the hook side on the pans and the loop side on the upholstery. All foam cushions shall meet the requirements found in TS 17.

All upholstery seams shall have high mechanical strength, and transverse seams in the area of the front upper edge of the seat cushion are to be avoided. The covers shall be sewn with #69 nylon thread. The thread color shall match the vinyl color in all visible areas. All stitching shall be a minimum of six (6) lock stitches per inch. Pull tabs shall be double stitched to the stiffeners. One (1) inch of each end of stiffeners shall be double stitched. All cushion assemblies shall be properly vented to prevent ballooning. The design and assembly drawings, materials data sheets, and detailed assembly procedures for all seat cushion assemblies shall be submitted to the Engineer for review and approval. [CDRL 04-012]

4.2.8 Flip Up Seat

For all cars, the general appearance and colors of the flip up seats shall match the transverse passenger seats. The flip up seats shall be similar in comfort and identical in strength to the transverse passenger seats. The flip up cushion seats shall consist of folding bottom and back cushions cantilever mounted to the side wall. The flip seat design shall consider the passenger side window size and location. Flip seat back cushions and support structure shall not obstruct the vision of any passenger window.

The seat bottom cushion assembly shall be hinged to fold up using an over center spring hold up device for the stored position and stay in the up position until lowered with the back of the cushion pivoting down. The seat back cushion assembly and seat bottom cushion assembly shall be mounted to the wall structure. The bottom cushion assembly shall be suitably hinged such that when folded up it provides the maximum clearance for parking mobility devices in the accessible area. Each flip up seat shall stay in the position, up or down, in which it is placed. Alternative designs may be submitted to the Engineer for review and approval.
The seat shall be mounted to side wall brackets with additional support structure and to the heater guard rail and floor structure as required. The area under the seats shall be free of obstructions and equipment compartments, boxes, and lockers to maximize floor space when seats are placed in the up position.

Due to the seat bottom not having a positive latch system, the seat bottom as exposed in the vertically stored position shall not be used for any retention device. However, the flip up seat structure may be designed to accommodate retention devices if desired.

### 4.2.9 Covering Material

The seat headrest/crash pad upholstery material shall be woven transportation grade fabric backed vinyl with a minimum weight of 34 ounces per yard. The seat back and bottom cushion upholstery shall be woven transportation grade fabric backed vinyl with a minimum weight of 30 ounces per linear yard. The upholstery shall meet all smoke, flame, and toxicity requirements and all physical properties in TS 17.24 and 49 CFR 238, Appendix B.

Abrasion tests of this material shall be demonstrated by testing to ASTM D4157 using the Wyzenbeek Method. Conditioning of samples should be accomplished in accordance with ASTM D751, Section 4 – Standard Conditions, Item 4.2 – Temperature Atmosphere. All test procedures and test data shall be submitted to the Engineer for approval. [CDRL 04-013]

The seat back and seat bottom cushion upholstery material shall be a transportation grade vinyl. The seat upholstery shall meet all smoke, flame, and toxicity requirements and all physical properties in TS 17.24 and 49 CFR 238, Appendix B.

A fire retardant moisture barrier shall be applied between the covering material and the foam if the foam absorbs or holds moisture.

Seat covering colors and texture shall be approved by the Engineer. [CDRL 04-014] One (1) interior color scheme shall be used on all cars.

Each seat shall accommodate up to four (4) colors or patterns. The material shall be applied and fastened in an approved manner and shall be easily removed from the cushions in an approved manner to facilitate cleaning. The completed seat cushions shall have a smooth appearance free of all wrinkles, puckers, and pulls. Two (2) 8 x 10 inch samples of each proposed seat covering material shall be submitted to the Engineer for approval prior to the purchase of any material. [CDRL 04-015] After the material is selected and approved by the Engineer, three (3) 8 x 10 inch samples of actual production materials shall be provided for SEPTA’s records. [CDRL 04-016]

### 4.2.10 Fire Resistance

The armrests, seat cushions, covering materials, and any other materials used in the seat shall meet the fire resistance, smoke emission, and toxicity requirements of TS 17.24 and 49 CFR 238, Appendix B.
4.2.11 Seat Mock Up

Mock ups of each seat type as defined in TS 1.6.6.5 shall be provided. The mock up seats shall be developed in conjunction with and to supplement the design drawings approved by the Engineer. In addition, one sample seat of each type and mounting configuration shall be submitted by the Contractor for public review and comment and for approval by the Engineer. Approval of both the design drawings and the mock up seats shall be required prior to proceeding with production. [CDRL 04-017]

4.3 ACCESSIBLE PROVISIONS

4.3.1 General

Seating provisions for two (2) passengers with disabilities shall be provided on each car. The side doors at the B-end intermediate level shall provide access to the car for passengers using mobility devices. The ADA seating area shall meet the requirements of 49 CFR Parts 27, 37, and 38, or latest regulation, and U.S. Department of Transportation Section 504 covering the barrier free transportation of the elderly and handicapped.

4.3.2 Accessible Seating

Two (2) and/or (3) three passenger folding seats as described in TS 4.2 shall be provided on all cars. In their normal position, the seats will be used as conventional passenger seats. When the seat cushion is raised, it shall provide space and features to accommodate a wheelchair. The Contractor shall submit their seating plan to the Engineer for approval. [CDRL 04-018]

The seats shall be similar in comfort, size, and strength to the other seats provided. The hinge mechanism for the seat bottom cushion shall be designed to hold the cushion in either the raised or lowered position. The movable bottom shall remain in the last selected position. A mounting bracket shall be permanently attached to the seat bottom cushion which shall allow for the future addition of a wheelchair restraint device. The bracket shall be mounted either on the frame below the cushion pivot point or on the cushion bottom.

Details of the seat designs and securement feature shall be submitted to the Engineer for review and approval prior to the manufacturing of the seats. [CDRL 04-019]

4.4 CEILING AND SIDE LININGS

4.4.1 General

Interior ceilings and linings shall meet the requirements as shown in TS 4.1.

Conformance with the performance and flammability standards shall be the responsibility of the Contractor, and all materials supplied shall have test data from an independent test laboratory and test results shall be submitted to the Engineer for review and approval. [CDRL 04-020]
4.4.2 Car Ceiling

A minimum ceiling height of 76.2 inches shall extend down above the aisle for the entire length of the upper and lower passenger seating areas.

All panels used for main upper and lower center ceilings shall be made of honeycombed material assemblies as described below for the intermediate area or of high strength aluminum sheeting of a thickness designed to be robust enough not to allow oil canning and/or drumming. If high strength aluminum sheet material is used, the thickness shall be chosen on its ability not to oil-can or drum after installation, but also contain stiffening elements to the back where not in contact with roof structural members to aid in sound dampening and stiffening if necessary.

It shall contain an exposed surface with a 0.040 inch thickness of integrally colored melamine bonded to the ceiling material. If the ceiling application contains a profile other than being flat, ceiling panes shall be pre-formed to the necessary arc prior to the application of melamine so the decorative surface is not in compression or tension after the application of the panel into the car. No apparatus shall be installed in the center of the center ceiling panels within four (4) inches above the open aisle. Covers for apparatus such as speakers and ambient sensors shall be low profile with smooth beveled edges and have no sharp corners.

The ceiling panel and associated side ceiling assemblies shall be of a solid color and texture as determined by the Industrial Designer’s plan approved by SEPTA. The integrated units shall consist of the overhead lighting units and HVAC supply ducts. The lighting units shall be of aluminum construction meeting the design requirements of TS 9.1. For the ducts, the interior of the duct assemblies shall be cleanable and constructed of aluminum or a combination of materials, proven equal to or better, and be approved by the Engineer. They shall interface cleanly with no gaps and integrate harmoniously with the center ceiling panels, all of which shall be adequately supported from the carbody roof and upper level floor structures. The shape of the integrated duct/lighting assemblies contours shall be smooth transitions within its shape with no sharp corners or edges exposed for both the unit and associated trim or apparatus that might be included in its design. There shall be no inside corners and all lines shall be angled in such a way not to allow “shelves” to catch and retain dust, dirt, etc.

Ceiling panels and assemblies in all areas shall have elastomeric tape applied at each mating surface between the car structure and the panels/assemblies to prevent squeaks and rattles and isolate vibration.

Sloped overhead transition panels such as those found in the stairwell shall be designed as locker doors using the requirements of TS 4.4.6.
Within the intermediate level, the ceiling shall consist of flat ceiling panels constructed of 0.375 inch overall thickness panels, faced on the exposed surface with an 0.040 inch thickness of integrally colored melamine bonded to 0.025 inch thick aluminum sheet with an epoxy adhesive, or approved equal. The core shall be 0.375 inch cell aluminum honeycomb, or approved equal. The back or top surface of these panels shall be closed off with a 0.015 inch thick aluminum panel, which shall have a 0.25 inch downward facing flanges. The entire joint shall be filled with epoxy adhesive thus bonding all three aluminum members together. The exposed transverse edge of this panel shall be closed off with a 0.015 inch thick aluminum angle, epoxy bonded to the top surface of the panel. Transverse joints shall be spaced no closer than four (4) feet. These panels shall be mounted to the upper structure appointments so as to allow easy removal for access for air duct cleaning. They shall not rattle or buckle in service and shall be mounted with a stainless steel, or approved equal, trim material or system allowing them, when in place and sealed, to be moisture resistant and air tight.

Hinged access panels and covers shall be provided to maintain the HVAC and other equipment mounted above the ceiling in the intermediate areas. The ceiling shall be composed of the minimum number of pieces consistent with the need for access to this equipment. Each panel shall contain a lockable latch to secure the panel closed. Maintenance points often accessed by different personnel, such as HVAC filters, shall have locks operated by a standard coach key. Any other drop panel that accesses electronics and/or diagnostic points shall use the electric locker barrel key as referenced in TS 4.13.

Hinged panels shall meet the requirements of TS 4.4.9, however the material of the access door may be the same as the honeycombed panel material used for the remaining ceiling material.

Longitudinal joints in this ceiling area are permissible only at light fixtures. The hangers shall be secured to the overhead structure either by welding or by an Engineer-approved mechanical fastener arrangement, and shall be spaced no more than three (3) feet four (4) inches apart.

No visible installation fasteners, as viewed by the passengers, shall exist on all ceiling mounting applications.

If door operator access is unable to be fully located above the ceiling line where access would be achieved through a standard ceiling access panel, an access housing fabricated of fiberglass reinforced plastic (FRP) may be added to allow enclosure and access to door operators and associated equipment. If so, its exposed surface and shape should be treated similar to the integrated HVAC duct assembly as found in the main passenger seating areas. The latches shall be of the barrel lock key latch.

### 4.4.3 Sagging and Drumming

All ceiling panels shall be adequately supported to prevent drumming and sagging. The ceiling panels and air diffusers shall be supported by hangers fixed to the roof structure on the upper level, the upper level floor structure on the lower level, and the equipment compartment structure on the intermediate level. These hangers shall be located at a maximum interval of 40 inches in any direction. There shall be no longitudinal seams on the aisle area ceiling panels except as required for access panels on the intermediate level. All transverse joints shall be supported and covered with approved battens. The color of the battens shall be compatible with the adjacent panels.
4.4.4 Side and End Walls

4.4.4.1 General

The end wall panels shall be 1/2 inch minimum thickness integrally colored melamine faced plymetal of balanced construction with a plywood core or approved equal. Stainless steel advertising frames of an approved design shall be mounted on the passenger side of the end walls. Any attachments to the wall must have inserts installed per the manufacturer’s instructions and tooling.

The side wall wainscot panels shall be constructed of 1/8 inch minimum thickness integrally colored unbalanced FR grade melamine or integrally colored melamine faced .081 inch aluminum. All joints shall be supported and covered with approved battens. All battens shall be designed to fit snugly without gaps. The color of the battens shall be compatible with the adjacent panels.

The exposed surfaces of these materials shall match the approved color layout per the industrial designer’s review. The color and surface finish and method of fastening shall be submitted to the Engineer for approval during the design review of the cars and before the manufacture of any parts. [CDRL 04-021] Unless otherwise specified, all exposed interior surfaces shall be smooth, uniform in color and appearance, and shall not deviate from the required contour by more than 3/32 inch in any 36 inches distance. The slope of any such deviation shall not exceed 3/32 inch in 12 inches.

4.4.4.2 Partitions

The partitions between the end of car vestibule and the passenger area and between the quarter point entranceways and the center passenger seating areas shall be of 1/2 inch minimum thickness integrally colored melamine faced plymetal of balanced construction with a plywood core or approved equal. Alternate facing materials may be submitted for approval if the alternate material has equal or better physical properties, cleanability, and durability to melamine. Stainless steel advertising or SEPTA route map frames of an approved design as described in TS 4.11.3 shall be applied to the exposed side of the partitions. The partitions shall support a vertical grab handle and one (1) end of a horizontal grab handle.

Any partition if not already stainless steel located in part of the vestibule or any other location to be determined a wet area shall have a stainless steel panel applied six (6) inches from the bottom edge. A seven (7) inch stainless steel kick plate shall be located on the exterior of the partition in high traffic areas.

Windscreens shall be provided between the quarter point entranceways and the end of car seating areas. The windscreens shall have brushed stainless steel trim at the aisle side to capture the aisle end, support a vertical grab handle, and one (1) end of a horizontal grab handle. The grab handles shall be mounted on the entrance side of the windscreen. The windscreen construction shall be of a robust design.
The upper part of the windscreen shall consist of 0.460 inch thick clear polycarbonate glazing with a mar resistant coating. The glazing shall be secured in a channel attached to the top of the trash module and the tower. The exposed edges of the polycarbonate shall be ground smooth. The top corner of the glazing shall also be secured to the vertical stanchion in an approved manner. The lower part of the windscreen shall be manufactured from fiber reinforced polyester and shall incorporate the trash receptacle module.

Windscreens in the wheelchair area may be narrower in width to provide adequate maneuvering space.

The horizontal grab handle shall be 36 inches above the finished floor and shall extend from the doorframe to the vertical trim on the aisle end of the partition and windscreen. At the vertical trim, the horizontal grab handle shall blend into the trim in a gradual radius so that the grab handle does not present an abrupt protrusion at the aisle end.

The partition shall have a stainless steel bottom. This stainless steel support structure shall function as a heater guard on the vestibule side to provide vestibule heat if required. The partition shall be directly connected to the structure supporting the floor and to the ceiling in a manner to support the loads expected from the use of the grab handles and/or a 500 pound horizontal, lateral, or longitudinal load applied over an area of 16 square inches at a height of 57 inches above the floor.

4.4.4.3 Window Masks

The interior finish between and around the side windows shall be constructed of 1/8 inch minimum thickness fiberglass reinforced composite panels or approved equal. DuPont Tedlar® or approved equal shall be used as a facing material. The facing material shall be of a grade recommended by the manufacturer and applied to the fiberglass in a post mold process approved by the Engineer. [CDRL 04-022] These panels shall completely mask the space between and around the windows and shall have edges adjacent to the glass and covered by the Neoprene glazing strips.

The masks shall be sloped to preclude dirt collection in this area. On the lower sloped surface adjacent to the bottom of the window light, the window mask shall have outlets for warm air discharge. The outlet holes shall have a maximum diameter of 7/32 inch. The outlet hole area shall be reinforced with a double thickness of the same material or a stainless steel insert securely fastened from the underside with no exposed fasteners.

The material to be used for these panels shall be submitted to the Engineer for approval prior to any purchase of material. [CDRL 04-023]
4.4.4.4 Wainscot Panels

Wainscot panels shall be located beneath the window masks and the seat mount extrusion and match the length of the window masks or sidewall panels above them. The wainscot panels shall be made of aluminum backed melamine meeting the requirements of TS 17.9.6. Each melamine panel shall accommodate a duplex passenger convenience outlet as described in TS 4.10. Holes to accommodate the duplex passenger convenience outlet and/or any electrical box shall be far enough beneath the window mask to clear any structural members and typically 24 inches forward of the seat back for transverse seats. Locations for convenience outlets on single transverse seats and wall mounted seats in the intermediate level shall be conveniently located to seats with special focus to mobility aid device parking areas and will be subject to SEPTA’s approval.

Any cut outs that result in inside corners either for the fit up of the wainscot panels to the car or cutouts for the duplex receptacles, the inside corners must be predrilled with a 0.25 radius to prevent future stress cracks.

4.4.5 Door Pockets

All door pocket panels shall be constructed of 3/8 inch minimum thickness integrally colored melamine faced plymetal with a plywood core. Other plymetal facing materials with improved properties may be submitted for approval. Stainless steel brackets approved by the Engineer [CDRL 04-024] shall be used to stiffen the plymetal panels. The exposed surface of the panel shall contain the melamine facing while the hidden surface of the panel shall be faced with type 304 stainless steel. The exposed surface shall match the finish specified in TS 4.6. The partition shall have a stainless steel bottom.

Each door pocket panel shall have a flush piano hinged access door which shall provide easy and full access to the door operator, linkage, emergency release mechanism, all limit switches, exterior lights, and terminal boards, for maintenance, service, adjustment, removal, and repair. The finish of the access door to the door pocket shall match that of the door pocket panel. The access door shall contain a lock using the standard SEPTA crew key. Any door panel greater than 36 inches in length shall have multiple locks. A hold open device shall be provided to keep the door open during servicing. The device shall be self-storing and rattle free when stored and not engaged. Door pocket panels shall be designed for full removal of any equipment mounted within.

Door pocket panels shall be adequately supported to prevent drumming. The minimum size of the door pocket panels shall be sized to accommodate standard SEPTA advertising frames and door latches. All door pockets shall have hinged access panels to allow easy access to the door tracks for each side door.

The transverse end panel of the door pocket shall be constructed of 1/8 inch thick integrally colored unbalanced melamine FR grade with a backing panel of 1/8 inch thick melamine or 3/8 inch thick integrally colored melamine faced plymetal with a plywood core. Other materials with improved properties may be submitted for approval.

4.4.6 Equipment Locker

There shall be two (2) classifications of equipment lockers:
a. Maintenance – Maintenance lockers shall house electrical/mechanical car equipment that will be accessed by maintenance personnel. Maintenance lockers shall be secured by a barrel key type lock set.

b. Crew Access – Crew access lockers shall be lockers that operating crews may access for either personal storage, general storage, or for access to equipment controls. Crew access lockers shall be secured using the standard lock set.

In certain circumstances such as an electrical locker with circuit breaker panels that may need to be accessed by crews, a door within a door concept shall be used. Electric lockers should be designed so circuit breakers are isolated and near the door’s surface. In this case, a door with a standard key lock will be used to access the breakers only, however full access to the electric locker will be via the use of the barrel key.

All equipment locker doors shall use slam to lock and key to open designs.

Equipment lockers shall be located in the intermediate levels or under the stairwells of all cars. The equipment locker shall be welded on all sides and joints and constructed of type 304 or 430 stainless steel panels on the sides, back, door, floor, and ceiling. Alternative materials may be submitted to the Engineer for review and approval. The stainless steel shall be lined with a minimum 1/8 inch thick "Haysite" insulating panels or approved equal. All wire passages, joints, and seams in wall linings shall be sealed with SEPTA approved firestop material.

The area above the intermediate ceiling and below the roof shall be designed to house the self-contained heating, ventilation, and air conditioning system, low voltage power supply, and battery charger. For major repairs and overhauls, the HVAC system shall be removable through roof hatches. Routine service and inspection activities shall be performed using hinged panels accessible from inside the car.

The access door shall utilize a continuous stainless steel piano hinge designed to support the door under all conditions. The door shall be bound on all edges with a satin finished stainless steel channel epoxy bonded in place and be flush with its surrounding surface when closed. The access door should be flush and squared with locker sides. A secure stainless steel hold open bar shall be incorporated into the door opening to prevent the door from closing when required for maintenance and operating the equipment. The hold open device shall be released manually by closing the door. It shall be rattle free when disengaged. All overhead and ceiling access panels and covers shall be equipped with spring safety catches and safety lanyards. Safety lanyards shall be designed with materials that will not allow rattling when the ceiling panel is closed and in its normal position. The safety catches shall engage to limit the panel opening to approximately four (4) inches below the finished ceiling height. When the catches are released, the lanyards shall limit the panel opening swing to approximately 45 degrees.

Arrangement and access of all equipment lockers and compartments shall be presented during the review of the mock ups and pilot cars. [CDRL 04-025]
### 4.4.7 Underseat Enclosures

Seats which are mounted with their back against a vertical surface, such as a partition, or back-to-back may be mounted on an underseat enclosure box, as approved by the Engineer, provided that there is no loss of passenger leg room. The seat enclosures shall be constructed of a stainless steel structural frame, and faced with sheets of fine grit finished stainless steel. The front face and aisle side of the enclosure shall be recessed four (4) inches from the side of the bottom cushion. All access covers shall be bottom hinged, face the next forward facing seat, be spaced at least one (1) inch above the floor to prevent water entry, have a key lock and close tightly against an elastomer gasket to prevent any rattles while in service. Bolt-on stainless steel gasketed covers using stainless steel fasteners may be used for access to apparatus not requiring maintenance more frequently than every 5 years. All exposed enclosure corners, including covers, shall be smoothly rounded. The enclosures shall be watertight to allow for floor washing.

### 4.4.8 Material Approval

For material samples proposed by the Contractor during the industrial designer program and during design review of the car for the Engineer's approval, the Contractor shall provide ten (10) samples of all colors identified by the Pantone Matching System (PMS) indicators along with textures and finishes of the material proposed for the cars. [CDRL 04-026] The samples shall be large enough to demonstrate the patterns but in no case shall samples be less than eight (8) inches by ten (10) inches. The source of these samples in melamine shall be Wilsonart or Nevamar Company; floor coverings shall be Altro; window glazing shall be GE Margard or Atohas Tuffack; seat upholstery shall be Uniroyal Corporation or approved equal. The Contractor may offer other materials and sources for the Engineer's approval, but the Contractor shall first ensure that these alternative sources meet the requirements stipulated in TS 17 or as required in this Section. It is preferred that the sources for all new interior components be selected from those having manufacturing facilities within the continental United States of America for ease of replacement. Exceptions to this requirement may be authorized by the Engineer if there are suitable reasons for the variance.

### 4.5 FLOOR AND FLOOR COVERING

#### 4.5.1 Floor Construction

The floors shall be constructed so that all applicable noise, vibration, strength, and fire requirements are met.

The Contractor shall immediately after installation provide a protective mat or hardboard sheeting over the entire composite floor to prevent damage from workers, equipment, tools, or material during the balance of the construction of each car shell.

The floor on all levels shall be constructed of minimum 0.750 inch thick composite panels faced on the entire top and bottom surface with 0.100 inch minimum thickness bi-axial fiberglass fabric impregnated with a Phenolic thermosetting resin. The fiberglass reinforced Phenolic skins shall be permanently bonded to an approved foam core through a compression molding process, co-curing the wet Phenolic resin impregnated skins directly against the core. (Refer to TS 17.9.7 for floor panel material requirements.)
For the upper level floor only, the Contractor may propose an alternative floor system that acts as an integral component of the floor support structure such as a one (1) piece aluminum extrusion modular floor system. Continuous full length steel tapping rails for seat mounting shall be incorporated into the side walls and modular floor system; tapping plates capable of securely mounting seat pedestals shall be included. The alternative modular floor system shall be service proven for commuter rail applications and shall demonstrate compliance with the design and performance requirements specified. The alternative floor system shall include a provision to attenuate airborne and solid borne noise and vibration along the path from source to passengers and crew. The floor construction and material shall be submitted to the Engineer for review and approval. [CDRL 04-027]

The panels shall be comprised of pieces as long as practical which shall extend in three (3) rows with two (2) rows being between the car sides and the structural pedestal support member for its respective side and the aisle located between both pedestal support members. All joints shall be located over structural members. All structural members shall have permanent metallic shims applied to bring their surfaces equal to any flange thickness of the structural pedestal flange to make the panel mounting consistent in height for both the perimeter connection surfaces and passive support where the panels pass over structural members. Transverse panel to panel joints may consist of ship lap joints or square butt joints as needed as long as the joint chosen does not allow the panel’s edge to deflect under load. When lap joints are used, the laps shall be arranged in such a manner that the vestibule panels are installed last. All final installation details must be reviewed and agreed to by the panels’ manufacturer in writing and is subject to SEPTA’s acceptance. [CDRL 04-028]

Under no condition shall there be any joints in the top or bottom face skins of the panel. The panels shall be insulated from the metallic structure by elastomeric tape. All exposed edges of the panels including interior pass through holes, cutouts for ducts and conduits, and joints between panels shall have a dense Phenolic syntactic composite edge machined smooth and free of sharp edges and burrs.

Each panel shall be secured around its perimeter using appropriate sized stainless steel flat head, countersunk fasteners. The location of the fasteners shall be within the solid core material surrounding the panel only, and countersinking shall extend below the surface of the panel so that the screw head is slightly inset from the surface and then later filled with leveling compound and made level.

A floor leveling compound approved by both SEPTA and the floor panel manufacturer shall be used to fill all gaps between panel junctions and panel interface joints to the carbody structure. The leveling compound shall then be used to level the floor.

The Contractor shall submit a full installation view showing the floor support details required in TS 3.3.2.1 along with all panel details for floor installations as described within this section for the review and approval of the Engineer. [CDRL 04-029]

The intermediate and lower level floor designs shall be tested to meet fire requirements prior to the Contractor’s procurement of production material (refer to TS 17.24).
4.5.2 Strength Requirements

The floor deck shall not deflect more than 1/250 of the shortest span between supports from a load equal to the sum of dead loads plus a uniformly arranged AW3 passenger load.

The composite panel used in the floor shall conform to the strength requirements of TS 17.9.7.

4.5.3 Floor Covering

Floor covering shall be of a vinyl/acrylate material with a minimum thickness of 2.5 mm. It shall have a minimum slip resistance of 0.68 D as measured by ASTM D2047. The floor covering shall meet the requirements as found in TS 17.24 for smoke, flame, and toxicity. The color of the floor covering shall be as approved from the color choices submitted per TS 1.5.2. If an alternative floor system is in the upper level, the top of the floor shall be flat (flatness) within 0.062 inch in three (3) feet in any direction.

The seams between the floor panel and vertical structure shall have an approved sealant applied to prevent moisture ingress. Sealant shall be applied prior to installation of the floor covering. The back of the floor covering sheet shall be sanded before it is laid and then securely bonded to the composite panels with an approved adhesive. The type of adhesive shall be as recommended by the floor covering manufacturer and installed as required by the manufacturer of the floor covering. The adhesive shall be selected on the basis of secure floor covering adhesion and serviceability while permitting future removal of the floor covering without damage to the floor panels. The floor covering shall be installed such that the covering in the aisles can be replaced without disturbing the covering under the seats or removing any seats.

The floor covering shall be laid in one (1) continuous strip the full length of each passenger section. The floor covering width under the seats shall extend from the side wall to the aisle area.

The floor covering in the aisle shall be applied so that it may be replaced without disturbing the covering under the seats or require removal of the seats, stanchion, windscreen, etc.

Where the floor covering reaches the walls of the carbody, it shall be finished with a suitable sanitary cove of stainless steel or approved equal which may be incorporated into the heater guard enclosure. Matching sanitary corner pressings shall be properly fitted and secured at all corners for ease of maintenance and cleaning. The cove shall prevent liquids on the floor from entering any cavities behind the walls and heater guards. A tinted sealant matching the floor covering shall be used to seal the edges. The maximum fill gap shall not exceed 3/16 inch. The sealant material shall be approved by the Engineer. [CDRL 04-030]

At all door openings, the floor covering shall connect properly to eliminate potential tripping hazards and form an approved watertight seal with the threshold plates.

The floor covering adhesive shall be epoxy based. Prior to use, the proposed adhesive shall be reviewed by both the floor covering manufacturer and the manufacturer of the composite floor panel to achieve concurrence that the adhesive is appropriate for the application. A test sample shall be done where sample flooring is applied to a sample panel for a peel test to determine that the floor covering can be removed without damaging the floor panel. This test shall be witnessed by SEPTA.
The pilot car floor covering installation shall be performed per the manufacturer’s instructions and under the surveillance of the manufacturer’s representative. All of the following floor covering installations shall be performed using manufacturing processes developed during this event. The process and materials shall be outlined and documented. Such documentation shall be reviewed first by the manufacturer for compliance and then by SEPTA. [CDRL 04-031]

4.5.4 Thresholds

All body end doors and side door thresholds shall be of stainless steel with a Darkar-coated surface and where required shall incorporate guides for sliding doors and drain holes to carry off water and accumulated debris. Adhesive backed non-skid "tape" shall not be permitted.

All thresholds shall have a permanent band of color(s) running the full width of the threshold which contrast from the adjacent floor by 70% as determined by the following formula:

\[
\text{Contrast} = \left[ \frac{(B_1-B_2)}{B_1} \right] \times 100.
\]

Where \( B_1 \) = Light Reflectance Value (LRV) of the lighter area, and \( B_2 \) = Light Reflectance value (LRV) of the darker area

Thresholds for sliding doors, which have door guides incorporated into the threshold, shall have renewable and adjustable plates to allow for minimizing the play in door panels when fully closed.

4.5.5 Bridge Plate Assemblies

Each quarter point doorway area shall have an approved bridge plate method of eliminating the platform gap and making that doorway ADA compliant wheelchair accessible to the intermediate levels of the car. It shall be permanently affixed in the doorway area and deployable by means of hinging and/or sliding into position only when the train is stopped, the doorway is configured for high platform loading, and the appropriate door leaf is open. The bridge plate shall be covered with a continuous replaceable or renewable nonskid material with a static dry coefficient of friction of no less than 1.25 in the deployed position. With the bridge plate in the deployed or stowed position, the floor in the doorway vestibule shall have the same anti-slip rubber as used in the remainder of the car’s aisle flooring and shall not have protrusions from the surface or vertical transitions greater than 1/4 inch. The bridge plate shall be capable of accommodating car floor heights from +1 to -5 inches greater than platform heights as determined in the design review.

All aspects of the bridge plate use will be under local train crew control. Bridge plate design shall prevent door closure when not properly stowed. The bridge plate shall be as light as possible, have smoothly rounded corners and edges, and be easily deployable not requiring more than 10 to 15 seconds of effort by a single crew person. The bridge plate shall be deployed manually with a process that will not involve undue lifting, turning, bending, stooping, pushing, or tugging manual effort. The bridge plate shall be robust and not affected by racking or rough operation or use. Alternate designs for bridge plate deployment will be considered during design review. The proposed design must be tested for strength by a 600 pound load concentrated on a single axle where it will be rolled across the bridge plate extended over a five (5) inch drop thus simulating a low platform condition without severe deflection to slow down the roll and leave no permanent deflection in the bridge plate’s ramp extension.
or damage to any other portion of the assembly. The bridge plate shall comply with the requirements of CFR Part 38.95. The design shall be approved by the Engineer. [CDRL 04-032]

4.6  DOORS

4.6.1  Side Doors

4.6.1.1  Construction

The side doors shall be of metal construction with honeycomb core, internally reinforced, and joined into an integral unit by resistance welding. The side doors shall be constructed of stainless steel and of an ample gauge to provide proper strength and rigidity to sustain a concentrated load of 300 pounds minimum applied perpendicularly to the plane of the door at the center of the front edge over a 16 square inch area. The side door shall sustain this load with a maximum deflection of 1/4 inch and without permanent set while the door is freely supported at both ends. Joints and edges shall be thoroughly sealed against moisture with drain holes located in the bottom edge of the doors to allow the escape of condensed moisture. Stainless steel reinforcements shall be provided internally for the attachment of all door hardware. Doors shall be vibration free and insulated against heat and sound transmission in accordance with TS 3.6 and as approved by the Engineer. [CDRL 04-033]

The interior and exterior surfaces of the doors shall be finished in a horizontal grit scratch finish to match the finish of the carbody. The interior and exterior surfaces of the doors shall be properly supported to prevent sagging and bulging.

The doors shall be free of dimples, warping, spot welding depressions, and other deformities. The bottom of the side doors shall be provided with 1/4 inch thick guide plates made of an approved plastic material adjustable in a vertical direction that interfaces with the guide track in the threshold.

Each side entrance door panel shall be equipped with a full height Neoprene rubber edge of an approved design on the leading edge of the door. [CDRL 04-034] It shall provide a tight seal against the passage of air, water, or sound to the car interior. The Neoprene edge for the leading edge of the door shall meet the obstruction detection requirements as described in TS 6.12. The outside leading edge of the door pocket frame shall incorporate a brush seal to prevent entry of snow and ice into the door pocket. The brush seal shall be in full contact with the outer door surface when the door is closed.

The doors shall be constructed so that all hardware, operating mechanisms, and window glazing shall be within the maximum allowable door thickness to allow the doors to operate into the door pockets or along the car side freely without obstruction.

Side doors shall be hung on ball bearing hanger assemblies having the carrier or stem members designed to be fastened to the door. They shall have provisions for accepting mounting hardware. The door hangers shall be as described in TS 4.6.4. Alternative arrangements may be submitted with supporting documentation demonstrating commuter rail applications to the Engineer for review.
Each side door shall contain a window as described in TS 3.6.5 and TS 3.6.6. Window openings, where glazing is to be mounted to the door using endless Neoprene rubber glazing molding, shall be blanked out of the inside and outside door sheets with the edges formed inward to be welded together. The cut out shall have proper radii for approved glazing and molding.

All mounting holes for door hardware shall be jig drilled to ensure interchangeability among cars and the door hardware.

### 4.6.1.2 Corner Vestibule Side Doors

Each end of each trailer car and the B-end of each cab car shall be equipped with a high low sliding-type side door on each side. The non-cab side of each cab car shall be equipped with a high level platform sliding type side door similar to that provided for the quarter point side doors. End side doors shall be mounted as close to the construction limit outline of the car as construction permits. Each end side door shall contain a fixed window. The arrangement of these features is to be considered in developing the design for this vehicle.

The high low end vestibule side doors shall be adequately weatherstripped for high speed service. The edge of the door shall be weatherstripped to form a seal with the door post seal when the door is in the closed position. The door and door post seals shall be applied in an approved manner which enables each to be easily replaced with the door in place. [CDRL 04-035]

The Neoprene edge of the door front on both the upper and lower door panels shall interlock with the door post Neoprene edge when the door is in the closed position and with the door post seal when the door is in the open position.

The end vestibule side doors shall be designed to conform to the car construction clearance line.

### 4.6.1.3 Quarter Point Side Doors

The quarter point car side doors shall be single panel sliding doors with a fixed window and for high level platform access only. The doors shall be mounted as close to the outside of the car as the construction limit outline permits. The leading edge of each door panel shall have a Neoprene edge which conforms to TS 6.12. Each car shall be equipped with four (4) quarter point side doors.

The doors shall be adequately weatherstripped for high speed service. The edge of each door shall be weatherstripped to form a seal with the front edge of the door pocket seal when the door is in the closed position. The space between the door pocket and outside surface of the doors shall be sealed to protect against stones, debris, or weather entering the door pockets when the door is opened or closed. There shall be no detectable drafts within the car or rattling of the doors at maximum speed.

The door pocket weather seal shall be applied in an approved manner which enables it to be easily replaced with the door in place.

Each quarter point doorway area shall have an approved bridge plate per TS 4.5.5.
4.6.2 Collision Post Doors

A hinged collision post door shall be provided at the F-end of each cab car which shall close off the space between the collision posts. The door shall have a fixed rectangular window and shall be equipped with a J. L. Howard Co. Number 2688 or approved equal jamb type lock operated by a standard coach key. The doors shall swing into the vestibule, cover and lock over the left side of the vestibule when in the open position, and be securely latched to permit free passenger movement from car to car. It shall be approved by the Engineer. [CDRL 04-036]

The collision post door shall be of stainless steel construction with a honeycomb core internally reinforced and joined into an integral unit by adhesive and welding. The door shall be constructed of ample gauge to provide proper strength and rigidity to sustain a concentrated load of 300 pounds and applied perpendicularly to the plane of the door at the center of the front edge over a 16 square inch area. The door shall sustain this load with a maximum deflection of 1/4 inch and without permanent set while the door is freely supported at the top and bottom. Joints and edges shall be thoroughly sealed against moisture with drain holes located in the bottom of the doors to allow the escape of condensed moisture. Stainless steel or painted carbon steel reinforcements shall be provided internally for the attachments of all door hardware. Doors shall be vibration free and insulated against heat and sound transmission in accordance with TS 3.6 and as approved by the Engineer. [CDRL 04-037] The exterior surface of the doors shall be finished to match the outside surface of the cars. The interior surface of the doors shall be finished to match the interior surface of the vestibule. The doors shall be free of dimples, warping, spot welding depressions, and other deformities. A self-closing keyhole cover shall be mounted on the exterior of the lock to prevent draft or moisture from entering the lock.

All mounting holes for door hardware shall be jig drilled to ensure interchangeability between cars and the door hardware.

An approved weather seal shall be applied to all four (4) edges (top, bottom, and both sides) of the door which will prevent air, rain, snow, and noise from entering the carbody at the point of interface of the end door and door frame of a lead car traveling 100 mph against a 35 mph head wind. The design and application of weatherstripping shall allow easy maintenance or replacement and shall be subject to the approval of the Engineer. [CDRL 04-038]

In addition to the snap type lock, the collision post door shall be equipped with two (2) approved wedge or "jam" type latches, J. L. Howard Co. Number 2782 or approved equal. The latches shall have handles for operation from inside the car when the door is closed between the collision posts. Handles shall be lowered from a 12 o’clock position to lock.

4.6.3 Vestibule End Doors

Each car shall be designed with a powered (open and close) sliding door at each end of the passenger area. An electric operator shall be provided to assist during the opening cycle. The vestibule end door design shall be approved by the Engineer. [CDRL 04-039]

The vestibule end doors shall meet the requirements of 49 CFR 239 and APTA-PR-M-S-018-10. The doorway at both ends of the coach shall comply with all applicable sections of 49 CFR 27, 37, and 38 latest versions for ADA compliance.
The door shall be provided with the following:

a. A door lock operated from the vestibule by the SEPTA standard coach key. The lock shall turn power to the door operator off when it is in the locked position.

b. Regardless of the condition of the door track, the door shall have equal opening and closing speeds.

c. Approved back lighted (LED type light bars) push touch pads shall be mounted on both sides of the vestibule end wall partition next to the door sensitive edge to control door opening and closing. The switches shall be back lighted when door operator power is “On” and provide visual instructions for operating the door electrically. They shall not light when any of the isolation switches are in the “Off” or “Manual” position. When in the “Off” position, instructions for operating the door manually shall be illuminated noting the door is in manual mode.

The vestibule end doors shall have sensitive edges that reopen the door for 15 seconds after sensing an obstruction before the door is fully closed.

The door operator system shall include the following features:

a. A passenger bypass toggle switch with two (2) positions: Normal and Manual

b. A waterproof vestibule bypass toggle switch with three (3) positions: Open, Normal, and Manual

c. A sensor to provide the same signal to the door operator control as does the sensitive edge switch

d. When either the passenger or vestibule bypass toggle switch is in the manual position, the door shall be easily moveable by hand. Door panel friction, including seals and hangers, shall allow the doors to be opened or closed manually without resistance within two (2) seconds with no more than ten (10) pounds force. When the vestibule switch is in the open position and the passenger switch is not in the manual position, the door operator shall keep the door open.

e. In Normal mode and when the doors are opened with the train at a standstill, door closing shall be interlocked with the “no-motion” circuitry so that the doors automatically close when the vehicle is either above zero speed or after three (3) minutes. The door closing time shall be fully adjustable by SEPTA using software parameters.

f. In Normal mode and when the doors are opened with the train in motion, the doors shall automatically close after five (5) seconds. The door closing time shall be fully adjustable by SEPTA using software parameters.
Vestibule end doors shall be of stainless steel construction, internally reinforced, and joined into an integral unit by resistance welding. They shall be constructed of ample gauge of the same metal as the car structure to provide proper strength and rigidity to sustain a concentrated load of 200 pounds applied perpendicularly to the plane of the door at the center of the front edge over a 16 square inch area. The door shall sustain this load with a maximum deflection of 1/4 inch and without a permanent set while the door is supported at both ends. Joints and edges shall be thoroughly sealed against moisture, and drain holes shall be located in the bottom of the doors to allow the escape of condensed moisture. Reinforcements shall be provided for the attachment of all door hardware. Doors shall be vibration free and well insulated against heat and sound transmission as approved by the Engineer.

Vestibule end doors shall be of rigid construction, free of dimples, warping, and spot welding depressions.

Vestibule end doors shall be hung on ball bearing hanger assemblies having the carrier or stem members designed to be fastened to the door and shall have provision for accepting mounting hardware. The door hangers shall be as described in TS 4.6.4.

The vestibule end door shall be equipped with a fixed rectangular window as described in TS 3.7.8. For each cab car, the cab end vestibule end door shall include in addition to features described in the above a feature that allows for quick safe egress of the Operator into the passenger compartment in emergencies.

### 4.6.4 Sliding Door Hanger Assemblies

Hanger assemblies shall be of the ball bearing type consisting of a track with a ball bearing cage and installed in the car shell with an adjustable locking arrangement. All door hangers shall be lubricated with an approved grease following installation. "T" shaped hanger members for sliding engagement with tapped holes to accept fasteners shall be provided to secure the door panel to the hanger. The hanger assembly shall be Morton Manufacturing Co., Drawing B106-008, or approved equal. Alternative hanger/roller assemblies that have railway vehicle applications may be proposed for approval by the Engineer.

The hanger member shall mate to the inside inboard surface of the upper door channel. The door shall be fastened to the hanger with approved fasteners and lock washers.

The door tracks shall be designed and installed so that a door can be removed from the track intact or a track can be removed by disengaging the fasteners securing the door to the hanger and the track to the car.

The door hangers for the high low end vestibule side doors shall be protected from the environment and be equipped with door threshold heaters.
4.6.5 Equipment Locker Doors

A door shall be provided for each equipment locker located in the quarter point vestibules of all cars. The locker door shall be constructed of the same material as the adjacent equipment locker as specified in TS 4.4.6. The door shall incorporate a continuous spring loaded high strength piano hinge resistant to permanent set or breakage resulting from normal use and shall be mounted flush with the locker surface. It shall have an approved standard SEPTA key lock and shall be easily opened using one hand. The locker door and locker walls shall be lined with “Haysite” or approved equal and shall have a flush mounted pull grip in the outside surface. A stainless steel hold open device as described in TS 4.4.6 shall be provided.

4.7 LUGGAGE RACKS AND STORAGE AREAS

4.7.1 Luggage Racks and Coat Hooks

A continuous satin finished anodized aluminum luggage rack of open construction with transverse rods and cast aluminum mounting brackets shall be provided in the upper passenger seating areas only. Location of the rack shall maximize passenger head room and luggage storage space.

Details of the design, construction, installation, and arrangement of the luggage racks shall be submitted to the Engineer for review and approval. Alternate designs with improved functionality or alternate materials with improved properties may be submitted for consideration by the Engineer.

The luggage rack shall be designed to provide longitudinal and lateral restraint for stowed articles. A three (3) inch high transverse lip shall be provided at each wall support location to prevent the longitudinal motion of luggage. The racks including all attachments to the carbody shall have an ultimate strength sufficient to comply with the requirements of 49 CFR 238.233 and APTA-PR-CS-S-006-98.

The luggage racks shall have sufficient strength to support a distributed load of 250 pounds applied in an area of over 100 square inches midway between adjacent supports without permanent deformation.

Cast end brackets that do not fit against a bulkhead shall be encapsulated in a soft rubber cap piece.

A #4 brush finish stainless steel rub strip shall be installed above each luggage rack section fastened to the side ceiling panel with approved fasteners to protect its surfaces from scratches or other damage. The front edge and each bracket of the luggage rack shall be of sufficient height to ensure retention of the luggage in the rack in emergency conditions.
The bed of the rack shall use transverse 0.50 inch diameter aluminum tubes circumferentially finished. These tubes shall be anchored securely to the front and rear longitudinal rails. The rear longitudinal rail shall have a vertical flange to prevent items from falling down between the rack and the car side wall. All extruded aluminum members shall be satin finished and anodized in accordance with TS 17. The entire luggage rack shall be free of burrs and sharp edges that might cause injury to the passengers, their luggage, or maintenance personnel. The design and construction of the luggage rack shall exclude all possibilities of rattles, squeak, or noise from the rack or its attachments during the operation of the cars. A formed pigmented vinyl fabric covered sponge Neoprene bumper pad shall be provided along the bottom front edge of each luggage rack, along the bottom of each mounting bracket, and at the end brackets. Individually applied strips of material applied with adhesive are not permitted. In mounting the luggage rack to the carbody wall, the mounting bolts shall be torqued to an approved value for the fastener size. Set screws if approved shall be recessed and locked in a manner approved by the Engineer.

On the lower level at each row of seats, a spring loaded flip up pull out flush wall mounted coat hook shall be provided. The coat hook shall be integrated into the window mask panel.

The design, arrangement, and installation of the luggage racks and coat hooks shall be submitted to the Engineer for review and approval. [CDRL 04-040]

### 4.7.2 Crew Storage Bin

A crew storage bin shall be provided at the B-end of each car adjacent to the stairway from the intermediate level to the lower level. The bin shall be equipped with a lockable flush mounted assess door and shall also accommodate the use of a personal padlock. The padlock area on the access door shall be recessed so the padlock and/or lock engagement loop does not protrude into the stairway. No hardware shall be exposed on the access door. The bin shall have a minimum clear storage space 24 inches deep x 20 inches wide x 20 inches high and shall be constructed to support the unrestricted load associated with the crew members, equipment, baggage, and clothing at the following accelerations:

- a. Longitudinal: 8 g
- b. Vertical: 4 g
- c. Lateral: 4 g

### 4.8 MOBILITY AID PARKING LOCATIONS

Each car shall have provisions for the parking of two (2) mobility aid devices located on the intermediate level(s). The spaces shall meet the requirements of 49 CFR 38.95 (D). The wheelchair parking areas shall have a clear approach by the device with ample room to maneuver. Space shall be provided using areas associated to flip up seats. The international wheelchair symbol and “Passengers with Disabilities” decals shall be applied adjacent to each designated area.
4.9 BICYCLE RETENTION

Each car shall contain a minimum of two (2) bicycle retaining devices located within an intermediate level of the car. The retention device shall securely retain a free standing full sized bicycle. A 29 inch model bicycle shall be used for design purposes. The device shall be easily engaged and disengaged. The location of the device shall not impede passenger flow in the stored position nor shall it allow the bicycle itself to become an obstruction that may cause injury to passengers.

The retention device may be incorporated into the intermediate level flip up seat structures and may be located in a mobility aid parking area allowing the space to have an alternate use; however, retention equipment and/or bracketry shall in no way hinder or impede the approach or use of the area by a wheelchair.

Any use of a vertical bicycle retaining device must meet all of the above requirements for passenger flow and obstructions in a stringent manner for both a retained bicycle and/or the bracket structure when not in use.

Decals for instructing the use of the bicycle retention device shall be provided and placed adjacent to the actual device. If the retention device is associated with a flip up seat, the seat bottom will be an acceptable location for the decal; however, an additional international bicycle decal shall be applied next to the wheelchair symbol in the adjacent area. Text, sizing, layout, and location shall comply with ADA and APTA requirements and be subject to approval by the Engineer. [CDRL 04-041]

The bicycle retention device shall be tested during the pilot mock up phase. The Contractor shall provide a full sized 29 inch bicycle for this purpose.

The design and application of the bicycle retaining device shall be subject to the approval of the Engineer. [CDRL 04-042]

4.10 PASSENGER CONVENIENCE OUTLETS

A flush style 120 VAC duplex convenience outlet shall be installed in the wall panel adjacent to seating within the car using GFCI circuitry. The outlets are intended to provide power for passenger electronic equipment such as lap top computers. The passenger convenience outlets shall be located next to each transverse seat as required in the wainscot requirements found in TS 4.4.4.4. The passenger convenience outlets in each car shall be protected by four (4) separate power circuits each of which shall be equipped with a 20 amp GFCI circuit breaker with test and reset buttons.

4.11 LETTERING, SIGNS, AND NUMBERS

4.11.1 General

The Contractor shall provide and install all interior signs in each car. Unless noted otherwise in the Specification, all decals and signs shall meet all applicable Federal, State, and Local laws and regulations, and all emergency egress/access decals shall also comply with the requirements of APTA-PR-PS-S-002-98 Revision 3 and APTA-PR-PS-S-004-99 Revision 2.
The Contractor shall meet with SEPTA to discuss general guidelines in respect to sizes, colors, quantities, and potential locations. It will be SEPTA’s preference to use existing decals when possible and SEPTA shall provide examples for replication by the Contractor.

Based on these discussions, the Contractor shall develop a car graphic signage layout proposal in PDF form. [CDRL 04-043] The layout shall consist of general arrangement drawings by area showing the location of the decals and frames in full detail to portray size and scale. A detailed graphic image shall be included for each decal and contain full details as to quantity per car, colors, material, dimensions, special attributes, and the Contractor’s part numbers. All exterior decals shall note if edge sealer will be required or not. Permanent installation of plate style signage shall be described in detail. Upon receipt of the proposal, the graphic layout shall be included in the design phase mock up review.

### 4.11.2 Signage

#### 4.11.2.1 Interior

**4.11.2.1.1 General**

a. “No Smoking” decals shall include the international symbol for no smoking and shall be placed on one (1) bulkhead at each end on diagonally opposite sides of the car in each passenger seating area. One (1) each shall be included in each intermediate area.

b. A “Keep Feet Off Seats – Throw Trash in Receptacles” decal shall be applied on one (1) bulkhead at each end on diagonally opposite sides of the car in each passenger seating area. One (1) each shall be included in each intermediate area.

c. A “For Customer Service and Security, Cameras May Be In Use On This Vehicle” decal shall include a pictogram of a camera. Decals shall be applied on one (1) bulkhead at each end on diagonally opposite sides of the car in each passenger seating area. One (1) each shall be included in each intermediate area.

d. A “BRAKE – EMERGENCY USE ONLY” decal shall be applied to all emergency brake locations within the passenger area. This decal shall be accompanied with an additional decal stating: “IT IS IN VIOLATION OF FEDERAL REGULATIONS FOR UNAUTHORIZED PERSONS TO CAUSE AN EMERGENCY BRAKE APPLICATION WHEN NO EMERGENCY EXISTS” in smaller fonts below or adjacent to the main decal.

e. Emergency window decals meeting the requirements of APTA-PR-PS-002-98 Revision 3 and 49 CFR 238 shall be applied to each emergency window. The emergency window decals shall consist of a set of decals covering three (3) aspects:

1) Emergency window location decals – these decals shall be designed and placed where either a sitting passenger or standee can easily identify and locate an emergency window.
2) Emergency window removal instruction decal – this decal shall contain step by step instructions using both text and illustrations to remove the window under emergency conditions.

3) Emergency window handle decal – a decal shall be included stating the handle cover must be removed to access the emergency window pull handle.

f. Priority seating decals stating the standard SEPTA “PRIORITY SEATING For Persons With Disabilities and Seniors – Yield These Seats” shall be applied adjacent to all flip up seats in mobility device parking areas and other seating as indicated by SEPTA based on the Contractor’s proposal for the intermediate level of each car. If no mobility device parking area exists at the intermediate level and the end of a car, a minimum of three (3) seats shall be identified as priority seats.

g. A “WATCH YOUR STEP” decal shall be applied to the middle step riser within the step set at both interior stairwells leading to the upper level seating and the low platform steps at the corners of the cars. Stepwell riser signs shall consist of a high contrast safety yellow with capital letters in black. Two (2) additional “Please Watch Your Step” decals shall be designed using pleasing colors and text that will be mounted over the headers of all stepwells leading down from the upper level.

h. A “FULLY EQUIPPED FRA TYPE II GLAZING” decal shall be applied to the end bulkhead at each end of the car within the intermediate level.

i. A “Handicapped/Mobility Device Parking Area” decal shall be applied adjacent to each flip seat area assigned to mobility device parking. The decal shall include or be accompanied by the international wheelchair symbol within the decal. Additional instructions to flip up seats to access the parking area must be included.

j. A bicycle retention decal shall be applied adjacent to the retention device and/or area. Signage shall identify the device and its associated area and include a simple diagram and text to instruct on the proper use of the device or the technique to properly retain the bicycle.

k. A set of decals for each passenger emergency intercom (PEI) shall be supplied for each PEI unit in the car. The set shall include decals that shall identify the PEI and provide instructions for its use. A second separate decal stating “This Is Car Number (XXXX)” shall be supplied and applied adjacent to the PEI decal. A third decal stating “IT IS A VIOLATION OF FEDERAL REGULATIONS FOR AN UNAUTHORIZED PERSON TO USE THE PASSENGER EMERGENCY INTERCOM WHEN NO EMERGENCY EXISTS”. The PEI decals shall comply with all requirements of 49 CFR 27, 37, and 38 and APTA-PR-PS-002-98 Revision 3.

l. Interior car number signs – car numbers shall be applied to bulkheads in both upper and lower seating areas and in each intermediate level. The numerals shall be 3.5 inches high using Helvetica medium font and of a color that will be of high contrast against the bulkhead lining’s surface. Within upper and lower seating areas, one (1) set of car numbers shall be applied to a bulkhead at each end of the seating area and be diagonally located from the opposite end. Applications of car numbers to the intermediate areas shall be at the top corner of the wall edge of the end vestibule door pocket lining.
m. 120 VAC receptacles – all 120 VAC receptacles regardless of being for maintenance or passenger convenience shall be identified by a decal stating “120 VAC”. The decal shall be placed either above or below the receptacle based on how they would normally be viewed (above for a receptacle low near the floor, below for receptacles mounted higher).

n. LLPEM – a low location exit path marking (LLPEM) system shall be provided per TS 9.8.

o. High voltage warning signs – “DANGER HIGH VOLTAGE” signs shall be located within electrical lockers where 150 V or higher voltage circuitry exists per 49 CFR 229.85. Signs shall be applied to all insulating covers (such as circuit breaker panels) and/or individual apparatus junction boxes within lockers or maintenance areas meeting the voltage threshold. Signs shall meet the standards as outlined in ANSI Z535.

p. A car builder’s plate shall be provided for each car denoting and identifying the car builder and their logo. The plate shall also contain text identifying the cars to be the property of the Southeastern Pennsylvania Transportation Authority along with the year of the pilot car acceptance. The plate shall be stainless steel heavily embossed or engraved with color filled text and logo and be permanently attached on the passenger interior side to the B-end/F-end vestibule end door.

4.11.2.1.2 Side Doors

a. Emergency door release identification and instructions – this signage shall both graphically show and simply instruct the use of the emergency door release used for motorized quarter point and corner car doors as deemed by the door system supplier. The location shall be adjacent to the emergency door release mechanism. Signage for the passenger area end door emergency release shall also be described by both graphics and simple instructions for emergency exiting under both powered and non-powered circumstances. Materials and descriptive content shall meet APTA RP-C&S-012-99 and 49 CFR 238 requirements.

b. An additional decal shall be included near the emergency door release instructions stating: “IT IS IN VIOLATION OF FEDERAL REGULATIONS FOR UNAUTHORIZED PERSONS TO OPEN SIDE DOORS WHEN NO EMERGENCY EXISTS”.

c. A “CAUTION – WATCH GAP BETWEEN TRAIN AND PLATFORM” decal in a single line of text shall be applied with its bottom edge four (4) inches above the bottom edge of the door. The decal shall consist of a safety yellow background with bold black letter text.

d. Door exit signs, two (2) each, meeting the requirements of APTA-PR-CS-S-012-02 and 49 CFR 238 shall be applied to each side door. The first decal shall be applied centered on the door above the window. The second decal shall be located with its bottom edge 18 inches above the floor and two (2) inches from the door’s side seal.

e. A “Do Not Lean Against Doors At Any Time” decal shall be applied three (3) inches below the door window and centered on the door for each side door. The decal shall have a safety yellow background, black bold text, and contain a restrictive pictogram.
f. Door number indicator decals shall be provided for each door. Door numbering shall match that of electrical schematics. Door number indicators shall be applied adjacent or near door control panels.

g. All signal buzzer button switches shall be identified by a decal stating “SIGNAL” for each push button.

4.11.2.1.3 Vestibule End Doors

a. Door exit signs, two (2) each, meeting the requirements of APTA-PR-CS-S-012-02 and 49 CFR 238 shall be applied to the interior side of each vestibule end door. The first decal shall be located three (3) inches from the top of the door and three (3) inches from the edge of the door panel at the door seal side. The second decal’s bottom edge shall be located 18 inches from the door’s bottom edge and three (3) inches from the door panel’s seal side.

b. A “This Door Must Remain Closed and Passengers Must Remain Inside the Car Until the Train Has Come to a Complete Stop” and include an additional line on the bottom in italics and smaller font “Thank You For Your Cooperation” decal shall be applied to the vestibule end door centered above the window.

c. A “Caution: Door Closes Automatically” decal shall be placed on the end bulkhead adjacent to the end door.

d. An emergency door release instruction decal shall be provided for each end vestibule door. The decal shall contain descriptive text for opening and latching the door open during emergency egress and/or using alternate means such as passenger pass through removable windows or panels that meet the requirements of APTA-PR-CS-S-012-02 and 49 CFR 238. Supplemental decals to identify associated equipment such as latches, locks, switches, etc., must be included if needed for clear quick understanding of the instructions.

4.11.2.1.4 Cab

a. A car number plate of deeply engraved aluminum powder coated black with the numbers’ paint filled in bright white shall be permanently attached to the console in each cab. The number characters shall be a minimum of 0.75 inch in height.

b. An interior noise level compliance plate shall be permanently affixed on the rear cab wall after successful completion of the interior noise level testing as required by TS 2.3.2.1. The plate shall read: “Cab Noise Level Requirements For This Cab’s Design Has Been Tested And Found To Be Compliant To 49 CFR 229.121 and 49 CFR 210.29”.

c. Any valves located within the cab (such as a horn cut-out) shall be identified by name. If the handle is mounted above a console surface, decals may be used to identify the valve. If the valve exists behind the console access door or plate, the valve must be identified using an engraved stainless steel I.D. plate with painted letters and be secured to adjacent piping with safety wire.
d. Space shall be reserved in the cab for SEPTA to apply the SEPTA Railroad Radio Channel Conversion Chart decal. Space requirements will require a 5 x 7.5 inch area for application.

4.11.2.2 Exterior

a. Car number sign decals – exterior car number signs shall be in "Helvetica Medium" font and applied as follows:

1) A four (4) digit eight (8) inch high car number sign shall be applied to each side of the car in locations approved by the Engineer.

2) An eight (8) inch high car number sign shall also be applied on each end collision post door of all cars below the window in a location approved by the Engineer. The numbers shall be black reflective material as produced by 3M Corporation and be subject to approval by the Engineer.

b. Illuminated car numbers – two (2) illuminated car number signs shall be installed on each cab car, one (1) on each side in the side frame just behind the cab in the letterboard area. The signs shall be large enough to contain four (4) digit eight (8) inch high numerals. The car number signs shall use a "Modulite" or approved equal fiberglass embedment mounted in a neoprene endless glazing section. Illuminated car number signs are not required on the trailer cars.

c. Exterior Graphic Scheme – the exterior graphic package previously approved from the industrial designer’s submission and approved during the design stage shall be professionally applied to the car sides and cab end.

d. Side decals and signage – side decals and signage shall be included as follows:

1) Doorways

a) A standard handicap symbol shall be applied next to all side door openings where mobility device parking is available within the intermediate level at that end of the car. If the particular end of the car does not allow for parking, the symbol shall not be used.

b) An international no smoking symbol shall be applied adjacent to all side door openings.

c) A “DANGER – Do Not Board Moving Train” decal shall be applied adjacent to all high platform door openings. The decal shall be approximately four (4) inches wide and high enough to accommodate the text aligned in a portrait orientation.
d) A bicycle decal stating: “Bicycles Welcome On All Peak Trains” including a symbol for a bicycle shall be placed adjacent to all door openings that open to an intermediate level that contains a bicycle retention area/device. If an intermediate area is not equipped with a retention area/device, no decal is needed.

2) American flag – an American flag decal shall be applied to the cab end of each cab car. The style of the flag shall be flat and rectangular. Left and right hand versions of the flag shall be used so that during application, the flag’s union (star field) is in the direction of the cab when operating.

3) A “DANGER – Do Not Board Moving Train” decal shall be applied to the side sill adjacent to each set of low platform stairs. This decal shall be formatted to be seven (7) inches long, high enough to contain two (2) lines of text, and applied in a landscape orientation.

4) A “Trap Door Release” decal shall be installed in the corner door low platform stairwell adjacent to the manual release mechanism.

e. Conspicuity tape/decals shall be applied to the side sill to meet the requirements of 49 CFR 224 and be marked as required.

f. Exterior identification plates for car side equipment access:

1) All equipment, cut-outs/isolation valves, drains, etc., shall be identified by I.D. plates permanently mounted on the side sill adjacent to the device locations. Access doors for enclosed equipment accessible from the exterior of the car shall also be identified and have I.D. plates applied adjacent to the doors. Any interior apparatus located within the exterior access points shall have plates to identify both the apparatus and any status of the switch or breaker by position (i.e. Off/On) All plates shall be made of stainless steel with heavily embossed, pre-etched and paint filled characters.

2) Trainline jumper instruction diagram – the trainline jumper diagram shall show the correct interconnection of all trainline connections at the end of the cars. The diagram shall be a stainless steel plate design with etched and paint filled illustrations and text. Diagrams shall be permanently installed at each corner of the car adjacent to the trainline connector groupings.

3) Car marking plate – the marking plate shall be stamped with the car number, car shell production serial number, actual weight of the total car, weight of the car at each end, weight of each truck, and the car class, i.e. cab or trailer car weight shall be as recorded from the requirements of TS 2.2.2. A marking plate shall be provided in a location approved by the Engineer.
g. High voltage warning signs – “DANGER HIGH VOLTAGE” signs shall be located within electrical lockers where 150 V or higher voltage circuitry exists per 49 CFR 229.85. Signs shall be applied to all insulating covers (such as circuit breaker panels) and/or individual apparatus junction boxes within lockers or maintenance areas meeting the voltage threshold. Each exterior corner containing trainline receptacles for both signal and HEP power shall have a “DANGER HIGH VOLTAGE” sign as large as possible made from materials with reflective qualities. Signs shall meet standards as outlined in ANSI Z535.

h. F-end symbol – the F-end of each car shall be identified using a cast stainless steel or aluminum plate riveted to the side sill on both sides in accordance with 49 CFR Part 229.11. The character shall be paint filled to a high contrast color (i.e. for stainless steel with natural finish, black F - if aluminum material is used, the plate must be anodized using black anodization and paint filled white F). If the chosen plate is aluminum, the back surface shall be coated with 3 m VHB foam tape to buffer electrolysis prior to being permanently mounted.

i. Emergency windows – each emergency window shall be identified using two (2) decals. The first decal shall identify the window as being an emergency window, and the second shall be an instruction for entry at the corner of the window. The decal material shall be reflective and sized to be easily readable from ground level.

4.11.2.3 Roof

a. Car number – a black car number decal shall be applied to the roof of each car. The decal medium shall be heavy duty and robust to survive direct UV sunlight and extreme weather conditions. The size of the numbers shall be 24 inches and as long as needed to be proportional using a Helvetica Medium font.

b. Roof emergency access – each two (2) previously determined “soft spots” chosen for emergency access through the roof shall be so marked and include the following aspects:

1) Shall be identified as: “EMERGENCY ACCESS”

2) The markings shall have dashed lines to indicate an outline where the roof material shall be cut. Text shall be included within the outline stating: “CUT ALONG DASHED LINES TO GAIN ACCESS”.

3) A second line of text shall be added below it stating: “CAUTION – DO NOT USE FLAME CUTTING DEVICES”.

4) A third line of text shall state: “CAUTION – WARN PASSENGERS BEFORE CUTTING”.

c. “Do Not Walk” decals shall be placed over surfaces of the HVAC unit where damage might be caused by the weight of maintenance personnel. Walking and load bearing areas of the unit shall have anti-slip self-adhesive material applied to flat surfaces. The anti-slip material shall allow a skid resistance minimum of R12 as tested per DIN 51130 and shall have a rating of “good” or higher for UV resistance.
4.11.3 Frames

4.11.3.1 General

All frames shall be designed for use with cardboard placard media. The design shall include the easy insertion and removal of all placards. The frame shall be stainless steel with a brushed finish. Mounting screws shall be hidden. No attachments shall be made with wood screws or other fasteners without having a tapped insert or tapping plate integrated into the panel or lining.

4.11.3.2 Interior

a. Inspection frames (all cars) – a stainless steel two (2) tiered pocket holder to hold 8 1/2 inches by 11 inches component data cards shall be provided along with one (1) polycarbonate single pocket. Frames locations are intended to be within chosen equipment lockers that have been approved by the Engineer.

b. Emergency evacuation instruction decal – upon review of frame assignment locations, space must be chosen and reserved for SEPTA’s Emergency Evacuation Instruction decal at each intermediate level of the car. The decal size will be approximately 20 inches wide by 28 inches high in size. The decal will be self-adhering, thus no frame will be required.

c. Passenger information – the passenger information frame shall be a single unit consisting of a combination of three (3) frames. The top portion of the frame shall consist of two (2) side portrait aligned frames designed to accommodate 8.5 inches by 11 inches documents or placards. The lower portion of the frame shall accommodate 11 inches by 17 inches media. Frames may be mounted over equipment locker doors and overlap the non-hinge side of the door as long as it extends over a permanent panel or mating bi-panel door.

d. SEPTA route – a stainless steel frame meeting the general requirements for frames shall be provided for the SEPTA route placard measuring 21 inches wide by 22 inches high at each intermediate level of all cars.

e. Advertising placard frames – a stainless steel frame meeting the general requirements for frames shall be provided for standard advertising placards measuring 21 inches wide by 33 inches high. Locations for advertising frames shall take place after all frame locations and video monitors for advertising have been assigned at which time space availability shall determine the location and quantity of frames. The Contractor shall plan on a minimum of six (6) frames per car.

4.11.3.3 Cab

a. One (1) 8.5 inches by 11 inches "blue form" inspection card frame with transparent cover conforming to FRA document size requirements shall be located on the inside face of the rear partition electric circuit breaker locker door as directed by the Engineer and in accordance with 49 CFR Part 229.23 (d).

b. An "air slip" inspection form clip holder for a three (3) inches by five (5) inches daily inspection form shall be located on the rear partition wall near the cab door.
4.12 EMERGENCY EQUIPMENT

A fire extinguisher and pry bar shall be mounted in a location approved by the Engineer. A five (5) pound dry chemical fire extinguisher shall be located on each upper and lower passenger level and in the cab area; a twenty (20) pound dry chemical fire extinguisher shall be located on each intermediate level; four (4) fire extinguishers per trailer car and five (5) fire extinguishers per cab car. The fire extinguishers shall be securely mounted on an approved bracket in a manner that shall prevent vibration and rattling. Access to fire extinguishers shall be provided with a maintainer’s key for maintenance purposes. Access for emergency use shall be provided by means of a clear frangible cover. A two (2) foot long painted steel pry bar shall also be located in each fire extinguisher mounting recess arranged to be easily visible as installed. It shall be mounted using a set of cushioned spring clips so as to prevent any rattles or noise during car operation. It shall be marked “SEPTA”. Details of the design, installation, and arrangement of the fire extinguishers, pry bars, and their housings shall be submitted to the Engineer for review and approval. [CDRL 04-044]

Each cab shall be equipped with fusees stored in a secure box. Details of the box and its installation and arrangement shall be submitted to the Engineer for review and approval. [CDRL 04-045]

The emergency tools shall be mounted in a location approved by the Engineer. [CDRL 04-046] The words “PROPERTY OF SEPTA” shall be etched on each tool. The tool shall be securely fastened in the case so that it does not rattle and shall be fitted with a quick release arrangement for removal.

4.13 STANDARD KEYS

The coach key (referred to in this Specification as the “standard key”) except as otherwise specified shall be used as the general key for door control and to open all doors and car interior access covers. All coach key locks shall accept the standard SEPTA coach key, J.L. Howard and Co. No. 2383. This key shall operate the Conductor door control panels, side door mechanical locks, body end door locks, cab door, side window locks, PA/IC system, equipment and storage lockers, crew lockers, and the like, with exception of cab car related electric lockers which for security reasons shall have barrel locks. Wherever a switch is operated by the standard door key, the tumbler shall be set back at least 0.5 inch from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver, handheld tool, or similar device.

Additional keys for equipment types may also be considered as standardized keys for special uses. These keys consist of master controller keys, PTC/ATC keys, and MC 30 keys for the fuse box located in the cab.

Upon the delivery of each car, one (1) set of standard keys shall accompany the equipment based on the car type (cab vs. trailer). The Contractor shall supply additional stock of standard keys as follows:

- Coach key – No. 2383 as manufactured by J.L. Howard and Co. 500 each
- Electric locker barrel keys 500 each
- Master controller keys 200 each
- PTC/ATC keys 100 each
- MC 30 key for fuse box 100 each
If during the design process additional locks are introduced, the appropriate key must be submitted with the car set upon delivery. The Contractor shall also include appropriations to supply 200 spare keys for the locks being added.

Standard keys shall be provided from the original lock manufacturer and meet all of the dimensional tolerance requirements for reliable daily use.

### 4.14 CONTRACT DELIVERABLE REQUIREMENTS LIST

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5 COUPLER, DRAFT GEAR, AND TRAINLINE CONNECTIONS

5.1 GENERAL
The passenger cars shall be equipped with APTA type "H" short shank tight lock knuckle couplers with Waughmat style double acting twin cushion draft gears. The Contractor shall be responsible to ensure the proper preload is achieved with the coupler, yoke, and draft gear installed. The coupler equipment shall be purchased in accordance with APTA-PR-M-RP-003-98’s knuckle strength requirement.

Separate hoses and jumper cables shall be used for pneumatic and electrical connections.

The intercar cables and hoses shall be compatible with SEPTA’s commuter locomotives and railcars.

The arrangement of the coupler, draft gear, and trainline connections along with a compatibility and interface analysis for existing cars and locomotives shall be submitted to the Engineer for review and approval. [CDRL 05-001]

5.2 COUPLER

5.2.1 Coupler
Two (2) APTA approved high tensile steel tightlock couplers double rotary operating type Buckeye Pattern Number SH-7-HT1 or approved equal with "H" head and type “F” shank six (6) by eight (8) inches tight lock heads and shanks shall be provided on each car. The coupler head shall be 34.00 inches from the tail to pulling face. The coupler shall be complete as illustrated on Buckeye Drawing CW-13108.

The couplers shall have sufficient lateral swing to allow the car to negotiate a 23 degree curve and track conditions described in TS 2.2 while coupled to any other SEPTA car or locomotive. The coupler height shall be adjusted to 34 1/2 inches from the top of the rail to the centerline of the coupler before leaving the Contractor’s plant. The coupler height shall be adjusted with the trucks leveled and adjusted in accordance with TS 11.8. No paint shall be applied to the coupler.

The coupler system and its mounting including, but not limited to, the draft gear and attachment to the vehicle underframe shall comply fully with the strength and other applicable requirements of the AAR and FRA 49 CFR 238.205 and 238.207 which define the requirement to meet the 800,000 pound compressive load and +/-100,000 pound vertical and horizontal loads.

5.2.2 Uncoupling Lever
Provision shall also be made for complete mechanical (non-pneumatic) uncoupling of every coupler from the sides of the car in accordance with FRA regulations.
An uncoupling arrangement shall be provided at each end of the car. It shall be a standard APTA type number 6 operating mechanism arranged for operation from both sides of each car end. The uncoupling arrangement shall be submitted to the Engineer for approval. [CDRL 05-002]

### 5.3 DRAFT GEAR AND YOKE

#### 5.3.1 Draft Gear

Each car shall be equipped with two (2) Waughmat style double acting twin cushion draft gears or approved equal that use separate sets of rubber pads for draft and for buff. They shall be designed for 22 3/16 inch pockets type WM-5-6 including followers for use with "H" head described in TS 5.2.1 or approved equal. It shall be capable within reasonable margins of safety of withstanding loads in accordance with AAR, APTA, and FRA standards.

#### 5.3.2 Yokes

Two (2) APTA approved high tensile steel tight lock coupler yokes type SY-271-HT2 or approved equal as shown on Buckeye Drawing Number D-14197 C or approved equal shall be provided on each car for use with the draft gear and short shank coupler. Yokes shall be complete with wear plates, bushings, and yoke pin. No paint shall be applied to the yoke, bushing, or pin.

#### 5.3.3 Material

The coupler heads and shanks shall be made of AAR Specification M-201 Grade C cast steel or other cast steel of equivalent or improved properties to achieve strength requirements and shall be manufactured in a facility conforming to AAR requirements for manufacturing and quality assurance. The coupler shank, where it meets the coupler carrier, shall be provided with a replaceable wear plate fabricated from 0.25 inch thick stainless steel or other material compatible with the carrier wear plate. The yoke shall be AAR Specification M-201 Grade C cast steel or other cast steel of equivalent or improved properties to achieve strength requirements. Fabrication of the yokes shall conform to AAR Specification M-211 and APTA-PR-M-RP-003-98.

### 5.4 COUPLER CARRIER

#### 5.4.1 Carrier

The coupler carrier for the "H" tight lock type coupler shall be a spring supported type with a Gatke style non-metallic wear plate with side and end rubber stop blocks designed to prevent metal to metal contact. The design shall permit adjustment to suit the AAR and APTA recommended practices for vertical and horizontal movement of the coupler head.
5.4.2 Centering Devices

There shall be no centering device. Lateral rubber stop blocks shall be applied to the coupler pockets to limit the coupler swing to either side of the centerline and to protect the pocket wings from damage when operating in accordance with TS 2.2.

5.5 TRAINLINE CONNECTIONS

5.5.1 Trainline Requirements

Trainline receptacles and cables shall be mounted at both ends of the car in such a manner and location to permit one end of one car to be connected to either end of another car or a locomotive. The trainline wiring shall be arranged such that a locomotive can control the operation of the train when coupled at either end of the train and that cars will properly operate irrespective of their location in the train. All receptacles shall be located above the uncoupling levers.

The connectors for the 27 wire locomotive control and the 27 wire communication trainline systems shall be arranged and mounted at both ends of each car in such a manner and location that either end of the locomotive can be connected to either end of a car and that the A-end of the car can be connected to the B-end of another car.

All connections shall be arranged to prevent the ingress of moisture including that from the car wash into the connector and receptacle.

5.5.2 Head End Power (HEP) Trainline

A 480 VAC power trainline system (head end power) shall be provided through each car. The pin assignments shall be in accordance with APTA-PR-E-RP-015-99, Figure 4. A power control trainline shall also be provided on each car to establish trainline completeness before connecting the power supply from the locomotive to the train. This wiring shall be adequately protected from damage in accordance with TS 17. Wiring shall be arranged so that the locomotive can be used on either end of the train, and the cars can be oriented in either direction in any location in a train.

The cab cars shall be equipped with a three (3) position selector switch in the Operator’s cab and with associated circuitry that shall remove the 480 VAC power from the front end receptacles. It shall make it unnecessary to loop the trainline manually at the front end of the train. The selector switch shall be interlocked with the control wiring to meet the following conditions:

a. Position 1: THRU (Car Batt.) – energizes the contactor from the car battery and connects the F-end receptacles to the HEP trainline

b. Position 2: THRU (Loco Batt.) – energizes the contactor from the locomotive battery and connects the F-end receptacles to the HEP trainline
c. Position 3: F END C/O – deenergizes the contactor and disconnects the F-end receptacles from the HEP trainline

Four (4) red 3/3 pole receptacles shall be provided at each end of the car. Each connector shall have three (3) main power contacts and three (3) control contacts, and shall be supplied at one end with, and mate with jumper cable Clements National part MPA-2-057-V01 or equal, each consisting of three (3) 4/0 single conductor cables and one (1) 3-conductor #10 cable. Storage locations shall be provided on board the car for unused jumper cables. Power receptacles and jumper heads shall be labeled and colored bright red. The four (4) 3/3 pole receptacles shall be located below the car end sheet immediately below the buffer wing and above the coupler operating lever handle and angled five (5) degrees downward. The HEP trainline system shall be compatible with existing SEPTA commuter rail cars and locomotives.

The portable jumper assemblies shall have an approved hanging device assembly at one (1) end to allow supporting the loose end of the cable during maintenance moves. An approved hook shall be located on each corner of the car to support the HEP cable assembly via the hanging device mounted on each cable.

The jumper plugs shall have three (3) power pins and three (3) shorter control pins. When any jumper is disconnected, the shorter control pins shall break contact first opening the trainline complete circuitry and as a result the output contactor of the HEP 480 VAC supply in the locomotive to prevent disconnecting the power pins under load.

Jumpers and receptacles shall be so designed and located to permit each jumper to be inserted into the adjoining receptacle on the next car or if an end car into the adjacent receptacle to complete the control circuit. If required, the loose ends of cables shall have a semipermanent chain and clasp support arrangement. This device shall allow for replacement of the cables including support chains and cords without the use of any special tools. The chain and clasp arrangement shall be used only when the jumper is not connected. When the jumper is connected, the clasp and chain shall not be required to ensure proper clearance.

With each cab car there shall be two (2) lengths of portable jumper cable assemblies supplied for installation at the B-end of the cab car. The short length jumper cable shall be installed in the HEP receptacle and used to complete the control circuit when the car is at the end of the train. The long length jumper cable shall be stored in the cable rack in the electrical locker and shall be used to connect to the next car when the cab car is operated in a location other than the end of train.

The voltage drop of the power trainlines through a 14 car consist shall not exceed 20 volts as measured at the load terminals. This assumes maximum car load, phase balance within tolerance, and equal distribution of the load among cars.

Trainline wires shall be 4/0 AWG (minimum) for power circuits and 12 AWG (minimum) for control circuits except as noted with Exane insulation in accordance with TS 17. HEP phases shall be rotated within each car to optimize overall phase balance, and each trainline phase cable shall be connected to all other trainline cables of the same phase within each car to optimize current sharing between cables. Trainline wiring shall be installed in accordance with TS 17.

HEP trainline control wire assignments and schematic shall be per APTA-PR-E-RP-015-99, Figure 4.
5.5.3 Door Control and Communication Trainline

A 27 conductor door control and communication trainline system shall be provided through each car.

A 27 pin male receptacle assembly shall be provided at each end of each car, and a dummy receptacle assembly shall be provided at the B-end of each car. The dummy receptacle shall be painted white.

At the B-end of each car, a jumper with two (2) female plug contacts shall be provided. It shall be semipermanently secured to the live receptacle at that end by means of a bracket with a stretch cord (Falstrom Part Number FC 97217 left and right), and its free end shall be arranged to be stowed in the dummy receptacle when not in use.

Jumpers and receptacles shall be of the same style and size as those used for the locomotive control trainline. They shall be Clements National jumper and CRA-27-AMTK receptacle or approved equal. Wires 8 to 9 and 23 to 24 shall be crossed over within the jumper. Wires to pins 4, 13, and 25 shall be 10 AWG; all others shall be 12 AWG with the exception of shielded cables which shall be 14 AWG.

Jumpers and receptacles shall have the necessary pins and conductors for door control, communication, battery trainline, and brake control functions. The pin assignments shall be in accordance with Table 5-1, Door Control/Communication Trainline Wire Assignments. Circuits shall be so arranged that the locomotive can be used on either end of the train. Three (3) spare train lines in addition to the 27 conductor trainline system shall be connected from end to end of each car and shall be terminated at terminal blocks in the end of car junction boxes.

Door control and communication jumpers and receptacles shall be located on the car end sheet and shall be painted medium blue. Dummy receptacles shall be painted white.

Table 5-1: Door Control/Communication Trainline Wire Assignments

<table>
<thead>
<tr>
<th>Pin</th>
<th>Wire Size AWG</th>
<th>Designation</th>
<th>Function</th>
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<tbody>
<tr>
<td>1</td>
<td>12 SH Shielded</td>
<td>SH</td>
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</tr>
<tr>
<td>2</td>
<td>10 BN Car Battery</td>
<td>BN</td>
<td>Car Battery Negative</td>
</tr>
<tr>
<td>3</td>
<td>12 Shielded</td>
<td>PA1</td>
<td>Public Address Audio 1</td>
</tr>
<tr>
<td>4</td>
<td>12 Shielded</td>
<td>PA2</td>
<td>Public Address Audio 1</td>
</tr>
<tr>
<td>5</td>
<td>12 Shielded</td>
<td>PA3</td>
<td>Intercom</td>
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<td>PA4</td>
<td>Intercom</td>
</tr>
<tr>
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<td>12 PA5</td>
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<td>Radio</td>
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<td>10</td>
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<td>11</td>
<td>12</td>
<td>SB</td>
<td>Snow Brake</td>
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<tr>
<td>12</td>
<td>12</td>
<td>DORL</td>
<td>Doors Open – Right Side Low Level</td>
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<tr>
<td>13</td>
<td>12</td>
<td>DORH</td>
<td>Doors Open – Right Side High Level</td>
</tr>
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<td>14</td>
<td>12</td>
<td>AOB</td>
<td>Doors Open – Right Side (Legacy)</td>
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</tr>
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<td>16</td>
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<td>12</td>
<td>DOLL</td>
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<td>22</td>
<td>12</td>
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<td>12</td>
<td>CL</td>
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<td>24</td>
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<td>27</td>
<td>12</td>
<td>DOLH</td>
<td>Doors Open – Left Side High Level</td>
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### 5.5.4 Locomotive Control Trainline

A 27 conductor locomotive control trainline shall be provided through each car.

The pin assignments shall be in accordance with Table 5-2, Locomotive Control Trainline Wire Assignments.

A black 27 pin male receptacle assembly, Clements National CRA-27-MU-BK or approved equal, shall be provided at both ends of each car, and a dummy receptacle assembly shall be provided at the B-end of each car. The dummy receptacle shall be painted white.

At the B-end of the car, a locomotive 27 pin control jumper shall be provided. It shall be semipermanently secured into the live receptacle at that end by means of a bracket with a stretch cord (Falstrom Part Number FC98343 left and right) and shall be arranged to be stowed in the dummy receptacle when not in use. It shall be manufactured by Clements National or approved equal. Wires 8 to 9 shall be crossed over in the jumper. In addition, wires to pins 8 and 9 shall be crossed over in the car wiring. Wires to pins 4 and 13 shall be 10 AWG; all others shall be 12 AWG.
Locomotive control jumper receptacles shall be mounted on the car end sheet and angled down five (5) degrees as follows: the centerline of the receptacles will be located 33.8 inches horizontally from the centerline of the car, approximately 50 inches vertically from the top of rail, and there shall be 15.8 inches between the pulling face of the coupler and the face of the receptacle.

All unassigned carbody trainline wires shall be connected through to the trainline receptacles. Three (3) spare trainlines in addition to the 27 conductor trainline system shall be connected end to end of each car and shall be terminated at terminal blocks in the end of car junction boxes.

Wiring to the locomotive control receptacles and the associated carbody trainline wiring shall be installed and routed to permit ready removal if cars are changed to full network control in the future. Locomotive control trainline wires with the exception of PC and N, which are the locomotive battery power supply trainlines, shall carry discrete control signals supplied by the car or locomotive battery (74 VDC).

**Table 5-2: Locomotive Control Trainline Wire Assignments**

<table>
<thead>
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<th>Pin</th>
<th>Wire Size AWG</th>
<th>Designation</th>
<th>Function</th>
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<tr>
<td>1</td>
<td>12</td>
<td>VC1</td>
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<td>12</td>
<td>SG</td>
<td>Alarm</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>DV</td>
<td>Engine Speed D</td>
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<td>4</td>
<td>10</td>
<td>N</td>
<td>Negative</td>
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<td>5</td>
<td>12</td>
<td>ES</td>
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<td>12</td>
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<td>Forward (B-end)**</td>
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<tr>
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<td>12</td>
<td>RE</td>
<td>Reverse (A-end)**</td>
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<td>12</td>
<td>RE</td>
<td>Reverse (B-end **)</td>
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<td>9</td>
<td>12</td>
<td>FO</td>
<td>Forward (A-end)**</td>
</tr>
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<td>12</td>
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### Table 5-3: Throttle Notch Trainline Response

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<th>BV</th>
<th>CV</th>
<th>DV</th>
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### 5.5.5 Digital Trainline Network Trainline

An Ethernet based digital trainline network as described in TS 15 shall be enabled through the use of trainline receptacles and jumpers distinct from the existing 27 pin MU and COMM jumpers.
5.5.5.1 DTN Receptacles

Each car shall have four (4) DTN receptacles, two (2) per each end of the vehicle. Each receptacle shall be prewired with one (1) ISO/IEC 11801 Category 7 cable for the Gigabit Ethernet network, and one (1) ISO/IEC 11801 Category 7 cable as a spare. Cable arrangement and routing shall be such to provide EMI immunity and shall be approved by Engineer. [CDRL 05-003] Each receptacle is to be wired to an Ethernet switch located inside the vehicle. The receptacle design, spare assignment, orientation, and operation shall be submitted to the Engineer for review and approval. [CDRL 05-004] The receptacles shall be such that when cables are not plugged in self-closing, covers shall prevent debris and moisture from entering.

5.5.5.2 DTN Jumper Cables

Two (2) jumper cables shall be provided with each vehicle. The jumper cable design shall be suitable for the environment it is to be installed in and sized according to the SEPTA’s track alignment and minimum turn radius. The jumper shall be designed with keyways to ensure proper mating with the trainline receptacle. In the case of a train separation without a disconnection of the jumper cable, the jumper cable shall be designed to break away without causing damage to the receptacle or vehicle body. Connection and durability of the jumper should be similar to the existing 27 pin HEP and other digital trainline network connectors and shall be fully removable. Both plug sides of the jumper cable shall be identical to allow plugging in either end to either vehicle. EMI mitigation techniques such as shielding and screening shall be incorporated into the jumper design to ensure the full 1Gbps of bandwidth is consistently available while operating throughout SEPTA’s environment.

5.5.5.3 DTN Cabling and Connectors

Two (2) Category 7 Ethernet cables shall be installed to connect the train switch at each end of the vehicle with each other. Cable arrangement including termination of shields shall be submitted to the Engineer for approval. [CDRL 05-005]

5.5.6 Terminal Blocks

All connections between door control and communication trainline and locomotive control trainline jumpers and receptacles and their corresponding trainline conductors shall be made in junction boxes by means of terminal blocks. The junction boxes shall be above the car floor level in an Engineer approved location and constructed so as to be watertight and to afford convenient access by maintenance personnel.

Connections between power trainline jumpers and receptacles and power trainline conductors shall be made by means of adequately supported lug to lug bolted connections with the insulation value at the bolted connection equal to or greater than the adjacent cable insulation. The method of insulating the bolted connection shall consist of taping the joint with one (1) wrap two (2) lap electrical tape per TS 17 and covering with a Clark Equipment Co. neoprene rubber sleeve, Part Number M105, and sealing between the sleeve and cable with a spacer held in place by the hose clamps provided with the sleeve.
5.5.7 Labeling and Color Coding

HEP trainline, door control and communication trainline, and locomotive control trainline jumpers and receptacles shall be labeled to indicate their functions and shall also be color coded to assist employees in making up trains as follows:

<table>
<thead>
<tr>
<th>Jumper and Receptacle</th>
<th>Color</th>
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<tr>
<td>Door Control and Communication Receptacles and Jumper Head</td>
<td>Blue</td>
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<tr>
<td>Loco-control Receptacles and Jumper Heads</td>
<td>Black</td>
</tr>
<tr>
<td>HEP Receptacles and Jumper Heads</td>
<td>Red</td>
</tr>
<tr>
<td>Communication – Dummy Receptacles</td>
<td>White</td>
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<tr>
<td>Locomotive Control – Dummy Receptacles</td>
<td>White</td>
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<tr>
<td>Jumper Outer Sheath</td>
<td>Black or Yellow</td>
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</table>

5.5.8 Location of Jumpers

HEP trainline, door/communication trainline, DTN, and locomotive control trainline jumpers and receptacles shall be so designed and located to permit movement of the cars coupled to one another or to a locomotive over the curves and crossovers specified in TS 2.2 without damage to the jumper loops and heads. Jumpers and receptacles shall be located as near as possible to the underside of the end sill but not higher than 50 inches above the top of the rail. Jumper hangers or supports shall be provided to prevent damage.

5.5.9 Plug and Receptacle Design

Jumper plugs and receptacles shall be designed so that if cars are separated before jumpers are unplugged, no damage will result to a jumper or receptacle. The method of achieving this shall be demonstrated to the Engineer for approval. The design and location of all trainline connections shall provide compatibility with existing cars with only 27 point locomotive control and door control of communication trainlines.

5.6 TRAINLINE INTEROPERABILITY REQUIREMENTS

5.6.1 Discrete Trainlines

All 27 point and other discrete trainlines shall conform to the Specification. Trainline functions shall be compatible with the existing coach cars and locomotives.
5.6.2 Spare Trainlines

Spare trainlines shall conform to the Specification. Trainlines and pin assignments shall be compatible with the existing coach cars and locomotives.

5.6.3 Trainline Interoperability Test

The supplier shall test both physical and functional interoperability between these cars and the existing SEPTA commuter rail fleet per TS 18.2.1.5 and TS 18.2.2.4.

5.7 CONTRACT DELIVERABLE REQUIREMENTS LIST

<table>
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<th>CDRL Number</th>
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<td>DTN Receptacles Cable Arrangement and Routing</td>
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<td>05-004</td>
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6 DOOR CONTROL

6.1 GENERAL

Power operated passenger entry side doors of the sliding pocket type shall be provided as described in TS 4.6. All trailer cars shall have four (4) single panel side doors located in the end of car vestibules capable of accommodating passenger boarding from low station platforms or high station platforms. Cab cars shall have the same door arrangement as trailer cars except the end of car vestibule on the F-end cab side shall not have a door. All cars shall also have four (4) single panel high station platform doors in quarter point vestibules.

Low station platforms are located at zero (0) to eight (8) inches above the top of the rail, and high station platforms are located at 48 to 51 inches above the top of the rail. The tread of the bottom step shall be approximately 18 inches above the top of the rail. Doorway clear widths shall be as identified in TS 2.2.11, and station platform dimensions are identified in TS 2.2.10. ADA compliant wheelchair boarding from both full length high platforms and short mini-high platforms shall be provided under local crew deployment of a car mounted bridge plate at each F-end quarter point doorway. The design, operation, installation, arrangement, and associated signage shall comply with the applicable FRA and ADA regulations. In addition, all doors and the door control system shall comply, unless otherwise specified, with the requirements of APTA PR-CS-S-012-02, Standard for Door Systems for New and Rebuilt Passenger Cars.

Each doorway entrance shall have one (1) door and shall be moved by a linear induction motor drive or engineering approved equivalent operator located in the header area above the doorway. The overall design shall be such as to minimize the thickness of the door pocket and maximize the interior space.

All doors shall be zero speed interlocked except as specified herein and also interlocked with the propulsion control on a trainline basis. Each door shall be arranged so that it can be manually opened in an emergency. All door operators, tracks, hangers, linkages, bridge plates, obstruction sensing, and electrical controls shall be manufactured or supplied by one (1) subcontractor. The logic and circuitry of the control system shall use techniques that are fail safe to the maximum degree that is practical without using any components not already in proven use at SEPTA or at other North American transit authorities. It shall be understood that the requirement for self-detection of failures such as welded contacts, open contacts, mechanical failure, shorted components, open components, failure to change state, etc., may require additional system components as well as a suitable system design. All door system components shall comply with the requirements of TS 17.

Human factors/ergonomic criteria shall be incorporated into the design, operation, installation, and maintenance of the door system. The detailed design of the door system, door operators, controls, and installation including an ergonomic study showing the accessibility of all door controls and door releases shall be submitted to the Engineer for review and approval during the car design review. [CDRL 06-001]
6.2 ARRANGEMENT

Each doorway shall be provided with one (1) door that moves linearly into sidewall pockets to open as required in TS 4.6, and each door shall have independent drive and controls. All doors must be arranged to close prior to train movement except for crew monitoring provisions at an attended doorway. Each end vestibule doorway area shall have an approved method of converting the doorway area during the time of train movement from a low level to a high level platform, or vice versa, so that when the train stops at the next station, the doorways will be instantly ready to open for the proper station platform height. During this conversion process, all doors must remain closed.

Each quarter point vestibule doorway accessing a mobility device parking area shall have an approved bridge plate method of eliminating the platform gap and making that doorway ADA compliant per TS 4.3. Sealed proximity sensors shall be used to provide information on the bridge plate status to the door control system. The bridge plate shall comply with the requirements of 49 CFR 38.95. The design shall be approved by the Engineer. [CDRL 06-002]

Doors shall fully close and protect steps when the cars are moving. A doorway configured for low level boarding shall be capable of safely serving successive low level stops by trainline initiated opening and closing. A doorway configured for high level boarding shall similarly be capable of safely serving successive high level stops by trainline initiated opening and closing. Crew access shall be provided to the car from the track level, low level platform, and high level platform height.

A communicating signal buzzer shall be provided as per TS 13.3.

6.3 BOARDING LEVEL (HIGH/LOW) CONVERSION

The capability of the car design to safely accommodate both high and low level station platforms is of great concern to SEPTA, and the Contractor shall provide full support for this effort. The design shall be as proposed by the industrial designer and approved by the Engineer. Special emphasis shall be provided on the use of safety guards, barriers, and the like to prevent injury to the passengers or train crew.

Each end of car vestibule doorway shall be provided with a means for quick and reliable conversion between high level and low level station platform loading configurations at the local door by the train crew. Such conversions will be made while the train is in motion during revenue service passenger operation, and multiple configuration changes need to be made during each trip. The Contractor shall propose for approval by the Engineer a methodology to be used for the boarding level conversion of a doorway from low to high level and high to low level. [CDRL 06-003] The complete conversion shall be as quick as possible and require no more than three (3) seconds of effort by a single crew person per doorway. The conversion process may be powered by hydraulic or pneumatic devices with manual backup or may be a manual process and shall not involve undue lifting, turning, bending, stooping, pushing, or tugging manual effort. The conversion effort of the present SEPTA Push Pull Fleet trap door is the upper limit of acceptable manual difficulty. Approved latches shall be provided to secure the doorway flooring in the high and low positions. It is expected that the width of the flooring section to be manipulated shall not exceed the width of the doorway. If a trap door arrangement is used when the lowered trap door is unlocked for raising, it shall be supported by an adjustable torsion spring so that the outer edge will rise six (6) – ten (10) inches for ease of grasping. The boarding level conversion design shall not present any tripping hazard.
Sealed proximity sensors shall be used to provide information on the boarding level status of each doorway to the door control system. All parts of the level conversion system shall be arranged to present no hazardous conditions to the passengers, train crew, or maintainers. All wall, step, and doorway surfaces shall be smoothly finished in all boarding levels. Suitable handrails shall be provided in both the low and high positions while still meeting all ADA clearance requirements.

Means shall be provided to permit the crew to safely and easily perform the doorway level conversion at a crew door boarding location while standing outside of the car at track level or at low or high level platforms so that the crew can safely board the car at any platform height regardless of the initial boarding level configuration.

### 6.4 Door Control

Door control panels shall be mounted on the interior of each side of each end of the car vestibule and each quarter point door vestibule. All door control panels shall be watertight and chemical resistant to exclude moisture, wash solution, and dirt during the cleaning of the vestibules. All door control panels shall have a brushed stainless steel finish and be arranged and dimensioned to the greatest extent practical. The panel shall be hinged along the top horizontal side and held secure on the opposite side with captive 1/4 turn fasteners of an approved type. All controls shall accommodate the size range and ergonomics of crew persons defined in TS 2.1.1 and also allow for boarding and dispersing passenger flow at that doorway. All controls and indicators shall be labeled with engraved black paint filled lettering and borders or an approved equal durable labeling. The wording shall be similar to “LOCAL”, “OPEN HIGH”, “OPEN LOW”, and “CLOSE”, and all wording shall be submitted to the Engineer for review and approval during design review.

The door control panels shall be fitted with 11 recessed watertight push buttons and three (3) door indicator LED lights. Nine (9) push buttons shall be arranged in three (3) vertical rows of three (3) push buttons each. One (1) indicator light shall be located above each vertical row of push buttons. The left vertical row of push buttons shall control doors forward of the control station, the center vertical row shall control the local vestibule door, and the right vertical row shall control doors rearward of the control station. The forward and rearward rows are reversed for opposite vestibule locations. Arrows shall indicate the part of the train that each set of push buttons controls. The tenth push button shall be used for the communicating signal buzzer and shall function without activating the control panel. The eleventh push button shall be a “LAMP TEST” push button to verify the operation of the indicators.

Open buttons shall have a green button cover, close buttons shall have a red button cover, and buzzer buttons and all other buttons shall have a black button cover.

Each panel shall be identically arranged, as far as possible, with individual two (2) pole spring loaded momentary contact push buttons for door control. Door control switches shall be of the momentary contact type, and circuitry shall be arranged so that once the button is pressed the operation cycle shall be completed even if the button is immediately released. All push button switches shall be of a heavy duty transit quality with 1 million cycle life, have positive detents, and provide tactile indications of operation.
Each door control panel shall require a standard SEPTA coach key to individually activate. The key switch shall contain a vertical keyway to insert the key in the "Off" position. Rotating the key 90 degrees clockwise shall energize the door control panel with the key captive in this position. The key switch shall be located on the outboard side of the door control panel, and the tumbler shall be set back at least 0.5 inch from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver or similar device.

Activation of the door control panel shall be required to make either the "Open" buttons or the "Close" buttons operative. It shall be possible to remove the key after the doors have been opened and have the doors remain open provided that the train is stopped; and to close the doors using a different door control panel from which they were opened with the zoning being reestablished at the panel being used for the closing doors. The door circuitry shall be so arranged that when the local side door at any control station is opened by a member of the train crew, the "no-motion" detection shall be bypassed for that door. If the key is removed when the local door is open and the train is moving, the local doors shall automatically close and remain closed at the next stop until specifically commanded to open.

### 6.5 CONTROL CIRCUITS

#### 6.5.1 General

The car level door close and lock safety loop circuit shall be a two (2) wire circuit fed from two (2) pole double break switches energizing both the positive and the negative sides. This circuit shall be fully isolated from all other car wiring and shall be fed by an isolated power supply. A door shall not change position unless specifically commanded to do so and shall otherwise remain in its last commanded position. After any power loss occurs if the door is not closed and locked, it will close and lock but shall detect any obstacle in the doorway until the closed and locked position is reached. However during any abnormal command sequence or similar situation, the door shall not move. This specifically applies during times of train activation and storage and shall be considered a design fundamental. A door shall instantly respond to a crew open command if closing and likewise shall instantly respond to a crew close command if opening. Door control shall be designed so that high level and low level doors on a train side shall be controllable only from door control panels on that side of the train.

With momentary trainline signals, the local door controls will latch and store an open command. This stored open command can create the risk of a latent unintended door opening. To enhance safety, the doors closed and locked indication function shall be configured such that the closed and locked indication can be obtained only when no stored open signal is present in any local door control apparatus and when all doors are truly closed and locked.

Door controls shall be interlocked so that no trainline door open signal can be initiated or executed when the car is above its zero speed threshold. Loss of the zero speed signal shall terminate a door open trainline command and initiate a door close command.

Crew access switches shall function at all times except when the associated door is mechanically locked out.
6.5.2 Trainline Circuits

Separate trainlined high level and low level door control circuits shall be provided for each side of the train. The trainline wiring through the couplers shall be configured so that the left side and the right side doors of a train are properly controlled regardless of the individual car orientation within the train such as if cars are turned.

The open high level door trainline command on each side of the car or train shall open only those doorways that are set up for high level boarding. These include the quarter point doors which are designed only for high level boarding. The open low level door trainline command on each side of the car or train shall open only those doorways that are set up for low level boarding. A low level trainline command shall not open quarter point doors. Door open commands shall not be stored. The trainline circuits shall provide for door control of the whole train by a single crew person. The door controls shall permit independent control of doors forward from and rearward from the activated door control panel. This direction independence is to allow the crew person to observe all of the doors under his control during the total door closing sequence. The close door trainline command shall command all doors to close regardless of whether they are open high or low.

6.5.3 Local Door Control Circuits

Loss of the local zero speed signal shall initiate door closing except at the local door which has a keyed up active doorway control panel. Current SEPTA practice is for one (1) crew member typically at the rear of the train to remain standing at the open doorway facing the direction of movement when the train departs the station to monitor for any unsafe conditions until the train has left the station platform. To allow for continued crew monitoring of the station platform, means shall be provided to allow any door to remain open for crew observation at any doorway which has an active door control panel without inhibiting propulsion or being subject to no-motion interlock. The Conductor will then use the communicating buzzer push button to signal the Operator to depart. The Conductor will remain at the open doorway observing the station platform until the train has departed the station at which time the Conductor will close the door and remove the key. If the key is removed once the train is above zero speed prior to the door being closed, the door shall immediately close under the command of the zero speed interlock. Details shall be submitted to the Engineer for approval.

6.5.4 Zoning

The activation of a door control panel shall establish a door control zone. Multiple door panels that have been activated shall create multiple door control zones. Trainlined door commands shall not be transmitted beyond an active door control panel or control an active door control panel. In the event that there are conflicting commands within a zone such as between two (2) activated door control panels, the door closing command shall take precedence in order to provide the safest mode of operation.
6.6 SAFETY ANALYSIS

Passenger safety is highly dependent upon the safe operation of the door controls. Each door shall be provided with vital sensing means to continuously verify that the door is fully closed and securely locked which shall be based upon the position of the door and not the door operator. Individual door closed and locked sensing signals shall be collected by a vital door summary circuit on each car using vital (non-welding) relays or vital microprocessor logic. The local closed and locked status of the doors at each doorway shall be indicated by inconspicuous means so that the train crew can quickly ascertain the status of each door while looking down the car aisle.

The status of the door summary circuit on each car shall be utilized in a trainline safety circuit for traction and brake interlocking functions. The status of the door summary circuit on each car shall be indicated inside the car on each door control panel and externally on each side of the car by door status indicating lights that are conspicuous when viewed along a train. Additional details are provided in TS 6.11.

Each door shall be equipped with an electric or pneumatic sensitive edge design which shall prevent passenger injury if struck by a closing door. Obstruction sensing during closing and response shall allow extraction of any passenger extremity, carried parcel, article of clothing, or personal accessory such as a handbag or backpack strap that may become trapped in a closing door. The response shall be to recycle to the fully open position and immediately re-close. Recycling shall continue as long as an obstruction is detected. Additional means of obstruction detection such as door operator motor overcurrent detection may be considered and shall require review and approval by the Engineer. Mechanical door pushback may be used to aid in extraction. A sensed door obstruction during closing shall inhibit propulsion. Motion obstruction sensing during opening shall be provided to prevent serious passenger injury arising from door surface discontinuities moving into the door pockets. The Contractor during design review shall establish a logic table to be approved by the Engineer listing every possible combination of a door control panel and crew switch status within a train and door obstruction response and the resulting status of door control to ensure positive understanding of the design of the door system. Regardless of the method of door control used on a train, information on the door closed status shall always be communicated to the active door control station(s) and to the active cab providing control of the train's propulsion and braking. The door control system shall be designed to prevent the doors from opening unless the train is below zero speed. Interlocking on a train basis shall prevent the train from developing propulsion power unless all doors are closed and locked and all door control switches and relays are in their proper (i.e., doors closed) position both in the cabs and in the door system itself.

The entire door system including interlocks, control drive, mechanical mechanisms, indicators, bypasses, cutouts, mountings, and all connected wiring shall be subjected to a failure mode and effects analysis (FMEA) for all hardware and software as well as a fault tree analysis for circuit and software design, and the results presented to the Engineer for approval during design review. [CDRL 06-004] The door system shall be designed and constructed so that any malfunction will be self-detecting and no single point failure can result in a hazardous condition. Self-detection may be attained by triggering interlock circuits to a safe condition or by stopping further door operation in a manner easily detected by the train crew. Door control inputs shall be protected against transient and spurious signals and shall be properly filtered to provide noise immunity.
6.7 EXTERIOR CREW ACCESS SWITCH

Exterior crew switches shall be installed on the exterior of the car adjacent to each end side door to allow the train crew to access the car. They shall be located above the floor level but accessible from low level platforms and the trackbed. Additional exterior crew switches shall be installed on the exterior of the car adjacent to each quarter point door at a position convenient for high platform operation. Crew switch arrangements shall be submitted for review and approval by the Engineer. The crew switches shall be flush mounted and operated with the standard SEPTA coach key. Exterior keyholes shall be recessed and covered with gasketed top hinged stainless steel snap covers to ensure weathertightness and attached to the carbody with stainless steel fasteners for ease of replacement. It shall not be possible to leave the covers in an open position. All exterior portions of the crew access switch shall be of a non-corrosive material. All crew switches shall be easily accessible with the doors either open or closed. All controls shall accommodate the size range and ergonomics of the crew persons defined in TS 2.1.1.

Each switch shall operate at the doorway whenever sufficient battery power is available on the car. It shall be possible to remove the key with the door in either the open or closed position. The switch contacts and terminals shall be guarded and located above the keyway so that any leakage of moisture that may occur will not reach them. The crew switch assemblies shall be attached to the vehicle wiring with an electrical connector. The design shall ensure that the integrity of the door system will not be jeopardized. The switches shall be a key operated momentary contact type of heavy duty transit quality spring loaded to the center position. The key shall be inserted or removed only when the switch is in the neutral center position. Turning to the left shall close the door, and turning to the right shall open the door. Operating positions shall be suitably labeled by engraving or other durable process. When a door has been opened by the operation of a crew access switch, it shall be possible to close it by means of any interior door control panel, and thereafter the door shall operate normally. Likewise when a door has been opened by an interior door control panel, it shall be possible to close it by means of the crew switch at that door. The crew switches shall function to operate the door in all car operating modes.

The external switch location shall also ensure that an exiting crew person is clear of the door when it is commanded to close by that switch. Approved means shall also be provided to release the trap door in the down and latched position as detailed in TS 6.3. When door control trainlines are deactivated such as during train storage, the local door controls including the crew door provisions shall not consume any battery system power. The crew switch shall be interlocked with the "no-motion" circuitry so this switch shall be inoperative when the vehicle is above zero speed. Interlocking shall be negated during periods of car storage with propulsion shutdown to permit crew access when the "no-motion" logic is unavailable. The overall crew access switch arrangement shall be approved by the Engineer.
6.8  DOOR ACTUATORS

6.8.1  General

Each door shall be carried by a unitized support track and actuator unit using a linear induction motor or engineering approved equivalent. An encoder or an Engineer approved equivalent to determine door position, door timing, pushback, and any other parameter involving speed or position of a door panel shall be utilized. All door position and locking sensing shall be incorporated into this unit and arranged for complete functional adjustment prior to installation on the car. The operator shall be one with prior use in the transit market. The door operators shall be mounted above the door in the header area and shall be securely mounted to the structure of the car. The carbody structure shall be reinforced as needed to prevent any flexure of the door operator assembly and door tracks, and this shall be coordinated by the Contractor. Each operator shall be arranged to be easily accessible for maintenance through a ceiling access panel. The operator shall be protected from wind driven rain, snow, or car washing spray. The clear opening of the doorways shall meet the requirements of TS 2.2.11.

Each door panel shall have a closing force when measured at the leading edge of between 20 pounds and 36 pounds which may not be exceeded near the end of travel. When the emergency manual release is operated, the door panel shall be able to be opened or closed manually within two (2) seconds without resistance with a maximum force of ten (10) pounds for the quarter point doors and 15 pounds for the full length end doors.

6.8.2  Door System Power

The door actuators shall be powered from the car battery voltage system and shall be classed as a critical load. This system is a nominal 74 volt direct current source fed by the low voltage power supply (LVPS) augmented by the car battery. The door actuator units shall provide uniform operation from 80 VDC to 65 VDC battery voltage. From 65 VDC to 55 VDC at the battery, the actuator units may operate slightly slower but must function sequentially and properly. Voltages below 55 VDC shall not degrade or damage the door system.

6.8.3  Door Opening

The door actuator units shall be capable of fully opening each door in 2.5 seconds with an adjustment range of 2.0 to 4.0 seconds. The door opening motion shall include an acceleration interval, a constant speed motion interval, and a cushioned deceleration interval ending in a smooth and bump free stop with the door fully in its door pocket. The door acceleration rate, constant speed, deceleration rate, and time spent in each interval shall be by software adjustable parameters in the local operator control unit.
6.8.4 Door Closing

The door actuator units shall be capable of fully closing each door in three (3) seconds with an adjustment range of 2.0 to 5.0 seconds. The door closing motion shall include an acceleration interval, a constant speed motion interval, a cushioned deceleration interval, and an augmented obstruction sensitivity interval ending in a smooth and bump free meeting with the door seal on the car structure. Confirmation of the door being closed and locked shall be sensed. The door closed signal shall be used by the door controls and the car summary circuit as part of the determination of the door position safety status. The door acceleration rate, constant speed, deceleration rate, augmented obstruction sensitivity interval, and time spent in each shall be by software adjustable parameters in the local operator control unit.

6.8.5 Adjustments

The door operator and its operating mechanism shall be designed so that sufficient damping action will be provided to keep the door from bouncing off its stops at the end of either the opening or closing cycle. Door open and close times shall be adjustable to values other than the factory setting within the range for opening and closing by SEPTA through the PTU interface as per TS 16.8. Temporary software parameter adjustments of all of the local control units on a car shall be possible from a single location and a single action sequence using the door control data network. Temporary parameters shall be lost when the local control powers down. Parameters shall revert to default values when the local control is repowered. Software uploading to a new control software version shall similarly be possible from the DCN and DTN by using a password protected loading sequence.

6.8.6 Door Operator Motors

The door operator linear induction motors for each door shall not require maintenance attention or lubrication for 15 years or 450,000 door cycles of normal service. Door drive motors and controls shall be capable of repetitive cycling between "open" and "closed and locked" conditions under maximum ambient temperature conditions without damage or degradation. All door operator motors shall be interchangeable from one door position to another. Automatically resetting overload protection devices shall be used except as approved by the Engineer. The motors shall accept stall currents indefinitely without degradation, and a thermal cutout switch shall not be required.

6.8.7 Door Locking

The door support and drive unit shall positively mechanically lock each door in the fully closed position. Locking may be achieved by inherent overcenter motion of a direct connected drive element or by the provision of an independent lock mechanism on the door. The mechanical method used shall keep all doors closed (when so commanded) without the need for continuous application of electrical power. If inherent locking is provided, no control failure sequence shall be capable of causing a door motor to operate in the open direction thereby unlocking that door. Also, no mechanical failure shall permit the door to move from the closed and locked position. If independent supplemental locking is provided, the lock shall be either capable of unlocking under the worst case of preload or the door operator shall include a power close before the unlock function to eliminate the lock preload during unlocking. Confirmation of the door being closed and locked shall be sensed. The door closed and locked signals shall be used by the door controls and the car summary circuit as part of the determination of the door position safety status.
6.8.8 Door Mounting and Support

The Contractor shall ensure that the carbody mounting interface with the door operator system and the door operator and door hanger system is suitably robust and immune from distortion from the worst case conditions of car loads and track geometry and condition. The door linear drive and door support mechanism shall not require lubrication more frequently than every five (5) years of normal service. The drive and support shall prevent door skew movement and maintain the mating door edges parallel and in alignment. When closed, the mating door nosing rubber edges shall interlock tightly to provide a weathertight seal. The shape, contour, and dimensions of these interlocking rubber edges shall enhance the detection of any trapped passenger extremity, carried parcel, article of clothing, or personal accessory such as a handbag or backpack strap that may be in a closing or closed door.

The mounting of each door to its unitized support track and drive unit shall provide for all necessary installation adjustments to obtain a good fit of the door in the pocket when open and in the doorway when closed. The term "good fit" covers providing a weathertight closure that excludes noise, prevents water entry, minimizes interior to exterior air flow, prevents door rattling, but does not introduce friction and does not detract from smooth door motion. The weatherstrip shall be designed to seal the gap between the door and the edge of the door pocket opening on both sides of the door.

All mechanism adjustments shall be by positive means such as interlocking serrated flat clamped surfaces or axial adjustment of threaded items with locking nuts, locking tabs, or similar securement that cannot drift or loosen. Reliance only on friction between clamped surfaces will not be acceptable.

All limit switches and/or proximity sensors shall be precision units that are positively and precisely located so that they may be replaced without the need for mechanism readjustment. Switch and sensor mounting shall be immune to normal variations in installation workmanship. All limit switch and/or proximity sensor adjustments shall be by positive means such as interlocking serrated flat clamped surfaces or axial adjustment of threaded items with locking nuts, locking tabs, or similar securement that cannot drift or loosen. Reliance only on friction between clamped surfaces will not be acceptable.

Contacts used in the door operator for limit switches, signal light circuit switches, etc., shall be a transit quality replaceable unit type approved in detail by the Engineer. The design and installation of these switches shall be such that they require no periodic adjustment, and the adjustment screws shall be held with a breakable thread locking compound. Signal light circuit contacts shall be arranged to directly verify the locking of each door. Switch design and orientation shall be such as to prevent ingress of dirt and moisture.
6.8.9 Door Operator Cutout

Each door operator shall be provided with a combination cutout switch and door mechanical lock assembly that effectively removes the door operator, control relays, and obstruction sensing system from the propulsion/doors trainline interlock circuit on an individual door basis and locks the door in the closed position. When this assembly is used, the interior door status indicator for the door shall flash, and power shall be removed from the door operator. The exterior door open indicator shall not be illuminated; however, the local door open indicator shall flash. The lock assembly shall be made of stainless steel and shall mechanically lock the door in the closed position independent of the door operator lock mechanism. The switch and locking device shall not be visible to passengers and shall be accessible with minimum disturbance. A location as high as practical from the interior floor through a wall mounted keyed access panel is preferred. This panel covering shall be unobtrusive, made of the same material as its surroundings, and require the standard key to operate. Operating positions shall be identified as "Normal" and "Cutout". This device shall be approved by the Engineer. Use of an emergency manual release for a side door shall also unlock this device and allow the door to be opened.

6.9 INTERLOCKS

6.9.1 Propulsion/Doors Interlock

Each car shall have a traction interlock to prevent a train from developing propulsion power unless every door in each car of a train (except the local door panel kept open for train crew observation) is within 0.25 inch of its fully closed position, no obstruction sensing device on the train is actuated, every bridge plate in each car of a train is in the fully stored position, and all door control relays including those interfacing with the door control signal trainlines are in a "close door" position. The interlock circuit shall operate on a local car basis but shall be part of a trainline circuit with the active cab of the train. This shall use a dedicated trainline and not a data bus system and shall also be used to operate the cab door status indicators, door control panel indicators, and exterior door open indicators. Use of the propulsion/doors interlock bypass switch shall not affect the operation of the indicators. A local sealed interlock bypass switch shall be provided.

6.9.2 No-Motion Interlock

All door controls (except the exterior crew access switches during periods of car storage with propulsion shutdown) shall be interlocked with a local car motion detector system.
6.10 SWITCHES

6.10.1 Propulsion/Doors Interlock Bypass Switch
To allow a train to be moved in the event of an unsolvable problem in the doors or their circuits, a sealed local car propulsion/doors interlock bypass switch shall be provided. Use of this switch shall functionally remove the propulsion/doors interlock on a local car basis and the door circuits feeding it. Use of the bypass switch shall not modify the operation of the cab console door open indicator LEDs in any way, i.e., it shall still accurately indicate the door status of the rest of the train. In addition, the use of this switch shall result in the doors of the car not responding to the door open control trainlines. The switch shall be labeled and sealed in the "Normal" position. Use of the switch shall be recorded in the car level and train level diagnostics systems.

6.10.2 No-Motion Interlock Bypass Switch
The cab car shall have a provision to permit the no-motion controls to be bypassed if the no-motion signal output is defective. Use of the no-motion bypass feature shall be recorded in the car level and train level diagnostics systems.

6.11 DOOR STATUS INDICATORS
Door indicators shall be approved long life high intensity LED array lamps having a rated life of at least 100,000 operating hours at 55-95 VDC. The LED array shall be arranged such that the failure of a single LED in the array does not affect the life of the remaining LEDs. Voltages lower than 55 volts shall not cause degradation or damage to the indicators. All indicators and their location and arrangement shall be submitted to the Engineer for approval. [CDRL 06-005]

6.11.1 Exterior Door Open Indicators
Each car shall be equipped with one (1) exterior red door open indicator light on each side of the car. The exterior door open indicator shall be visible to an Operator leaning out of a cab side window or to the train crew on the station platform in bright sunlight. The light shall be designed and incorporated into a bi-directional housing and focused so that at a distance of 12 car lengths on tangent track a person with normal visual acuity can determine whether the light is "on" or "off" in bright sunlight. The lenses shall be shaded to assist in achieving the required visibility. Exterior door open indicators shall illuminate when one (1) or more doors on either side of the car are not fully closed and locked and not locally cutout. The unit shall have a low profile stainless steel or anodized aluminum housing, and electrical connections shall be made with carbody wiring by use of an in-line connector.
6.11.2 Interior Indicators

6.11.2.1 Local Door Open Indicators
Four (4) pairs of high intensity red "door open" indicating lights shall be mounted on the interior ceiling, one (1) at each quarter point door and end door vestibule. The indicators shall illuminate when the door adjacent to that indicator is open or unlocked, and the door control panel adjacent to that door is not activated. If a door control panel is activated adjacent to an open door, the indicator will turn off. When a door is cutout, the indicator adjacent to that door shall flash at a one (1) second on and off rate (adjustable 0.5-3 seconds). Lights shall be easily visible in the daylight.

6.11.2.2 Door Control Panel Indicators
Each door control panel shall have two (2) green LED indicators which shall illuminate when all side doors in the zone forward or rearward from the activated control panel are closed and locked. The vertical row in which the indicator is mounted shall define which indicator shows forward and which indicator shows rearward. Each door control panel shall also have a red LED indicator mounted in the vertical row for local door control. This red indicator shall illuminate when the local door control panel is active.

6.11.2.3 Cab Door Status Indicators
The cab of the cab car shall have a green LED indicator which shall illuminate when all side doors in the train consist are closed. If one (1) or more doors are open in the entire train consist and the door control panel adjacent to the open doors are not activated, the green LED Indicator will be off. The cab of the cab car shall also have a red LED indicator which shall illuminate when any side door in the train consist is open. If all of the doors in the entire train consist are closed, the red LED indicator shall be off.
6.11.3 Trainline Door Closing Indicators

Each of the eight (8) side doorways shall be equipped with a set of auditory and visual warning signals to alert passengers of closing doors meeting the requirements of 36 CFR Part 1192.93 (c). This warning signal shall only be given at a doorway when it receives a trainline command to close from another location on the train. The auditory and visual warning shall not function during local door control panel operation or crew switch closing commands. The LED warning lamp fixture shall be a low profile amber beehive lens located in the center of the overhead doorway header. The location shall be such as to be visible from outside of the car when the doors are open but shall maintain the required vertical clearance of the doorway. Also located in each doorway header shall be a solid state beeper with an adjustable audio output of 75 to 95 dB(A) at two (2) feet having a tone of 2,900 Hertz with 0.25 second duration produced two (2) times a second. The operation of the warning signals shall be fully adjustable by PTU software settings which are password protected, and a range of SEPTA adjustable timings and features shall be provided. The cars shall be initially arranged so that when the trainline door close command is received at a doorway, the warning lamp shall flash at a 0.5 second on and off rate, and the beeper shall sound until the door is fully closed. If desired, SEPTA can also select a warning sequence in the future where the doors will have an adjustable time delay of 0.5 to 3.5 seconds prior to starting their closing movement so that the warning signals will provide an advanced warning of door movement. The circuitry shall be so arranged that if the doors are commanded to open during a closing cycle, the warning signals shall immediately stop, and the doors shall immediately start to open. If the door closing button is pressed before the doors are fully open, the doors shall immediately close without going through the signal and timing cycle. Once the doors are fully open, the signal and timing cycle shall be restored to its starting points. All details of the warning system shall be submitted to the Engineer for approval.

6.12 OBSTRUCTION SENSING

6.12.1 Door Profile Obstruction

The door system shall monitor the opening and closing profiles and determine an obstruction by failure to achieve a door’s profile. This obstruction shall be reported to the monitoring and diagnostics system.

The door system response resulting from a profile obstruction shall only be affected by major discrepancies as approved by the Engineer during design review. The profile shall be set with criteria that does not cause nuisance faults and shall be adjustable.

Alternative methods using overcurrent detection shall be approved by the Engineer.
6.12.2 Sensitive Edge Obstruction
An electric or pneumatic sensitive edge design shall be incorporated into each door panel and associated door post to sense an obstruction or something trapped in the doorway. Controls for the doors shall be arranged so that any obstruction as defined in APTA PR-CS-S-012-02 can be sensed throughout the closing cycle until the panel is closed and locked. If an obstruction is sensed by the panel, that panel shall recycle to the fully open position and immediately re-close. Recycling shall continue as long as an obstruction is detected. Sensitive edges shall be designed so as not to sense an obstruction when meeting with the mating edges, and after the panel has closed and locked, deflection of the sensitive edge shall have no effect on the door control system. Soft rubber edges shall be designed to permit the withdrawal of obstructions that could be undetected between a closed side door and its mating edge.

Obstruction detection shall not be activated once the door is in a fully closed and locked position.

6.12.3 Door Pushback
If door pushback is proposed to facilitate extraction of a trapped item after door closure and locking, the pushback force shall be sufficient to not allow door movement under any specified car operating inertial loads. Door pushback shall be sensed by the door closed switch. After door closure and locking, the loss of the closed signal from either door shall extinguish the cab console's "Door Closed" indicator and flash the "Door Open" indicator as well as flash the car interior indicator referenced in TS 6.11.2, and the propulsion/doors interlock shall prevent application of propulsion so as to alert the Operator and train crew that an item has been inserted or may be trapped in a doorway and is at risk of being dragged or that a passenger is attempting to force a door open. The pushback mechanism shall include a method to detect door movement of more than 0.25 inch when in the locked position. The pushback mechanism shall not function on a cutout and mechanically locked door. Total permitted pushback shall not exceed two (2) inches per door. All details shall be submitted to the Engineer for approval.

6.12.4 Detection Sensitivity
The sensitivity of the obstruction detection system at the point of the door interlocking elastomer nosing engagement shall be as follows:

a. The system shall detect a flat bar 0.25 inch wide and three (3) inches high held rigidly between and perpendicular to the door. This sensitivity shall be required along the entire height of the nosing. This obstruction shall cause the doors to respond as described in TS 6.12.4.

b. The system shall also detect a 0.375 inch diameter round object held rigidly between and perpendicular to the door at all locations along the entire height of the nosing. This obstruction shall cause the doors to respond as described in TS 6.12.4.

c. The force applied on the obstruction shall not exceed 36 pounds.
6.12.5 Door Guidance

Variations in the door support and guidance friction shall be recognized in setting the obstruction sensing parameters. The door bottom guides shall be arranged so that the accumulation of dirt, debris, salt, sand, or ice shall not cause erroneous closing obstruction detection. The guidance provisions shall be self-cleaning and self-clearing if foreign matter is introduced.

6.13 EMERGENCY DOOR RELEASE

Each door shall be designed to be manually opened from inside and outside of the car for emergency egress and rescue access. This shall be achieved by the manual release of the operator which when activated shall automatically open the door one (1) – two (2) inches and allow the door to move without resistance. The emergency door release handles shall release the adjacent door and initiate movement of the door panel by means of a pull cable or other approved mechanism. The interior emergency release for each end side door and quarter point door shall be located adjacent to the door in an enclosure recessed in the vestibule wall. It shall provide safe clearance from other parts of the door and door linkage. The exterior emergency release for each door shall be mounted adjacent to each door and shall be reachable for both high and low platform access, located above the side sill adjacent to the door. All mounting locations shall be submitted and approved by the Engineer. [CDRL 06-006]

The internal and external emergency door release shall meet the requirements of 49 CFR Parts 238.235, 238.305, 238.307 and 239 and shall be included in the door system. These emergency door releases shall be located and protected so as to minimize their misuse by passengers and crew. The interior emergency door release covers shall be hinged and open without the use of a key or tools. The exterior emergency door release shall be flush mounted, and the handle shall be protected by an opaque frangible cover which will allow access without tools yet discourage unwanted vandalism. The exterior emergency door release frangible cover shall have the ability to be opened using the SEPTA standard coach key to allow SEPTA to periodically test the mechanisms without damaging the covers. The location of these emergency devices shall be clearly indicated for any approaching rescue personnel. The cover shall be capable of removal by a 5th percentile adult female without requiring the use of a tool or other implement. If the method of removing the protective cover or screen entails breaking or shattering it, the cover or screen shall be scored, perforated, or otherwise weakened so that a 5th percentile adult female can penetrate the cover or screen with a single blow of her fist without injury to her hand.

Activation of any emergency door release shall interrupt the doors/propulsion interlock and indicate an open door condition. The release control location and method of operation shall be similar for each door. The emergency releases shall be simple for passengers to understand and operate especially under stressful conditions of accident, fire, smoke, etc. Adequate signage and operating information shall be provided on the covers and adjacent as required by SEPTA and APTA standards. Use of this device shall release any mechanical door locks, disable the door operator, and shall not be inhibited by the prior engagement of any cutouts, locks, etc. The data car network shall log the activation of all activated emergency door releases and shall be transmitted through the data train network to the cab. All details including signage shall be submitted to the Engineer for approval.

Bowden cable length and routing shall be subject to Engineer approval.
6.14 DOOR SYSTEM ONBOARD DATA LOGGER

Each door control unit and system control unit shall have its own internal data logger. The data loggers shall store faults, commands, and responses of all inputs and outputs with an associated time/date stamp. The data logger capacity shall be sized such that a minimum of seven (7) days of data will be stored in the worst case condition of writing data. When the data logger is full, the data shall be overwritten on a First In First Out (FIFO) basis. The data shall be easily reviewable in graphical and tabular formats using a laptop and shall be useable in determining intermittent problems. SEPTA shall have the ability to search for particular events and sort data by criteria. The data shall be able to be retrieved by the PTU whether the unit is on the car or on the bench. The data shall be exportable as a csv file. The data shall be printable. The design of the onboard data logger shall be submitted to the Engineer for review and approval. [CDRL 06-007]

6.15 POWERED VESTIBULE END DOORS

Powered vestibule end doors shall be provided at each end of the passenger area as described in TS 4.6.3.

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7 CAB AND LOCOMOTIVE CONTROL

7.1 GENERAL CAB REQUIREMENTS

An operating cab shall be provided at the F-end of the cab car. The cab shall contain all controls and apparatus necessary for operating the train from the cab car with the locomotive in the trailing (pushing) or leading (pulling) position or elsewhere in the train. The compartment shall have an Operator’s control console on the right side of the car. All controls and panels shall be sufficiently compact to enable the Operator freedom to move about the cab with minimal restriction. The Operator's control area panels, switches, and displays shall be organized in a logical manner. Details of the design, arrangement of the cab, and the locomotive controls shall be submitted to the Engineer for review and approval. [CDRL 07-001]

The operating cab shall be a full width design. The interior of the cab shall present a clean pleasing appearance and shall be free of sharp edges and protrusions. An equipment locker behind the cab shall be provided for jumper cables, dummy receptacle plugs, radio power supply, event recorder, cab signal equipment, and any other apparatus that should logically be located there. There shall be space in the locker for the Operator's personal effects.

The cab shall be designed so that all devices and equipment are integrated (built in and flush mounted) into the console, walls, ceiling, or floor. The design shall group controls and instruments for function, maintenance, and servicing. All equipment shall be attached with machine screws to either tapping plates or captive nuts.

The cab shall have upper and side panels and a desk console located directly in front of the Operator’s position. The cab equipment layout and console configuration shall be designed to ergonomically accommodate Operators ranging from the 5th percentile female to the 95th percentile male. Seat placement shall consider the Operator’s relationship to the console and the windshield. The relationship between the Operator and the windshield shall be designed to optimize the field of view. The cab layout shall provide the Operator with an effective field of view to the right and left of the direction of travel. Obstructions to the field of view shall be minimized.

Primary console features shall be positioned to be accessible and functional from the Operator’s seated position with all primary operating controls and displays mounted within the Operator’s console desk. Normal operation shall not require awkward or unnatural positioning, extension, or excessive movement by the Operator. All primary console controls shall have unobstructed access and sufficient clearance for normal operation.

Secondary controls, switches, and features not used for train operation shall be placed on panels more remote but accessible to the Operator. Electrical and control enclosures shall be designed to preclude the intrusion of water and dust. To the extent possible, indicator lights shall be grouped together in a panel with a single push to test button.
A mock up of the layout of the cab shall be provided by the Contractor per TS 1.6.6.5 and in the pilot cab car to assure proper apparatus fit. The final layout shall be approved by the Engineer prior to any production. [CDRL 07-002]

### 7.2 CAB CONSTRUCTION

A cab layout shall be installed to provide a clean cab environment complying with the requirements of 49 CFR 229 and 49 CFR 238, the Specification, and DOT/FRA/ORD-98/03, Human Factor Guidelines for Locomotive Cabs, as applicable. The cab layout shall include the following features:

a. The F-end right side shall not incorporate sliding side end vestibule doors, trap doors, or stepwell assemblies. The area of the opening for the end side doors shall be a continuation of the car side structure. A drop sash type window complying with TS 17.8 and TS 3.7.5 shall be provided for the Operator.

b. The F-end left side shall incorporate a sliding pocket door suitable for use at high platform stations. There shall be no trap door or steps at this location. The door operator and controls shall be the same as those provided for the quarter point doors. When the cab is energized, this door shall not operate in response to trainline signals but shall be operable by use of local controls.

c. The floor covering in the Operator's control area shall be the same as used in the car interior and shall comply with TS 17.9. The cab floor, side wall, and end sheets shall be insulated in accordance with TS 3.6.

d. The Operator's seat shall be a fully adjustable type with rugged, hinged, padded armrests, infinitely adjustable lumbar support, a minimum of six (6) inches fore/aft adjustment, seat back cushion with 20 degrees range of tilt, and spring suspension used in Commuter Rail service and shall comply with the requirements of TS 7.6, APTA-PR-CS-S-034-99 Revision 2.

e. A flag holder and a fireproof closed metal container for fusees shall be provided in accordance with 49 CFR Part 229.119 (f) and as directed by the Engineer.

f. The front cab wall below the window shall be arranged to contain a floor heater, grille, and blower with a minimum capacity of 1.5 kW meeting the requirement of TS 8.5. The heater shall provide heat to the floor area under the console and in front of the Operator's seat. Controls for the heater shall be located above the console in a location approved by the Engineer during review of the cab mock up. Cab heaters may be enabled for layover operation, as necessary, to maintain the layover temperature conditions even if the cab is not activated.
g. The cab area of the car shall include two (2) lockable hinged door panels: inward swing, left hand hinged collision post door and outward swing, left hand hinged cab door. When the cab area is in use to control the train or otherwise occupied by the crew, the collision post door shall be securely latched and dogged to close the intercar passageway and isolate the cab from the exterior environment. When not in use as a cab or occupied by the crew, the cab door shall be closed and securely locked to close off the console/control area from passenger access. When in use as a cab or occupied by the crew, it shall be possible to close the cab door and operate the train. The cab door shall be equipped with push bar release on the interior (console) side and a key operated lock and handle on the exterior side (aisle side) using JL Howard hardware or approved equal.

h. The body end door shall be a sliding pocket door similar to that provided on the B-end of cab cars and both ends of trailer cars, but it shall include a feature to allow the Operator to exit quickly in the event of an emergency. Details of the emergency exit feature shall be submitted to the Engineer for review and approval. [CDRL 07-003]

i. Two (2) air diffusers (anemostats) shall be installed in the ceiling to maximize cooling and ventilation and to enable the Operator to manually adjust the air flow.

j. The area under the console and above the floor shall be clear of all piping and obstructions to provide room for the Operator's feet and legs. An approved footrest shall be provided as well as all specified foot switches.

k. One 8.5 inch by 11 inch "blue form" inspection card frame with transparent cover conforming to the FRA document size requirements shall be located directly in the cab or accessible on the inside face of a locker door as directed by the Engineer and in accordance with 49 CFR Part 229.23 (d).

l. An "air slip" inspection form clip holder for a 3 inch by 5 inch daily inspection form shall be located near the “blue form” inspection card frame.

7.3 CAB DOOR

The cab shall be equipped with a lockable hinged door to be used for cab entry and egress. In the closed position, the door shall enclose the Operator's control area.

The cab door shall consist of a minimum 0.75 inch solid phenolic core which is not susceptible to moisture or rot and sheathed with a minimum 0.050 brushed stainless steel sheathing. The core shall contain stainless steel reinforcements as necessary for attachment of all hardware where used such as the hinge hardware and shade attachments as a minimum. The door shall be bound on all four (4) edges by permanently attached stainless steel trim. It shall be hung by a continuous full length stainless steel piano hinge with a stainless hinge pin. The door shall be cushioned within the door frame across the top and sides with a neoprene elastomeric cushion to avoid any rattles, squeaks, and assist as a soundproofing barrier. The door frame shall be suitably sturdy to encase the door under all conditions. The door shall be sufficiently rigid within its frame to withstand 330 pounds applied at any point without permanent deformation and proved out during the pilot phase of the car assembly. [CDRL 07-004]
The door shall have a window in its upper portion sized and located to offer the best view into the vestibule and through the end collision door window when the cab door is in the fully opened position. The window material shall be a 0.25 inch thick mar resistant polycarbonate tinted the same as the side windows. The window shall be glazed in an extruded neoprene rubber section and mounted to the door using a two (2) piece frame (inner and outer) aluminum extrusion which shall be satin finished and anodized. The exterior frame shall have no exposed fasteners. On the interior of the door, the window shall have an opaque roller curtain shade to allow the Operator to block any light transmission through the door window into the cab.

A sight-tight louvered heavy duty nonadjustable stainless steel air grille shall be located in the lower part of the cab door for ventilation. Louvers shall be a minimum of 0.125 inch thickness and shall be reinforced by 0.125 thick vertical stiffeners. The size of the grille shall be approximately seven (7) inches vertically by nine (9) inches horizontally, located on the centerline of the door, and at least 12 inches above the floor.

A transit grade door closer shall be applied to the cab door. The door closer shall have an integral door hold open feature that will enable the door to remain open during normal operation. The door closer force and speed shall be capable for full door lock engagement but adjusted to where the door will automatically close when not in its hold open position but not engage the cab door lock so as to prevent accidental lock out conditions.

The cab door shall contain a heavy duty stainless steel transit grade door lock designed to use the standard coach key as described in TS 4.13. The lock shall contain a single latch device and be designed in such a way where once the lock is engaged and latched within the striker assembly, no unauthorized opening will be possible by the latch being retracted from the outside by the use of a knife and/or other tools. The exterior lock handle shall be a 90 degree full grip lever handle designed with sufficient strength that forcing the handle down during an attempt of unauthorized entry will not break or damage the lock. The cab side door lock release shall be a paddle style strike plate that will fully release the locked condition and allow fast emergency exiting of the cab. The cab door lock and the striker assembly shall be installed by pass through fasteners which are applied from the inside of the cab.

7.4 CAB CONSOLE

An Operator’s console shall be provided in each cab. The console shall include switches, indicators, the communications control panel, a control transfer switch, the reverser, the master controller, an alerter control acknowledge switch, and audible and visual warning indicators. The console shall have a panoramic configuration. The control panels facing a seated Operator shall be provided with a dull black powder coat finish to eliminate glare. Modular console construction shall be used with quick opening captive fasteners used to retain components. Fasteners used for the attachment of console panels shall have a black anodized finish to match the surrounding area. The console display panel shall be shaded against direct sunlight and positioned centrally to the Operator’s forward line of sight. The console shall be ergonomically compatible with adults from the 5th percentile female to the 95th percentile male. All operating controls shall be placed within the normal reach of the Operator in the seated position.
The cab console shall be illuminated for day and night operation without causing reflections on the windshield. The console light shall be controlled by a rheostatic dimmer switch as described in TS 9.16. The console light shall be located so as to properly illuminate all switches and gauges necessary for train operation.

All controls and indicators located in the Operator's cab shall be arranged in a logical and orderly manner. All indicators used in normal operation shall be positioned within the Operator's normal line of sight when seated. Controls shall be located such that they can be conveniently operated based on their importance or frequency of use. Controls or indicators associated with a specific side of the train shall be positioned on the associated side of the console or indicator panel.

All annunciator lights shall use light emitting diodes (LEDs), and shall have a self-test feature or a separate test switch to verify operation. All indicator lights and controls shall be either permanent engraved white paint filled identification signs on a flat epoxy powder coat black background or other approved techniques with equal permanence.

The cab console shall include an area for writing train orders with a paper holder clip.

The Contractor shall submit renderings of at least three (3) unique designs of cab console layouts. Details of the design and arrangement of the console shall be incorporated into the cab mock up and shall be approved by the Engineer. [CDRL 07-005]

### 7.5 LOWER CAB

The area under the console and above the floor shall be clear of all piping and obstructions to provide room for the Operator's feet and legs. A raised platform, approximately six (6) to eight (8) inches above the floor, shall be provided in front of the cab seat. An approved full-width footrest shall be provided as well as all specified foot switches, which shall be arranged similar to the SEPTA Silverliner IV and V cars.

A properly identified and recessed horn system pneumatic cutout cock shall be located below the center console where it can be easily reached by the Operator. A properly identified and recessed cab signal/PTC penalty magnet valve pneumatic cutout cock shall be located below the center console where it can be easily reached by the Operator. The cutout cock shall be self-locking so that the valve handle will not move to opposite of normal safe operating position by gravity or vibration. This cutout cock shall be sealed in the “open” position.

A full length footrest shall be incorporated within the bottom of the console for the optional comfort of the Operator. The footrest shall be manufactured from stainless steel and be the full width of the front console. The footrest shall be hinged to either stay in the deployed down position or stored and locked in the up position. Cushioning devices shall be used at the hinge points to cushion up and down movements of the footrest as it’s being deployed or stored and shall not allow the footrest to drop down into place in a loose and noisy fashion. There shall be no rattle points in the assembly’s design. As an extension of the footrest’s design, foot switch extension plates for floor mounted switches such as the alerter and deadman shall be included with the overall design concept and application. They shall be similar to those used within the Silverliner V cars which will allow the Operator to effectively engage the switches with their foot on the footrest if they are inclined to do so.
7.6 OPERATOR’S CAB SEAT

A heavy duty upholstered adjustable operator’s seat shall be installed in the cab of each cab car. The seat shall be fastened to the cab floor in a manner approved by the Engineer. The seat shall be designed to provide satisfactory comfort, proper access to all operating apparatus, and good visibility. The armrests, back panels (if used), seat cushions, upholstery materials, and any other combustible materials used in the operator’s seat shall meet the requirements of TS 17. The operator’s seat configuration and installation shall comply in all respects with the requirement of 49 CFR 229, 238, APTA SS-C&S-011-99, and, as applicable, Human Factors Guidelines for Locomotive Cabs, DOT/FRA-98-8.

The cab seat shall be designed to accommodate operator sizes from the 5th percentile female through the 95th percentile male as defined in MIL-STD-1472E. The cab seat shall be adjustable vertically and horizontally. The seat back shall have an infinitely adjustable mechanical lumbar support and a back shell to protect the rear cab wall from damage. There shall be no sharp edges or surfaces which could cause injury.

The seat shall contain mechanical components only and shall provide simple smooth adjustments while an Operator is seated. The seat shall have a minimum of six (6) inches fore/aft adjustment (nine (9) inches being desirable if the cab arrangement permits) with roller bearing slides each having locking mechanisms. The seat height adjustment range shall be a minimum of six (6) inches and shall not allow the seat to “free fall”. The seat bottom cushion shall have a range of eight (8) degrees of tilt, and the back cushion shall have a range of 20 degrees of tilt past the vertical if the car arrangement permits. Recliner mechanisms shall be double gear with a tooth and sprocket on both sides of the seat. Adjustment devices using simple notched cam plates with flat sides for setting heights or pitch are prohibited.

The cab seat shall be designed and tested to demonstrate compliance with the static load tests, dynamic load tests, cushion durability tests, and life cycle tests as defined in APTA-PR-CS-S-011-99.

7.7 CONTROL COMPONENTS

All switches, controls, and indicators on the control console or adjacent panels shall be rugged high quality devices suitable for rail vehicle application and readily available from domestically available commercial sources. Selection of switches shall conform to MIL-HDBK-1132 - Switches Selection Use and MIL-SPEC documents referenced therein as applicable. A minimum number of different types of devices shall be used, and individual functional designations shall not be marked on the device. Designations shall be attached to or engraved on the console. Multiposition controls shall have all positions identified. Adhesive bonded tags shall not be permitted. All device types shall be subject to approval by the Engineer. The arrangement of the devices shall be subject to approval by the Engineer. [CDRL 07-006]

7.7.1 Apparatus, Switches, and Indicators

Apparatus, switches, and indicators to be provided in the operating cab area shall be located as approved by the Engineer [CDRL 07-007] and are as follows:

a. Automatic Brake Control (TS 12.2)
b. Conductor’s Control Panel (TS 7.8)
c. Control Head-Radio, PA, Intercom (TS 13.2, TS 13.4, and TS 13.6)
d. ATC/PTC Display and Speed Indicator (TS 14.3)
e. Alerter Acknowledging Pushbutton Switch (TS 14.10)
f. Communications Control Panel (TS 13.5)
g. Horn Valve (TS 7.14.1)
h. Windshield Wiper Switch (TS 7.11)
i. Windshield Heater Switch (TS 7.11) (one (1) switch for all windshields)
j. Cab Ceiling Fan Switch (TS 8.1)
k. Cab Heater Switch (TS 8.2.2.2.5 and TS 8.5.1)
l. Windshield Defroster Assembly (TS 8.5)
m. Auxiliary Light Selector Switch (TS 9.11)
n. Headlight Selector Switch (TS 9.19)
o. Bell Pushbutton (TS 7.14.2)
p. Parking Brake Applied Indicator (TS 12.22)
q. End Doors Closed Indicator (TS 6.5.1)
r. Operator Quarter Point Doors Closed Indicators (TS 6.5.1)
s. HEP Ground Fault Indicator (TS 7.4)
t. Ground Reset Pushbutton
u. Locomotive Alarm Indicator (TS 7.4)
v. Locomotive Alarm Reset Switch (TS 7.4)
w. Locomotive Wheel Slip/Slide Indicator (TS 7.4)
x. Locomotive Traction Motor Cut-Out Indicator
y. Locomotive Generator Field Circuit Breaker (TS 7.7.6.f)
z. Brake System Pressure Gauges (TS 12.11)
aa. Brake Application Indicator (TS 9.17.2)
bb. Locomotive Sanding Switch (TS 7.7.6.g)
c. Cab Car Sanding Switch (TS 7.7.6.g)
dd. Sanding Indicator (TS 7.7.6.h)
e. Snow Brake Switch (TS 12.8)
ff. Cab Console Light and Dimmer Switch (TS 9.16)
gg. Cab Ceiling Light Switch and Dimmer (TS 7.13)
hh. Cab Reading Light Dimmer
ii. Cab Reading Light Switch
jj. Status Display Screen (TS 7.12)
k. HEP Phase Indicator Lights
ll. HVAC Shut Down Indicator
mm. Destination Sign (TS 13.8)
n. ECP Breaker Assembly
oo. Marker Light Switch A-end
pp. Marker Light Switch B-end
qq. Alarm Bell
rr. HEP Trainline Switch
ss. Conductor Signal Buzzer and Pushbutton Switch (TS 13.3)
t. Vestibule Light Switch A-end
uu. Vestibule Light Switch B-end
vv. Smoke Detector Indicator, Test and Reset Pushbuttons
ww. Battery Breaker Open/Closed Indicators
xx. Pantograph Raise Control (TS 7.10)
Deadman Pedal
ATC/PTC Acknowledgement Switch and Pedal (TS 14.10)
Excessive Current Indicator
No Power Brake Indicator
Lamp Test Pushbutton
Traction Mode Selector Switch

7.7.2 Sealed Switches
The following switches are to be sealed in the normal (down) position using a wire with a lead seal. A 0.1015 inch (number 38 drill) diameter hole shall be provided in each switch toggle and in an adjacent sealing wire standoff for each switch:

a. Propulsion/door Interlock Bypass
b. No Motion Bypass Switch
c. Alerter Cut-out Switch
d. Pantograph Lower Control (TS 7.10) – provide lid but will not be sealed

7.7.3 Observer Controls
The observer side of the cab vestibule shall have the following controls:

a. Emergency Brake Dump valve
b. Windshield Wiper Switch Left Side (TS 7.11) – only active if cab active
c. Observer Reading Light Switch – only active if cab active

7.7.4 Cab Circuit Breakers
The circuit breakers shall be provided in the switch panel located in the cab side of the vestibule wall behind the Operator per TS 10.6. The brake microprocessor circuit breaker shall be accessible regardless of the seat position.

7.7.5 Sun Visor
An approved, adjustable sun visor shall be installed in each cab which meets the flammability and smoke emission requirements of TS 17.24. An adjustable roll-down opaque sun shield shall be provided for each exterior window such that the Engineer can limit sunlight coming through the windshield and side window. The sun shield shall be positional over the full height of the windows. Vibration and normal vehicle motions shall not cause the shield’s adjusted position to change.
The visor assembly shall consist of a black, anodized aluminum spring loaded roll and dual channel assembly designed to accommodate travel of the shade material. The roller assembly shall be mounted above the windshield with the channels mounted vertically down both sides of the windshield. The shade height shall be controlled at the bottom of the shade material with a spring loaded friction brake rod, which runs within the channel. The rod shall have sufficient spring force to hold the shade in place during normal operation and above average vibration of the car when in use. The friction brake “feet” that engage the bottom of each channel shall be sized so as not to enable the rod to become cocked or stuck in the channels during height adjustments. The rod shall contain “pinch point” finger tabs to relieve the spring pressure so the shade height can be adjusted to meet the height of the Operator’s needs. The shade material shall be black, opaque cloth, and of a gage to ensure blocking of light transmission and rugged enough for years of use. All exposed parts of the assembly shall be low glare black finish, and all corners shall be rounded. The design and placement shall be approved by the Engineer. [CDRL 07-008]

7.7.6 Other Cab Items

A two-position key switch operated by the standard key shall be included in the cab console in an approved location, for use by the Conductor and train crew in a trailing cab of the train. When this switch is turned 90 degrees to the right, it shall power the cab ceiling lights and cab gauges, and the communications system (radio, public address and crew intercom). All traction and brake controls shall remain inactive. The key shall be captive in the On position. This switch shall activate controls for the locomotive to be remotely stopped and started. If the cab controls have been deactivated and another cab in the consist has not been subsequently enabled, the cab shall command the locomotive to shut down and start up following delays specified by the Engineer and adjustable by SEPTA.

The following shall be provided in each cab:

a. A permanent car number identification plate shall be applied to the console in a prominent location near the speedometer.

b. Two flush, heavy duty, spring loaded coat hooks with integral rubber bumper shall be located on the rear partition between the circuit breaker panel and the outside wall.

c. A clipboard-type spring loaded holder shall be installed with a clear area sufficient to hold 8.5 inch by 11 inch bulletin orders and shall be located within easy reach of the Operator.

d. A cupholder to retain a coffee cup or soft drink container shall be mounted on the side wall below the side window sliding sash and forward of the Operator’s seat. It shall be a rugged basket style design containing a folding feature to permit the stowing of the cup holder when not in use.

e. A flat writing surface sufficiently large to hold 8.5 inch by 11 inch paper shall be located directly in front of the Operator, at the base of the windshield, in order to permit the Operator to write train orders.
7.7.7 Control Functions

The specific items listed above shall have the following functions:

a. **Locomotive Engine Run Circuit Breaker** – A circuit breaker labeled “ENGINE RUN” which shall interface with the control positive trainline and when “ON” energizes the “Engine Run” trainline and provides power to the master controller.

b. **HEP Fault Indication and Remote Reset** – A system shall be provided to monitor the “HEP Ground Fault”. Upon the appearance of a voltage on this trainline, a red light labeled “HEP FAULT” shall light and an alarm bell shall sound. A separate push-button switch labeled “FAULT RESET” shall when depressed if the “HEP FAULT” light is ON apply voltage to the trainline ground reset and silence the alarm bell. The “HEP FAULT” light shall not extinguish until the HEP ground fault trainline is cleared by resetting the HEP unit in the locomotive, and a second “RESET” push-button switch located in the electrical locker is depressed.

c. **Locomotive Alarm and Reset System** – A system shall be provided to monitor the locomotive alarm trainline. A red light labeled “ALARM” shall light, and the alarm bell shall sound when a voltage appears on this trainline. Depressing a push-button switch labeled “ALARM RESET” shall silence the alarm bell and momentarily energize the ground reset trainlines. The ALARM light shall remain lit until the ALARM trainline is cleared.

d. **Locomotive Wheel Slip/Slide Indication** – A red light labeled “WHEEL SLIP” shall be provided to monitor the locomotive WHEEL SLIP trainline. An audible alarm shall sound when a wheel slip/slide has occurred on the locomotive. The audible alarm shall sound only once at the beginning of each wheel slip signal. Automatic sanding shall be provided when the cab is active and also light the sanding light whenever the wheel slip/slide circuit is activated.

e. **Power Knock Out System** – A system shall be provided which shall interrupt the engine run trainline and all engine speed trainlines when activated. Activation of this system shall occur from an emergency brake application, a safety system brake application, a non-corresponding door control interlock, or a local power knockout request. A red light labeled "TRACTION CUTOUT" shall light whenever this system is activated. Power knock out shall automatically reset upon returning throttle to the IDLE position.

f. **Locomotive Generator Field Circuit Breaker** – A circuit breaker labeled “GENERATOR FIELD” shall be provided to energize the locomotive generator field trainline. This circuit breaker shall be energized from the control positive trainline and interlocked through the master controller so that the generator field trainline shall be enabled only when the train direction has been selected and an engine speed is requested.

g. **Locomotive and Cab Car Sanding** – A three (3) position lever type spring return toggle switch labeled “SANDING LOCO-OFF-LOCAL” shall be provided. When moved to the LOCAL position, it shall operate the sanders on the cab car lead truck forward direction only. It shall not be trainlined. When moved to the LOCO position, it shall energize the SCF trainline and cause the locomotive to sand at the proper location for the direction of the travel of the train.
h. Sanding Indicator – A red light labeled “SANDING” shall be provided and light whenever the locomotive or cab car sanding is activated in either automatic or manual commands.

i. Deadman Pedal – A deadman function, which is comfortable to use for extended periods, shall be provided by means of a large foot pedal which must be held depressed by the Operator’s right foot in order to operate the train. Release of foot pressure shall result in application of the emergency brakes without wheelslip protection except when either the propulsion master controller deadman is properly activated, the brake controller has been placed in the suppression position, or the brake controller has been deactivated (cut-out). Activation of any deadman feature shall be subject to a two (2) second delay to allow for recovery from an accidental activation without penalty.

j. ATC/PTC Acknowledgement Pedal – A heavy duty, moisture-sealed cab signal acknowledgement foot switch shall be located on a raised platform, designed to be operated by a left foot.

### 7.8 CONSOLE CABINET CONSTRUCTION

The control console and display panels shall be user friendly and easily removable for replacement with maintenance, servicing, and operation as major considerations in their design, construction, and installation. The display portion of the console shall be easily viewed within the Operator’s normal line of sight. The console desk surface shall be sloped 15 degrees downward toward the Operator. The control console shall be designed so that liquid spilled on the surface will not damage or interfere with the operation of components, apparatus, or wiring. Its finish shall be easily cleaned with a soap and water solution.

The console surfaces shall incorporate a sound absorbent material.

The console surface shall be hooded to block direct sunlight and shall be constructed of a stain, burn, and corrosion resistant integrally colored non-glare material. The console cabinet shall match adjacent cab lining materials.

All controls and displays shall mount to hinged panels fastened to the console cabinet. Any vertically openable panel shall have a hold open device. Controls shall not mount directly to the console cabinet. The panels shall have a means to be held in the raised or open position. All mounting panels shall be fastened to the console cabinet with approved captive threaded fasteners on permanently mounted spacers. The console desk surface shall be easily removable for replacement.

The console shall not obstruct or interfere with the Operator’s ability to open and use the cab side windows to inspect the train.
7.9 MASTER CONTROLLER

7.9.1 General

The proper ergonomics of the design and operation of the master controller is of great importance, and it shall be as proposed by the Industrial Designer and approved by the Engineer, taking into account the human factors guidelines referenced in TS 2.1.1. The master controller handle axis of rotation shall possess an ergonomically comfortable arc travel, and a maximum turning force of twelve (12) pounds. A quarter-turn rotating handle type deadman function shall be used, having a positive, yet comfortable spring force as low as possible. The controller shall be rugged and designed for the railroad or transit cab environment. The deadman feature design shall be as simple as possible. Deadman handle rotation of approximately sixty (60) degrees from the release position toward the operating position shall initially satisfy the deadman circuit. Once the handle is released, handle rotation of approximately sixty (60) degrees from the operating position toward the release position shall initiate a deadman application unless the foot pedal deadman switch of Section 7.7.7.i is satisfied. The deadman feature shall function similar to the deadman foot pedal. Rubbing surfaces shall be enclosed to exclude dust and dirt. The controller shall be rugged and designed for the railroad or transit cab environment. The details of the controller shall be approved by the Engineer. [CDRL 07-009]

The master controller interfacing with the control trainlines (TS 5.5.4) and capable of performing all functions of a locomotive master controller shall be installed on the console. The cab car shall be able to control the locomotive only when the master controller in the cab car is energized, the master controller reverser handle or key is turned “ON”, and the cab and locomotive are properly configured.

The master controller shall have a removable reverser-handle as approved by the Engineer to prevent the unauthorized use of the controls. The reverser and main controller handle shall be interlocked mechanically as described below. The main controller handle shall be permanently attached. It shall be possible to move the reverser handle only with the master controller handle in the Coast position. With the reverser handle in the neutral position or in the "Off" position, the master controller handle shall be mechanically immobilized in the Coast position. The mechanical interlocking mechanism shall be robust and require no lubrication, cleaning or maintenance other than at the major overhaul periods for the rest of the propulsion equipment. The electrical connections between the controller and the car wiring shall be by means of sealed electrical connectors per Section 17.18.5. The controller shall be bolted to the cab. The bolts shall have open access, and the entire controller shall be easily removed and replaced for maintenance purposes.

7.9.2 Control Functions

The reverser handle interface of the master controller shall have four positions, "Off", "Reverse", "Neutral" and "Forward", and shall control other car equipment to produce the following functions. In the "Off" position, the car shall have all operating systems other than the low voltage power supply, cab signal/ATC/PTC equipment rack, crew access switches and marker lights shut down, unless layover heating is requested or as otherwise commanded by control trainlines, as detailed in this Technical Specification. In "Neutral" all operating systems other than propulsion control shall be powered, and the master controller handles shall remain mechanically locked. In "Forward" and in "Reverse" all systems shall be operable. The reverser handle shall be removable in the "Off" and "Neutral" positions. Logic circuits shall be provided so that only one cab per train can be functional in "Neutral", and only one cab in a train can be controlling in "Forward" or in "Reverse".
Circuits needed to establish the controlling cab and provide the interface with all the other car systems, such as doors, annunciators, etc., shall be carefully designed for safety, reliability and simplicity. Since such circuits can contain single-point failure locations that are capable of incapacitating a cab, or a train, the Contractor shall treat them as a subsystem worthy of special attention. In evolving his designs, the Contractor shall treat the need to operate from other than the lead cab of the train as potentially hazardous and as a solution of last resort. When design has reached the appropriate stage, the Contractor shall prepare a document which contains four items for the Engineer's approval [CDRL 07-010]:

a. An analysis of potential failures, their operational importance and how they will be annunciated to the Operator.

b. Explanation of how each of the identified failures can be overcome by the train crew, i.e., what provisions have been incorporated in the design for reestablishing train operability.

c. Explanation of how the recommended troubleshooting procedures, test equipment supplied and features of the basic circuit design will direct the attention of maintenance personnel to the point of failure.

d. An FMEA to confirm that no hazardous failure modes exist.

### 7.10 PANTOGRAPH RAISE AND LOWER CONTROL

Trainlined controls for raising and lowering the pantographs of electric locomotives shall be provided by a covered "lower" switch and a momentary contact "raise" switch in the Operator's cab. These controls shall be as follows:

a. Pantograph Up Pushbutton (PUPB) – A spring loaded push button switch, active only when the cab car is in control of the locomotive.

b. Pantograph Down Switch (PDS) – A single pole single throw switch shielded to prevent accidental operation, active from any cab car in the consist. The two positions shall be labeled "Normal" and "Lower". This switch shall be active at all times.
7.11 WINDSHIELD WIPER, WASHER, AND HEATER SWITCH

An approved, heavy duty, automatic electric windshield wiper powered by the low voltage power system shall be installed at the top of the Operator’s windshield at each cab. The wiper motor shall be thermally protected against stall conditions, have RFI suppression, and shall be easily accessed and removable from inside the end of the car, using quick disconnect fittings. A super heavy-duty transit quality tubular low wind lift pantograph wiper arm shall be used, with all visible parts having a black finish. A curved-glass type black finished heavy duty wiper blade with a replaceable rubber element sufficiently long to wipe eighty (80) percent of the glass shall be used, mounted with a saddle type connector. The system shall operate successfully in rain or snow at wind speeds (vehicle plus ambient) of 120 mph. A windshield wiper control knob shall be provided in the cab arranged for ease of Operator use. It shall have an off position, a variable delay of 10 to 0.5 seconds between each cycle, and either a variable speed of approximately 30 to 90 cycles per minute or two (2) fixed speeds. The wiper shall automatically move to a park position to the left of the Operator when turned off.

An approved service proven electrically or pneumatically operated windshield washer, with fan-type pattern spraying nozzles mounted on the windshield wiper arm, shall be provided. The washer system shall effectively cover the entire portion of the windshield within the sweep range of the wiper. A windshield washer reservoir of five (5) gallon capacity shall be mounted under the car. It shall be easily accessible and refillable from track level, and require no special hardware for filling.

A windshield heater switch shall be provided which energizes the windshield heater contactor when set to the ON position.

7.12 STATUS DISPLAY SCREEN (SDS)

Each cab car operating compartment shall have a status display screen. The status display screen (SDS) shall provide information from trailer car based microprocessor systems to a display screen to provide the Operator with status, diagnostics, and additional levels of control of the auxiliary systems of the trailer car based systems and locomotives. The SDS shall receive data from the digital trainline network (DTN) whereby system status, train number, consist orientation, and car number information from each car in the consist shall be provided. The Contractor shall provide the power and trainline wiring for the SDS.

7.13 INTERIOR LIGHTING

Each cab shall be provided with at least two (2) LED ceiling lights that shall be part of the emergency lighting circuit. The fixtures shall be suitably placed in the ceiling to illuminate the Operator’s console and the general cab area. The light shall be properly diffused to avoid glares on the windshield. The illumination intensity measured on the Operator’s console shall be 20 foot candles. The cab ceiling light shall be controlled by a two (2) position switch on the Operator’s console.

Red emergency lighting shall provide a minimum of five (5) foot candles of illumination at the cab floor level. Passenger area pathway lighting shall continue through the vestibule.

The console lighting shall be part of the low voltage distribution network. A dimmer control shall be provided for adjustment of the intensity.
The control console shall be illuminated by a small adjustable light mounted on the ceiling or a side wall. It shall be controlled by a dimmer switch located on the console.

The complete cab lighting arrangement shall be included for review and approval with the cab mock up.

### 7.14 HORN AND BELL

#### 7.14.1 Horn

A Nathan No. KSLA five (5) chime low profile air horn, mounted on a single bracket, shall be provided at the cab end of the cab car, operated by a modulating horn valve with cushioned located on the cab console. The valve shall be a Graham-White Manufacturing Company model 353 series, or approved equal, metering horn valve with a vertical padded handle orientation, prior successful use in this application, and a high cycle life. The air supply to the horn shall be through a vented cutout cock recess-mounted in the lower cab console. All horn bells shall face forward and shall be equipped with a stainless steel snow/bug excluding cones. The method of debris and snow deflection shall be subject to the approval of the Engineer. The horn sound level shall comply with the requirements of 49 CFR 229.129. The supplier shall submit a minimum of six (6) unique horn tones for evaluation. To reduce vibrations transmitted into the carbody, the horn shall be mounted on a 0.5 inch thick rubber mounting pad with steel bushings in the bolt areas to allow for the torquing of bolts during installation. Activation of the horn shall cause the auxiliary lights to flash alternately at a rate as required by 49 CFR 229.133 and as approved by the Engineer. Air pressure regulation shall be placed in line with the horn to regulate sound levels. Details of the horn installation shall be approved by the Engineer. [CDRL 07-011]

#### 7.14.2 Bell

An electronic warning bell, Graham-White Model 373-010 or approved equivalent, with sound output equal to or greater than that of a warning bell with a pneumatic ringer shall be provided on the F-end of each cab car. The bell shall produce a repeating sound with a one second repetition rate in response to continuous switch activation. The sound level emitted by the bell shall be a minimum of 75 dBA at 50 feet. The bell shall be mounted under the floor with adequate protection in a location approved by the Engineer. [CDRL 07-012] A pushbutton located on the control console shall be used to operate the locomotive bell. The pushbutton switch action shall be press to activate bell and press again to release locomotive bell application. The operating controls shall be placed within easy reach of the Operator. Activation of the bell shall cause the auxiliary lights to flash alternately at a rate as required by 49 CFR 229.133 and approved by the Engineer. [CDRL 07-013]

### 7.15 REAR VIEW MIRRORS

Each side of the cab shall be equipped with a rear view mirror. The size of the mirror shall be approximately six (6) inches by ten (10) inches and be adjustable by thirty (30) degrees on both the horizontal and vertical axes. Mirrors shall be manually accessible from the cab for easy access and adjustment.
### 7.16 CONTRACT DELIVERABLE REQUIREMENTS LIST

<table>
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<td>Cab</td>
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8 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

8.1 GENERAL REQUIREMENTS

8.1.1 System Requirements

The cars shall be provided with an integrated heating, ventilating, and air conditioning (HVAC) system to meet the requirements identified in this Section. All system components shall be service proven and supported by design and test information to demonstrate compliance with the Contract requirements.

For the purposes of HVAC control, the car interior shall be divided into two (2) independent zones at a minimum. Zone 1 shall be the A-end intermediate level, lower level, and upper level. Zone 2 shall be the B-end intermediate level, lower level, and upper level. The HVAC unit installed in the A-end equipment bay above the intermediate level passenger area shall provide the temperature control, cooling, and overhead heat capacity for Zone 1, and the unit installed in the B-end equipment bay shall provide control, cooling, and overhead heat for Zone 2. The ducting running the full length on the upper and lower levels shall allow the supply air to be equally distributed from both units. The control scheme for cooling and heating, including baseboard heaters, shall be arranged such that in the event of one unit not operating, the interior temperature remains uniform, except for the intermediate level with the affected unit. If one unit fails, the other will supply conditioned air to the entire car.

The Contractor may propose alternative zone arrangements that provide efficient distribution of the conditioned air and optimize the sizing of the duct work. Alternative zone arrangements shall be service proven for commuter rail application and shall demonstrate compliance with design and performance requirements specified.

Details of the system capacity and performance calculation, design, arrangement, installation, and operation of the HVAC system shall be submitted to the Engineer for review and approval. [CDRL 08-001]
### Design Criteria

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature (Summer)</td>
<td>95 degrees F dry bulb (DB), 78 degrees F wet bulb (WB)</td>
</tr>
<tr>
<td>Ambient Temperature (Winter)</td>
<td>-7 degrees F dry bulb, 50 percent relative humidity (RH)</td>
</tr>
<tr>
<td>Passenger Load</td>
<td>225 or AW3 capacity, whichever is greater (not less than 450 Btu/hr per person with 55 percent SHR)</td>
</tr>
<tr>
<td>Interior Design Conditions</td>
<td>72 degrees F DB and 55 percent RH (cooling)</td>
</tr>
<tr>
<td></td>
<td>70 percent F DB (heating)</td>
</tr>
<tr>
<td>Fresh Air</td>
<td>1600 cfm (minimum)</td>
</tr>
<tr>
<td>Total Airflow</td>
<td>Sufficient to meet the internal temperature, humidity, and car pressurization requirements of this Specification (5600 cfm minimum)</td>
</tr>
<tr>
<td>Carbody Heat Transmission</td>
<td>In accordance with the Contractor’s carbody and insulation design to meet the requirements of this Specification</td>
</tr>
<tr>
<td>Lighting Load</td>
<td>Total wattage of interior lights</td>
</tr>
<tr>
<td>Solar Load</td>
<td>Maximum mid-day for Philadelphia, PA in accordance with ASHRAE calculation methods</td>
</tr>
<tr>
<td>Miscellaneous Equipment</td>
<td>In accordance with Contractor’s design data and shall include, but is not limited to, interior lights, blowers, and equipment</td>
</tr>
</tbody>
</table>

The cooling system shall be able to start and operate without damage at any time of the year when exterior temperature is above 45 degrees F. The system design shall allow full cooling operation, without the influence of modulation control with the ambient temperature, up to maximum anticipated conditions at the condenser and fresh air intakes.

The HVAC system shall be designed and constructed to operate under the shock and vibration conditions specified in TS 2. The HVAC system shall not impose vibrations greater than those specified in TS 2 to the carbody in any mode of operation. Interior and exterior sound levels shall meet the requirements of TS 2.

A comfort control system shall be designed to automatically provide the specified control of car interior temperatures with any ambient temperature, from -7 degrees F to 95 degrees F at the specified wet bulb conditions, with or without variable internal heat loads such as passengers, motors, lights, and solar gain, at nominal applied voltages. The cooling system shall also remain in operation at reduced capacity, if necessary, with ambient temperatures, as defined in TS 2.2.5 and TS 18.2, at the condenser and fresh air intake and design internal and solar loads.
8.1.2 Required Interior Conditions

The average temperature throughout the passenger area shall be maintained at the following temperatures for the respective ambient temperatures:

<table>
<thead>
<tr>
<th>Temperature Conditions</th>
<th>Exterior Ambient</th>
<th>Interior Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 60 degrees F</td>
<td>68 degrees F – 72 degrees F</td>
<td></td>
</tr>
<tr>
<td>60 degrees F to 95 degrees F</td>
<td>70 degrees F – 74 degrees F</td>
<td></td>
</tr>
<tr>
<td>95 degrees F to 110 degrees F</td>
<td>Not higher than 20 degrees F below the ambient dry bulb</td>
<td></td>
</tr>
<tr>
<td>Above 110 degrees F</td>
<td>As the system will provide</td>
<td></td>
</tr>
</tbody>
</table>

The interior relative humidity shall not exceed 60 percent at any time when the HVAC system is operating in the cooling mode.

The temperature in the cab (of cab cars only), with the side window closed and the operating compartment heater turned to "OFF", shall conform to the requirements for the interior car temperature when air conditioning is in use.

The setting of the supply air diffusers, along with the mixing efficiency of fresh air and return air, shall ensure that the air entering the conditioned space is at a uniform temperature and that the resultant temperature and air speed does not cause uncomfortable draft conditions. The average air velocity at any seated passenger position shall not exceed 40 feet/minute, measured 3 feet below the diffuser.

When operating in the heating mode with the car interior temperatures within the range specified, the supply air leaving the diffuser at the slot outlets shall be within 10 degrees F of the required interior condition and shall not cause the interior conditions to be exceeded.

When operating in the cooling mode with the car interior temperature within the range specified, the supply air leaving the diffuser at the slot outlets shall be within 25 degrees F of the required interior condition, shall not allow condensate to form, and shall not cause the interior conditions to be exceeded.

The following variations in interior car temperatures are the maximum that shall be allowed throughout the entire car. The criteria below apply to the upper, lower, and intermediate levels of the car:

a. At any given time, except during pull down and warm up, among all points in the same horizontal plane from one end of the car to the other: 4 degrees F

b. At any given time, except during pull-down and warm-up, between any point approximately 48 inches above the floor and the corresponding point six (6) inches above the floor in a vertical plane: 4 degrees F
c. At any given point in the car, in the entrance ways, and at least 12 inches from the ceiling and 6 inches from the floor and walls over a period of time: 5 degrees F

d. The average car temperature shall recover within 2 degrees F of the required interior car conditions within 2 minutes maximum following a 30 second door opening. It shall be demonstrated that this requirement can be met during 1 hour of continuous door cycling of 30 seconds open and 2 minutes closed, at design conditions in both air conditioning and heating modes, at the climate room test specified in TS 18.2.

8.1.3 Ventilation and Pressurization

The evaporator blowers shall operate to ventilate the car whenever the HVAC system is energized. The minimum fresh air supply to the car shall not be less than 1600 cfm.

At a minimum, the following fan design parameters shall be submitted for review and approval by the Engineer: [CDRL 08-002]

a. Type, dimensions, model number, and manufacturer of the wheel and housing

b. Head flow and power flow curves for the selected wheel in the selected housing

c. Manufacturer's maximum allowable wheel speed

d. Fan wheel balance requirements

The system design shall ensure that the minimum interior pressurization of 0.10 inches of water is obtained in a stationary car with all doors and windows closed and all equipment operating under normal conditions. Positive interior pressure must be maintained at all car speeds regardless of the car’s position in the consist or the direction of travel.

On cab cars only, the cab door shall be provided with a grille. It shall permit the conditioned air supplied to the cab to return to the passenger compartment.

On all cars, exhaust shall be accomplished statically without the use of exhaust blowers. Removable stainless steel static exhaust grilles shall be utilized and properly balanced to assure that the car’s minimum positive pressurization and required fresh air quantities are attained. The final balancing settings for the entire air distribution system shall be determined at the climate room test.

A sealed watertight air duct shall connect the interior exhaust grilles with the exhaust openings in the car roof or approved alternative location. The exhaust duct shall be designed to prevent the entrance of wind driven snow and rain and shall be sloped to drain any moisture which may enter the ducts to the outside of the car. The duct shall be arranged such that no water traps can exist.
8.1.4 Maintenance

All components shall be designed for long service life and shall be mounted in a manner which facilitates maintenance and ease of removal and installation. Access panels to serviceable components shall open in such a manner so as not to obstruct passage or restrict maintenance access. All ceiling mounted equipment shall be designed so that when ceiling access hatches are opened, there is no collection of dust and dirt to fall upon the car interior. Temperature sensors and air filters shall be removable without dismantling the assembly. The system shall be designed to allow full access for condenser back washing. Any component requiring periodic servicing shall be maintainable from inside the car. Any component over 50 pounds shall require lifting lugs or eyelets to facilitate removal and handling. No component including air filters shall require maintenance in less than 92 day intervals. The condenser and evaporator shall not require maintenance more often than once every six years, except cleaning.

8.2 HVAC SYSTEM CONTROL

8.2.1 General

The control of the HVAC system shall be designed to automatically maintain the car interior temperature (including the cab on cab cars), at the specified conditions, with or without variable internal heat loads such as passengers, motors, lights, and solar gain. All control components and circuits shall operate from the 74 VDC power supply. The sensitivity and accuracy of the controls shall permit the requirements of TS 8.1 to be met. The temperature control of each zone shall be independent.

Activation of the train level HVAC systems shall be automatic when HEP and 74 VDC power are available, and the HVAC circuit breakers are in the “On” position. Activation of a cab in a cab car or locomotive will start the HVAC. When no cab is active, the HVAC shall be in layover mode.

The HVAC system shall sense air dry bulb temperatures, as required, with thermistor sensors. Thermistors shall be encapsulated in a protective stainless steel tube. Thermostats may be used in the cab and observer areas to provide layover control. The layover thermostat used in those areas shall be a passenger rail service proven bimetallic or liquid filled type.

Temperature sensors shall be robustly mounted and located to ensure that they are not unduly influenced by local sources of heat such as motors or resistors; they are easily accessible for maintenance and replacement; they are protected from damage during routine maintenance and servicing such as replacing filters; and they are not unduly influenced by fresh air. Sensor accuracy shall be as required to comply with the requirements of this Specification.

The temperature control unit (TCU) shall control the heating, ventilating, and air conditioning contactors directly through power switching transistors provided as part of the unit without the use of pilot relays or solid state relays. The controls shall be arranged to prevent damage to the units due to incorrect operation, and to prevent liquid “slugging” through the refrigerant compressors.
The temperature control unit (TCU) electronics shall be selected in strict conformance with the specified requirements and shall be packaged in a single rugged, totally enclosed sheet metal enclosure. Required heat dissipation shall be accomplished by convection; if necessary, the Contractor may propose external cooling fins arranged to avoid the collection of dirt to the Engineer for review and approval. The unit enclosure shall be arranged for quick removal and replacement with no more than four (4) captive fasteners. Electrical connections, including portable test unit connections, shall be by means of a 1/4 turn Litton-Veam or equivalent environmentally sealed connectors.

Complete means shall be provided to SEPTA with the PTE laptop units, using suitable password-protected software as approved by the Engineer, to allow it to revise all temperature setpoints for the control system at no additional cost, both on a temporary and a permanent basis. Approved methods shall be provided to identify such changes by means of a revision level or similar to permit ease of identification of revisions to the system software. This capability shall be demonstrated as part of the supplier First Article Inspection, and later at the climate room test of the completed car.

The final selection of temperature control, equipment, and arrangement shall be approved by the Engineer and shall be verified at the system qualification and vehicle climate room tests [CDRL 08-003].

The HVAC system status and failure event information shall be reliably and accurately transmitted through the DTN to the MDU. The reporting methodology and format of the display of this information shall be submitted to the Engineer for review and approval. [CDRL 08-004]

8.2.2 Control Operation

The operation of the HVAC system shall be fully automatic at all times that low voltage 74VDC and 480 VAC power is available. The system shall function to maintain the required interior conditions listed in TS 8.1 for each zone.

In the event of power interruption causing sudden shut down of the HVAC system, the control system shall restart the HVAC equipment upon power restoration in such a manner as to prevent damage to any components of the system. The Contractor shall include analyses of all possible power loss scenarios in the FMECA along with the effects of preventive measures to protect the equipment from damage.

8.2.2.1 Cooling Control

Each control system shall control the operation and unloading of the refrigerant compressor(s) and the staging of the overhead heat (reheat) in response to the sensed return air temperature (including the rate of temperature change), refrigerant pressures, ambient temperature, and other factors as necessary to maintain the interior conditions listed in TS 8.1. The control logic shall prevent rapid cycling of any device.

To minimize the effects of motor inrush currents on the head end power system, the compressors shall start in their maximum unloaded condition as applicable for the compressor type. The controls shall incorporate a randomized startup sequence method to ensure that only one (1) compressor per consist attempts to start at any given time. Alternate schemes may be proposed to the Engineer for approval.
8.2.2.2 Heating Control

The overhead heat shall be controlled such that the power offsets the fresh air ventilation heating load except during pull up when the overhead heat shall operate at full power. The floor heaters shall be cycled as required to offset all other losses and maintain the interior conditions within the requirements of TS 8.1 for each zone. The size of each stage shall be arranged and controlled to minimize the cycling of the heat control contactors.

8.2.2.2.1 Overhead Heat

A duct temperature sensor shall be provided for use in controlling the overhead heat. Each control system shall cycle the overhead heater power, as required to maintain the delivered air temperature as measured by the duct sensor, at or no more than 8 degrees F above the return air temperature.

In order to reduce cold car pull up time, the overhead heat shall operate at full power when the return air sensor reading is 10 degrees F or more below the required interior temperature. The use of fresh air dampers shall not be permitted.

8.2.2.2.2 Floor Heat

Each control system shall cycle the floor heaters power as required to maintain the required interior temperature. Control schemes, which utilize the rate of change of the interior temperature as well as the actual value, are encouraged.

8.2.2.2.3 Layover Heat

Thermistor sensors, used for the normal temperature control for each zone, shall be used for layover control. In the layover mode, thermistors shall operate the floor heaters in each zone to maintain an average interior temperature of 45 ± 5 degrees F at any ambient temperature below 40 degrees F. Thermostat(s) may be provided for the cab and observer area to operate the cab and observer heaters, when control switch is in the OFF position, with enough capacity to maintain the same temperature as in the passenger area.

8.2.2.2.4 Protective Heaters

Protective heating elements, using approved power sources and control methodology, shall be provided at the air compressor automatic drain valves, the coupler, and as required for the proper operation of other vehicle systems as recommended by the equipment supplier. No heated surface associated with a protective heater shall exceed 125 degrees F. The protective heaters shall be controlled by the HVAC unit to operate when the ambient temperature is below 35 degrees F. Heaters shall be provided in a manner which facilitates maintenance, shall be protected from accumulations of moisture and salt, and shall use environmentally sealed electrical connections. Protective heaters shall be sufficiently isolated from other systems so that failure of any protective heater shall not cause shutdown of any other devices, including other protective heaters. All protective heaters shall be approved by the Engineer. [CDRL 08-005]
8.2.2.5  Cab Heat

Cab heat control shall be via a manual four (4) position switch (Off, Low, Medium, High) mounted on the console. The fan shall operate in all heat positions. The fan shall be driven by a fully enclosed, lubricated for life, sealed ball bearing, and heavy duty 120 VAC motor. The cab heat control switch shall be energized even if the cab is not active.

8.2.2.6  Doorway Heaters

The upper and lower side door panel door thresholds for each exterior side doorway shall be equipped with a protective heating system, designed to prevent freezing in the threshold area, whenever the exterior ambient air temperature is below 35 degrees F. The system shall consist of a 120 volt AC self-regulating heating cable mounted along in the area of the lower door guideways in the threshold plate. The heating cable shall be secured by metallic clips; adhesive tapes shall not be used. All cable and electrical terminations shall be environmentally sealed to withstand exposure to cleaning chemicals, deicing salts, brine, etc., present in the door area. The system shall operate whenever a cab control key is used to activate the train or when the train is in layover mode, and a control signal from the HVAC control system indicates that the ambient temperature is below 35 degrees F. It shall also operate whenever the layover heating system is in operation. No heated surface which could be contacted by a passenger or be in contact with any nonmetallic door seal or guide shall exceed a temperature of 125 degrees F. Access shall be provided to all electrical terminations for maintenance. The threshold heater system shall be approved by the Engineer. [CDRL 08-006]

The cable arrangement used to power the sliding threshold heater shall be routed in such a way that it does not fail as a result of chaffing or fatigue due to the cycling of the side door or trap door. The cable assembly shall resist without failure 200,000 low platform door opening and closing cycles. The Contractor shall design the cable assembly such that it can be easily replaced in approximately 15 minutes by one man in the field utilizing common hand tools. The cable assembly shall be installed so that it does not present a snagging or tripping hazard to passengers utilizing the stairwell assembly. The Contractor shall conduct a cycle test of the cable assembly as required in TS 18.2.1.4. The design of the cable assembly shall be submitted to the Engineer for approval. [CDRL 08-007]

8.2.3  Control Unit

The HVAC control unit shall be powered by the 74 VDC system. The unit shall be designed and constructed to properly interface and control the HVAC system and to communicate with the monitoring and diagnostic systems and the train level control scheme.

The unit shall include an interface for servicing the unit and for software and event information downloads to a laptop computer. The interface port shall be serial, Ethernet, or USB, latest version, or approved equal, and shall be the same as provided on other vehicle systems to minimize the number of different cables required. The appropriate cables for connection of a laptop PTE to the control unit shall be provided. The interface shall be readily accessible without removing any components. The Contractor shall supply, 30 days prior to the delivery of the first car, the software required to access and service the unit. [CDRL 08-008]
8.3 HVAC UNIT REQUIREMENTS

8.3.1 General

Each vehicle shall have two (2) independent, roof mounted, self-contained modular HVAC units. The units shall be identical and interchangeable among all cars and between ends. The unit shall include an evaporator, fresh air and supply air fans, compressor, condenser and associated fans, electric heating elements, control unit, thermostat assemblies, and filter assemblies.

All hardware and fasteners shall be of non-corrosive stainless steel material.

The unit shall be constructed of stainless steel except as specifically approved otherwise by the Engineer. The units shall be capable of being removed and replaced with the use of an overhead crane with a capacity of 2 1/2 tons. Separation of the unit from the car shall be facilitated by quick disconnect mechanical and electrical means and removal of mounting attachments. Taper guide pins shall be provided for ease of precisely locating the unit on the roof. The taper pins shall be mounted to the carbody. The Contractor shall minimize the distance required to lift the unit from the roof. If a lifting jig is required to safely remove the unit, four (4) such jigs and their associated manufacturing drawings shall be provided to SEPTA at no additional cost. The time required to remove and replace the HVAC unit on the car shall not exceed two (2) hours for two (2) workers.

The top of the HVAC unit shall serve as a walkway for maintenance personnel to travel from one end of the car to the other and as a platform/work surface for safely performing maintenance, troubleshooting, and repair tasks. The designated walkway/work surface shall be sized to allow for maintenance personnel to safely access equipment and perform required tasks through covers panels, and in no case shall it be less than twenty-four (24) inches wide. The surface shall be capable of supporting a 300 pound man without oil canning. The walkway/work surface shall be clearly marked with etched and black paint filled stainless steel labels. The walkway/work area shall have a non-skid surface and shall meet the same load requirements as the roof structure and as encountered for maintenance, service, and repair activities. For a sloping roof design, a designated roof top walkway for HVAC maintenance shall be provided alongside the HVAC units and the surface shall meet the criteria in this Section.

Equipment design and installation shall provide full accessibility for maintenance, troubleshooting, and repair without interference with other systems.

The following components shall be part of the unit and shall be easily accessible for servicing and replacement either through a hinged grille, which provides access to the return air plenum from the inside of the vehicle, or through an interior access door located in the intermediate level ceiling:

a. Air filters
b. All electric and pressure controls, including the TCU
c. Contactors and circuit breakers
d. Refrigerant gauge ports
e. Liquid line sight glass
f. Return air thermostats
g. System fault and status LEDs
h. Crankcase oil sight glass, if applicable

A diagnostic test plug for the HVAC PTE shall be located in a locker on the intermediate level.

All other components shall be easily accessible for servicing and replacement from within the equipment bay. Air filters and return air thermostats shall be accessible via the return air plenum and the other components through interior access doors in the intermediate level ceiling.

All electrical connections to the units, with the exception of the grounding strap, shall be by means of quick disconnects in accordance with TS 17.18 for each voltage level.

The units shall be secured to the car structure using a maximum of eight (8) threaded fasteners. The mounting system shall be such that the air conditioning unit shall be safely retained to the vehicle even in the event of failure of up to 25 percent of the fasteners. A ground strap shall be provided between the unit frame and the carbody. The unit shall be furnished with lifting provisions, approved by the Engineer, and shall be removable without disassembling refrigerant piping. [CDRL 08-009]

### 8.3.2 Ventilation

#### 8.3.2.1 General

Ventilation of the car shall be accomplished by centrifugal fans supplied as part of each unit. Ventilation shall be available at all times in accordance with design criteria specified, when the units are operating, including conditions when heating and/or air conditioning functions have failed. The ventilation system shall maintain a positive static pressure at all car operating speeds and direction of travel.

Interior air shall pass through the return air grill and return air filters to the plenum where it shall mix with the filtered fresh air. The mixed air shall then pass through the evaporator coil, overhead heater coils, and evaporator blower. Mixing efficiency of fresh and return air shall ensure that the mixed air entering the coil is at a uniform temperature. Airflow velocity shall be uniform within 10 percent across the entire face of the filters and evaporator coils. In no case shall the air velocity across the air filters exceed 300 feet per minute and across the evaporator coil exceed 500 feet per minute at any location.

Radiused entry nozzles in the fresh and return air duct work, if needed, shall be used to control the volumes of fresh and recirculated air. Nozzle sizes shall be determined as part of the computational fluid dynamics model (CFD) analysis required by TS 8.10 and revised as necessary during the ventilation prototype test and car climate room test. Nozzles shall be located far enough upstream of the filters to allow full airflow across the face of the filters and over the thermostats.

Temperature sensors shall be positioned and protected, if required, to ensure they sense the correct unbiased temperature of the fresh, recirculated, or supply duct air, as appropriate.

Turning vanes, flow straighteners, and a sound attenuator shall be included as necessary to ensure that all other provisions of this Specification are met.
The ventilation system shall be designed and integrated into the vehicle to ensure that it does not contribute to the lethality of a fire. For this purpose, each car shall have smoke detectors installed in the passenger compartments and, if required, in other areas of the car. The detectors shall be powered from the low voltage power system and shall be rugged, reliable, and vandal proof. The detectors shall not be sensitive enough to detect cigarette smoke but shall detect smoke in such a concentration which can be considered a threat to passengers. When an unsafe condition is detected, the ventilation system on the car shall shut down and activate a trainline visual indicator in each cab. Activation of the indicator shall be recorded in the car level and train level diagnostic systems. The alarm in the cab shall remain on until acknowledged, and the alarm in the affected car shall remain on until reset. The design shall include a press to test switch. The reset and press to test switches shall be in an approved location that is accessible to the crew and maintenance personnel and not visible to the passengers. Details of the design, operation, installation, and testing of the alarm feature shall be submitted to the Engineer for review and approval. [CDRL 08-010]

8.3.2.2 Motor-Blower Assembly

A motor-blower assembly shall be supplied as an integral part of each unit. It shall blow or draw the air from the mixing plenum through the evaporator and overhead heater assembly and force it into the supply air ducts from where it shall be discharged into the passenger and cab areas.

The motor-blower assembly shall be balanced in accordance with IEEE Standard 11. Imbalances shall be less than 0.001 peak to peak displacements in any direction at the motor end bells when mounted in the unit. The motor blower assembly shall be isolated such that motor and fan vibration and noise transmitted to the car structure shall be below the limits specified in TS 2.3.

The blower motor shall be of a permanently lubricated roller bearing TENV design. It shall operate from the 3 phase 480 VAC HEP supply and have a service factor of 1.15.

Motors and blowers shall be easily removable for repair, cleaning, or replacement either individually or as an assembly. Motors and blowers shall also be accessible for routine inspection and maintenance. Blower wheels shall be direct mounted and keyed to the motor shaft. The motor shaft shall be of a corrosion resistant material and an anti-seize compound shall be applied to prevent the blower wheels from seizing to the shaft.

The design of the blower wheels and their enclosures shall meet the pressure and volume requirements while producing minimal noise.

8.3.2.3 Unit/Carbody Transition Ducts

The HVAC unit to carbody interface shall be such that connection of the unit’s discharge to the main air duct is automatic when the unit is installed on the car. The design shall prevent the entry of water, dust, or other contaminants into the duct system. Alternate methods of transition may be considered if they do not require tools to connect and disconnect.
8.3.3 Overhead Heat

Overhead heaters shall be supplied within the evaporator compartment to provide tempering for fresh air intake and for reheat to maintain humidity control under partial cooling operation of the air conditioning apparatus. The heater coils shall be located downstream from the cooling coils and shall have sufficient capacity to heat the total input of fresh air from −5 degrees F to 68 degrees F at 480 VAC within 30 minutes. The heater elements shall be of the low thermal inertia, open coil, resistance wire type with terminations and insulated supports as approved by the Engineer. Alternative configurations may be proposed and shall be submitted to the Engineer for review and approval. The heaters shall be powered from the nominal 480 VAC supply and shall be staged to provide variable power operation.

The heater unit shall be designed to allow easy removal and replacement by means of a maximum of ten (10) captive fasteners. Alternately, individual heater coils shall be capable of being replaced without removing the heater from the HVAC unit. There shall be no exposed, uninsulated, or unprotected high voltage components, wiring, or terminal connections in the heater area, except the heater element coils.

The heater elements shall consist of a stainless steel finned, corrosion resistant sheath surrounding a nickel chromium resistance wire, embedded in a compressed and baked refractory material. Silicone rubber shall be used to insulate the electrical terminals from the sheath. The maximum surface temperature of the sheath shall not exceed 572 degrees F. Alternate heater element designs may be proposed for approval by the Engineer. Direct electrical connections to the heating elements shall utilize high temperature solderless ring lug terminals and bolted connections utilizing tinned flexible stranded copper cable, with a maximum strand size of 24 AWG, and approved Teflon insulation with UL certification for continuous service at a minimum of 302 degrees F. Wire terminations shall be resistant to thermal cycling and be approved, and insulated supports shall be used. High temperature clear heat shrink tubing shall be used to protect terminations. There shall not be any exposed, uninsulated or unprotected electrical components, wiring, or terminations, except for the heating elements themselves.

8.3.3.1 Overhead Heat Protective Devices

The overhead heater elements installed in each HVAC unit shall be protected by circuit breakers. Each stage of overhead heat shall be switched independently by a suitable electromechanical contactor.

Three (3) stages of overhead heater protection shall be provided. They shall be:

a. Proof of Airflow

A differential pressure switch or evaporator blower current monitoring device shall be employed to detect and prove airflow through the evaporator section. The proof of airflow method, device, and application shall be approved by the Engineer. [CDRL 08-011] The overhead heaters shall not be allowed to be energized if proof of airflow has not been established and loss of airflow, while the heaters are energized, shall cause the heaters to be immediately deenergized.
b. Overheat Thermostat

An automatically resettable overheat thermostat shall be installed in a location to reliably and accurately sense the temperature in the area of the heater coils. The overheat thermostat shall be wired directly in series with the coil of the overhead heat contactor and shall also provide feedback to the control logic. The set point shall be selected such that the overhead heaters may cycle indefinitely on overhead thermostat control with no damage caused to any HVAC system components. The set point shall also prevent nuisance trips from any condition that may be expected to arise during normal operation including operation over the allowed range of input voltage and air filter maximum recommended pressure drop.

c. Backup Protection

Backup protection shall be provided to positively remove power to the overhead heater elements in the event of a control failure or failure of the overheat thermostat. The backup protection shall be a fusible link. The set point shall be selected such that no damage shall occur to any HVAC component by temperatures reached before or after the backup protection device actuates. The setting of the backup device shall be coordinated such that it will not actuate under any conditions which may be achieved with normally operating controls and functional overhead thermostat.

All protective devices shall have their ratings, type, and locations designed such that protection is provided without any nuisance activations under all possible combinations of operating conditions including unexpected ventilation blower shutdown. Airflow switches are prohibited unless approved by the Engineer. Sensors, thermostats, and thermal fuses shall use approved electrical and mechanical attaching methods to allow rapid replacement.

8.3.4 Cooling System

8.3.4.1 General

The air conditioning system shall be capable of cooling and dehumidifying the car with direct expansion electromechanical vapor cycle equipment.

The system shall utilize and be delivered with R-407c refrigerant.

Every pressure containing component of the equipment, except piping, shall be listed as having been pressure tested and approved by a nationally recognized testing laboratory. Alternatively, each component shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand five (5) times the design working pressure. All such components shall be factory tested to at least 1.5 times the design working pressure for which it is rated.
Two (2) scroll design refrigerant compressors shall be supplied for each unit. They shall be of the highest efficiency available, lightweight, supplied from an approved U.S. manufacturer, and have previous successful North American rail application experience. The compressors shall be able to operate without damage on 480 volts 60 Hertz 3-phase AC power from the auxiliary power supply inverter. The application of the compressor shall take into account that auxiliary power interruptions of up to 150 times per hour may frequently occur and that pump down may not be performed prior to every power interruption. This shall not have any negative effect on the operation or life of the compressor. Pump down, if used, shall be initiated by closing the liquid line solenoid valve after an “OFF” signal has been received. System refrigerant shall be transferred to the condenser section until the compressor suction pressure drops to an approved value. Controls shall be arranged to equalize operating time on both compressors within a unit.

Crankcase heaters shall not be used unless approved. The motor shall be equipped with internal overtemperature protection, and safety devices shall be provided to stop the compressor motor if the pressure exceeds either the high or low preset limit. High and low equalizing lines shall not be utilized. Check valves shall be provided to prevent the liquid refrigerant from entering the compressor. An electrical unloader shall be used if required to reduce the load required to start the compressor. Service manifold valves with gauge ports shall be provided in each compressor suction and discharge line connections to provide for isolation and replacement of each compressor without loss of refrigerant charge. The compressor shall be dynamically balanced; installed using approved resilient mounts and safety straps, and electrically grounded. The compressor shall be approved by the Engineer. [CDRL 08-012]

Proof of airflow shall be required to initiate or maintain compressor operation. A pump down shall be immediately initiated if a loss of airflow is detected while the compressor is operating.

An approved suction line accumulator shall be provided between the evaporator and the compressor to prevent liquid slugging of the compressor(s). The selection of the suction line accumulator shall be in accordance with the accumulator manufacturer’s guidelines for the application and approved by the Engineer. [CDRL 08-013]

Refrigerant piping shall be sized in accordance with recommendations contained in the latest edition of ASHRAE Fundamentals.

### 8.3.4.2 Evaporator Section

The evaporator coil fin assembly shall be housed in a rigid stainless steel frame. The tubes shall be supported at each end and in the center of the coil. The tube support sheets shall be constructed of stainless steel with die formed support collars for each tube. The evaporator coil shall be of copper fin and copper tube construction with nominal fin thickness of 0.008 inch for flat or wavy fins and with a maximum of ten (10) fins per inch. The tubes shall be expanded to positively retain the fins in position and provide positive thermal contact.

The evaporator coil circuitry shall be split into two (2) separate circuits, using an interlaced circuit arrangement, with each half of the coil being fed by its own liquid line solenoid valve and thermal expansion valve.
The design of the evaporator unit shall provide a space of not less than three (3) inches between the evaporator coil and the heater elements to enable the cleaning of the coil by either back blowing or washing. The unit’s design shall also prevent any air bypass through the drain pan or around the heat exchanger of the evaporator and heater elements. The average airflow velocity over the face of the coil shall be low enough to prevent condensate moisture carryover into the fan plenum or the main duct, but in no case shall this velocity exceed 500 feet/minute. The spot velocity at any location shall be within 10 percent of the average face velocity.

### 8.3.4.3 Condensate Drain System

A condensate drain pan shall be provided beneath the evaporator coil, headers, thermal expansion valves, and coil “U” bends in order to collect condensation. The drain pan shall be made of stainless steel with stainless steel fittings. The drain pan and fittings shall be designed so that water cannot spill over into the ceiling area under any operating conditions, including the worst case combination of negative evaporator section pressure, grade, super elevation, acceleration (positive or negative), and car roll. The drain pan shall be mounted in such a way to permit inspection and cleaning of evaporator coils.

Condensate drain lines shall be sloped using general bends and piping for positive drainage to the underside of the car, shall not be routed through electrical or electronic cabinets, and shall not discharge on car structure, wheels, brake equipment, or undercar equipment boxes. An elastomeric flapper valve, or “kazoo”, shall be attached to the drain line termination underneath the car to prevent backflow. Drain lines shall be arranged to eliminate any potential water traps. The condensate drain lines, coil housing, and pan shall be insulated to prevent condensation formation.

Connection between the HVAC unit’s drain pan and the carbody condensate drain lines shall be made with heavy gauge flexible tubing meeting the smoke and flammability requirements of TS 17.24. Clear access to the connections shall be provided from the interior of the car or equipment bay to allow for unit removal. The Contractor shall provide an automatic self-sealing arrangement for connecting the drain pan to carbody drain lines subject to approval by the Engineer.

### 8.3.4.4 Air Filters

Fresh and recirculated air, or fresh and mixed air, shall be filtered by disposable type two (2) inch thick pleated media filters of the cardboard frame type in a commercially available standard size. Face velocity shall not exceed the manufacturer’s recommendation.

Initial clean filter pressure drop shall be a maximum of 0.12 in. of water. Filter performance shall have a maximum pressure drop of 0.5 inches of water at a constant velocity of 300 ft/min. Filter efficiency shall be:

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<th>Test Standard</th>
<th>Requirement</th>
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<tr>
<td>ASHRAE 52.1</td>
<td>Average dust spot efficiency – 25 percent</td>
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<td>ASHRAE 52.1</td>
<td>Arrestance – 90 percent</td>
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<td>ASHRAE 52.2</td>
<td>MERV 7</td>
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The filters and filter holders shall be sealed at their edges to prevent filter bypass. The filter holders shall incorporate hinged spring retaining clips to securely hold the filters in position. Support of the filter elements shall be provided to prevent blowout of the filter elements under clogged filter conditions. Filters shall be readily accessible for replacement from inside the vehicle through the recirculated air opening.

Air filters shall meet the requirements of UL Standard 900 Class 2 and the requirements of TS 17.25.

### 8.3.4.5 Other Evaporator Components

Other components, which shall be included as part of the evaporator portion, are as follows:

a. A liquid line solenoid valve for each evaporator circuit. The solenoid valves shall be of a compact design with pilot operated disc construction. Solenoid valves shall have an operating differential rating of 300 psi minimum.

b. Thermal expansion valves (TXV’s) for each evaporator coil circuit. TXV’s shall have external equalizers and field replaceable working parts. The TXV diaphragms shall be flat (not corrugated) stainless steel. The TXV’s shall be located to provide easy access for maintenance and servicing. The TXV’s superheat shall be set at 10 degrees F, ±2 degrees F, and the adjustment screw or cap shall be sealed.

c. An easily removable and serviceable brass bodied liquid line "Y" strainer with 80 or 100 mesh size or a filter drier fitted with a filtering mesh 100 mesh size.

d. A liquid line sight glass and moisture indicator between the strainer and tee for each coil circuit. The liquid line sight glass and moisture indicator shall be located to be visible by an individual standing in the vehicle floor. It shall allow observation of the refrigerant flow state. Their location and access shall be subject to approval by the Engineer. [CDRL 08-014]

e. Two (2) air pressure taps for measuring evaporator coil air pressure drop. The pressure opening diameter in the side wall shall comply with Figure 2 of ASHRAE Standard 51.

### 8.3.4.6 Compressor/Condenser Section

The compressor/condenser portion of the self-contained unit shall meet the following requirements:

a. Refrigerant Compressor

The refrigeration compressors shall be a heavy duty reliable scroll type suitable and service proven for operation on rail transit equipment. Crankcase heaters shall not be used unless approved by the Engineer.

A capacity control shall be provided in at least five (5) capacity steps (approximately 35 percent, 50 percent, 70 percent, 85 percent, and 100 percent). The capacity control shall be accomplished by multiple compressors along with the multiple refrigeration circuits in the heat exchangers.
The compressor shall be resiliently mounted. Flexible copper straps shall be provided to electrically ground each compressor to the unit frame.

The HVAC compressors shall be powered from the 480 VAC HEP supply.

b. Condenser Coil Assembly

The condenser coil(s) shall be housed in a stainless steel frame with suitable fan shrouding and protective screening. The coil(s) shall be of a copper tube and copper fin construction with minimal fin thickness of 0.008 inch for flat fins. The maximum number of fins shall be eight (8) per inch. The tubes shall be expanded to positively retain the fins in position and provide positive thermal contact. The tube support sheets shall be constructed of stainless steel with die formed support collars for each tube. A center tube support sheet shall be provided if the total tube length is greater than 36 inches. The coil shall utilize copper tubes of sufficient wall thickness to withstand system pressure. The coil shall be designed with adequate capacity to provide a maximum condensing temperature no greater than 30 degrees F above the condenser cooling air temperature under conditions of full rated load. The coil shall be also be designed to ensure that the air conditioning system can operate under extreme ambient conditions without the risk of creating abnormal system pressures.

The condenser coil shall be proof tested by the manufacturer at 1.5 times the maximum pressure or 600 psig, whichever is greater. As an alternative, the first coil may be burst tested to demonstrate a positive margin of safety, and all other coils proof tested to 425 psig.

c. Condenser Fan and Motor

The condenser fan(s) shall be powered by 3 phase 480 from the 480 VAC HEP supply. The motors shall have a service factor of 1.15 and be totally enclosed and rated for wash down applications with permanently lubricated rolling element bearings and have sufficient capacity to drive the condenser fan under all load conditions. A flexible copper strap shall be provided to electrically bond the condenser fan motor frame to the HVAC unit structure. Motor installation, with its shaft vertically up, shall require the application of a slinger on the motor shaft to prevent moisture penetration to the inside of the motor. The motor shaft shall be of a corrosion resistant material, and anti-seize compound shall be applied to prevent the fan hub from seizing to the shaft.

The fan(s) shall be a multiblade axial fan(s), and the blades shall have airfoil profiles or approved equal to ensure optimum fan efficiency and minimum noise generation. Connection of the fan hub to the motor shaft shall be by a tapered bushing type hub with a key.

d. Condenser Airflow

Condenser cooling air shall enter the unit through the condenser air intake grill and enter the coil. Condenser intake grille shall be fitted with appropriate meshing to prevent entrance of leaves.
Hot air, discharging from the condenser coils, shall pass through the condenser fan(s), a stainless steel duct, and shall be discharged through the roof mounted discharge grill. The grill shall be designed so that condenser airflow is not affected by the direction or speed of car motion.

Connections between the intake and discharge ducts and the intake or discharge grill and between the ducts and HVAC unit shall be through neoprene coated fiberglass fabric isolators. The use of tools shall not be required to disconnect the condenser air ductwork from the HVAC unit.

The entire condenser system air side shall be sealed such that water or snow entering the condenser section cannot enter the equipment bay under any operating or non-operating condition.

The condenser section shall be provided with drains, separate from the condensate drains, discharging under the car. The drain pipes shall be fitted with elastomeric flapper valves.

e. Other Condensing Section Components

1) A serviceable "catch all" type filter drier assembly as manufactured by Sporlan or approved equal shall be provided in the liquid line. The filter dryer capacity of water, refrigerant flow, filtering area, and acid removal shall be specified based on AHRI Standard 710. The filter drier shall have rust proof shutoff valves on each side to isolate it for servicing. An access fitting shall be provided on one (1) valve to allow recovery and evacuation of the filter drier section.

2) A discharge line check valve.

3) A fusible plug as recommended by UL 1995.

4) Service valves in the compressor suction and discharge line connections to provide for isolation and replacement of the compressors. The service valves shall also be provided with service access ports, at least one (1) of which must allow access to the compressors when the associated valve is front-seated (closed).

5) All service valve caps shall have a metal to metal seal. Service valve and sight glass caps shall be safety chained to the unit to retain them with the valve or sight glass when removed.

8.3.4.7 Refrigeration Control Compartment

The refrigeration control compartment shall be accessible from the return air plenum with the unit installed on the car. The refrigeration control compartment shall contain the following devices:

a. Low-Pressure Cutoff Switch
A low pressure cutoff switch shall be provided to monitor compressor suction pressure to protect the compressor and other system components from potentially damaging low pressure operation. The switch shall directly deactivate the control circuit to the compressor motor when the pressure drops below the safe limit. The switch shall automatically reset and energize the compressor motor when the pressure rises; suitable hysteresis shall be provided in the system to prevent short term system cycling at the cutout pressure.

b. High Pressure Cutoff Switch

A high pressure cutoff switch shall be provided to monitor the compressor discharge to protect the system from excessively high system pressures. The switch shall immediately deenergize the compressor when the discharge pressure reaches the preset value determined by the HVAC equipment manufacturer and confirmed during the HVAC unit qualification testing. The switch shall be wired directly into the compressor contactor control circuit and shall be monitored by the TCU. The switch shall automatically reset and energize the compressor motor when the pressure drops to the preset value determined by the HVAC equipment manufacturer and confirmed during the HVAC unit qualification testing. The circuit shall be arranged such that the condenser fan operation is not interrupted by the high pressure cutoff control. A time delay of 15 seconds (minimum) shall expire prior to the restart of the compressor following achievement of the reset pressure. The high pressure cutoff switch shall be provided with an external pulsation snubber.

c. Modulation Pressure Switch or Transducer

A modulation pressure switch or transducer shall be provided to monitor discharge line pressure and maintain system operation by reducing the air conditioning system capacity when conditions cause discharge pressures to approach the high pressure cutoff point. The control shall force the system into modulated cooling when the discharge pressure exceeds an approved value. The control shall automatically reset when the pressure drops to restore full cooling operation.

d. Unloading Control Transducer

An unloading control transducer shall be provided to monitor the compressor suction line and control the compressor capacity. The compressor capacity shall be reduced to match compressor capacity to the existing load and to prevent the saturated suction temperature from falling to an unacceptably low level. Other suction pressure based control functions, including compressor shut down after pump down, may also be controlled from this transducer. Alternate methods of capacity control may be proposed for consideration and approval by the Engineer.

e. Pressure Switch and Transducer Construction and Mounting

All pressure switches shall be snap acting with stainless steel wetted parts. The fluid side of the switch shall be hermetically sealed.

Transducers shall have stainless steel wetted parts and shall be hermetically sealed.
Pressure switches or transducers shall be connected to the system using flare type connections. The system side of the connection shall be equipped with a check valve to allow switch replacement without the need to recover the entire refrigerant charge from the system.

f. Gauge and Service Ports

High and low side gauge and service ports shall be provided. Each port shall be fitted with a self-sealing Schrader type valve with chain retained, metal to metal seal caps. Each line shall be equipped with a diaphragm type manual isolation valve. The manual valves and gauge connections shall be color coded red for high side and blue for low side.

8.3.4.8 Piping Design and Installation

The refrigerant piping design, installation, and piping materials within the unit shall meet the requirements of TS 17.14. The length of pipe between joints shall not be less than the maximum length which can be installed without damaging the pipe or equipment. The piping installation shall be such, however, that it shall be possible to replace any length of pipe using ordinary methods and without having to remove any other equipment.

All pipe insulation shall meet the flammability and smoke emission requirements of TS 17.24.

Flexible vibration eliminators or piping loops shall be provided where any refrigerant line attaches to a resiliently mounted assembly including the compressor suction and discharge lines. The flexible vibration eliminators, if provided, shall have neoprene covering over the flexible bronze wire braid to provide resistance to abrasion and present condensation from freezing behind the ferrules. Suction lines shall be designed and constructed without horizontal traps and sized for a maximum pressure drop of three (3) psi. The liquid line shall be sized to prevent flashing due to pressure drop. All refrigerant lines shall be adequately supported to prevent vibration, chafing, fatigue, and stress of joints. All capillary tubes shall be arranged so as to prevent any metal to metal rubbing caused by vibration.

8.3.4.9 Electrical Compartment

The electrical compartment shall be an integral part of the unit. It shall be accessible for system maintenance and servicing through the return air grill or ceiling access panel.

The electrical control compartment shall contain the following components:

a. Relays, contactors, solid state power controllers, and individual component isolation circuit breakers
b. Electrical controls
c. Diagnostic test plug for attachment of the PTE
d. Power and control wire terminals
e. Main and control power disconnect switches
f. Temperature Control Unit

g. Fault and status indication panel

Contactors for floor heat control may be installed in the HVAC unit electrical compartment or may be installed in a separate enclosure.

8.3.5 Insulation

All portions of the air conditioning system, which may at any time be reduced in temperature to the ambient air dew point such as the condensate drain pan, refrigerant suction lines, and all concealed condensate piping, shall be insulated with a fire retardant closed cell foam insulation installed with a fire retardant water resistant adhesive. All insulation corners shall be mitered and sealed. Insulation shall have sufficient thickness to keep the outer insulation skin temperature above the dew point at all times. The insulation system must meet the smoke and flammability requirements of TS 17.24 and shall be approved by the Engineer. [CDRL 08-015]

8.3.6 Evacuation-Dehydration

The HVAC equipment manufacturer shall, at a minimum, evacuate and dehydrate the system to 50 microns pressure or less. This vacuum must be maintained for a minimum of two (2) hours with the vacuum pump running. After two (2) hours, the vacuum pump shall be isolated from the system. The system pressure shall not rise above 300 microns in a two (2) hour period after vacuum pump isolation.

8.3.7 Refrigerant Charge Determination

The refrigerant charge weight shall be determined during the equipment qualification test and confirmed during the vehicle climate room test. The refrigerant charge established at this test shall be included on the unit nameplate.

8.4 FLOOR HEATERS

The total floor heat capacity shall be zoned to provide even temperature distribution throughout the car in accordance with the specified requirements. The total floor heat capacity in each zone shall be divided into stages of approximately 1/3 and 2/3 of total capacity, allowing for HIGH, MEDIUM, and LOW power operation. An alternative capacity regulation method may be provided for approval by the Engineer.

Floor heating shall be provided using electric strip heaters, powered from the 480 VAC HEP supply, mounted behind stainless steel heater guards along the side walls at the floor. The floor heat shall have sufficient capacity to heat the car interior from –5 degrees F to 72 degrees F with the ventilating fans and overhead heat inoperative and without benefit of solar or passenger loads. A five (5) mph wind wipe effect shall be reflected in the floor heat capacity determination. The required capacity shall be available at 480 VAC. The heaters shall be uniformly distributed.
The electric floor heater elements shall be of the strip heater type consisting of a nickel chromium resistance wire embedded in a baked compressed refractory material sealed within a rust proof high heat transfer metal sheath. The maximum allowable watt density shall not exceed 125 watts per linear foot of element when operated at 480 VAC. The heater strip mounting design shall allow freedom for thermal expansion and contraction of the heater strip as well as provide full electrical insulation between the heating element sheath and the carbody. The heater elements shall be mounted on approved insulators attached to the carbody not the heater guard. No more than three (3) types of heater elements shall be permitted.

Each heater circuit shall have its own breaker and ground fault protection. Each circuit shall have current input to and output from the floor heaters monitored by the differential relay which energizes for a predetermined difference between the two. When this relay energizes, both the positive and negative feeds to the affected floor heater circuit shall be interrupted.

The ground fault type circuit shall remain latched in the disconnected mode until manually reset by means of a momentary reset button located in the HVAC control box. The fault trip must not be affected by control power loss or fluctuation. A tripped ground fault circuit shall be annunciated by means of an LED indicator on the ground fault detection device in the HVAC control box and transmit to the fault monitoring network. The sensor device shall be designed such that it is not necessary to disconnect heater power leads to remove and replace the ground fault detection unit. A separable sensing coil, or other approved method, shall be provided to accomplish this requirement.

Alternate methods of ground fault detection and protection may be submitted for consideration to the Engineer.

The heater elements shall be series wound internally. Electrical connections to the floor heater elements shall be so arranged that electrically live points cannot be reached with a long thin object inserted through the holes in the heater guard face and section. A probe, illustrated on Figure 7.1 of the UL 1995 Standard, shall be used for verification of this requirement.

The lower section of the heater box construction shall prevent accumulation of dirt. No floor heat shall be provided in the end of car vestibules.

Air shall enter the heater guard through slots at the bottom, pass over the strip heaters, and rise by convection. Holes or slots shall be provided at the top of the heater guard vertical face so that the heated air will exit through the top of the vertical face of the heater guard. The holes or slots shall be small enough to promote convective heat flow while preventing litter accumulation. Where the heaters are located under a window, a portion of the air shall rise through a vertical duct behind the wainscot lining and discharge through perforations in the window mask just below the window. Perforations shall not exceed a 7/32 inch diameter.

All surfaces of the floor heater enclosures accessible to passengers shall be insulated, if required, to limit the surface temperature to the lowest practical value and in no case higher than 125 degrees F.
Floor heater guards shall be of at least 0.060 inch thick stainless steel. The heater guard front panels shall be constructed so that sections may be removed for replacement of heating strips without dismantling seats. The heater guard front panels shall be fastened at the top and bottom with no more than five (5) captive stainless screws per panel, unless otherwise approved by the Engineer. The top of the heater guard shall be sloped at least 15 degrees to prevent collection of dirt. On the upper and lower levels, the heater guard shall have a smooth transition from the floor to the side wall with no perceivable top panel to maximize foot area. Stainless steel screens shall be provided on the inside of the heater guard to prevent paper and debris from entering the heater area.

### 8.5 CAB HEAT AND DEFOGGER

#### 8.5.1 Cab Heater

The operating cab and observer’s position of the cab car shall each be provided with forced air cab heater, each having a minimum capacity of 1.5 kW, and so designed as to maintain a temperature not less than 65 degrees F in the compartment with overhead heat shut off and -7 degrees F ambient giving full consideration to heat losses to be expected at maximum operating speed.

The housings shall be constructed of heat resistant material. The heater circuitry shall be such that the heating elements shall not function unless the fan is operable. An overtemperature thermostat shall be used to remove power in the event of excessive heat and shall self reset. There shall be no drafts when the cab heater is not in use. No surface, which can be contacted by the Operator, shall exceed 125 degrees F.

The heater elements and fan shall be applied so as to provide ease of access for maintenance.

Cab heaters may be enabled for layover operation, as necessary, to maintain the layover temperature conditions even if cab is not activated.

#### 8.5.2 Heated Cab Windshield

Defrosting or defogging of the Operator’s and opposite windshield shall be by means of an electrically heated windshield. The windshield element shall be designed to clear the entire window of frost or fog. The time required to defrost and defog the window shall not exceed 15 minutes at 0 degrees F ambient and a car interior temperature at layover condition.

The windshield shall have its heating system controlled from the adjacent cab console by use of a rocker or push button switch and an amber LED to indicate its energized state. The switch shall only function in an active cab or one where the Conductor’s control panel has been activated and the outside ambient air temperature is below 72 degrees F.
8.6 MAIN AIR DUCTS

Air distribution ducts for the upper and lower levels shall run the length of the level in the corner at the intersection between the side wall and ceiling. The internal cross sectional area of the ducts shall be adequately sized to allow flow from either unit and shall maintain a constant static pressure differential across the diffusers. Turning vanes, flow straighteners, and sound attenuators shall be included as necessary to ensure that all other provisions of this Specification are met.

Restriction plates can be provided as an alternative to the taper ducts provided the airflow distribution is uniform along the car.

The material selection for the duct work shall be approved by the Engineer [CDRL 08-016]. Considerations shall include, but are not limited to, thermal insulation performance as required to prevent condensation on the exterior of the duct under all conditions, acoustic insulation such that the interior noise requirements of TS 2 are met, weight, appearance, and the ability to clean and repair. The air velocity within the duct work is not specifically limited but shall be such that in combination with the acoustic insulation, shape, and diffuser design, the interior noise and vibration requirements of TS 2.3 are met.

Air ducts for the intermediate levels shall be located inside the equipment bays.

8.6.1 Auxiliary and Cab Distribution Ducts

On cab cars, the ductwork for the cab end intermediate level shall be extended to supply the cab diffusers described in TS 8.7.

8.6.2 Insulation

All carbody and air conditioning system air ducts (including the fresh air ducts) shall be fully lined with a minimum one (1) inch thickness of an approved density of Owens-Corning Fiberglass Corp. Aeroflex, Manville Corp. Linacoustic, or with a minimum of 0.16 inch thickness of an approved E-glass insulation or other approved thermal and acoustical glass fiber duct lining insulation of a flame resistant design. It shall be cemented to the duct with a water and fire resistant adhesive and mechanically attached, including all leading edges to the airflow. If the duct or adjacent parts are constructed of aluminum, the insulation shall be the borosilicate or other type suitable for contact with unpainted aluminum. The minimum “R” rating of the applied insulation shall be 4.5. If approved by the Engineer, exterior duct insulation may be used in place of interior linings. Particular attention shall be given to the reduction of noise, by use of techniques such as use of a perforated metal insulation facing. Other techniques for noise control may be proposed to the Engineer for approval.
8.7 AIR DIFFUSERS

8.7.1 Passenger Compartment Diffusers

8.7.1.1 Upper and Lower Levels

A continuous linear slot diffuser shall run the length of the air ducts in the upper and lower levels. The passenger area of the car interior high ceiling shall have two (2) continuous rows of double slot type air diffusers to provide uniform distribution of air and shall be a part of or adjacent to the passenger lighting fixtures. Diffusers shall be connected to the main air distribution duct.

Diffusers shall be powder coated or anodized aluminum in a color in accordance with the interior design requirements.

Diffusers shall be easily adjustable on the climate room test car only. All other cars shall have non-adjustable diffusers with the same settings as approved in the climate room test.

The diffuser design shall prevent a cylinder two (2) inches long and ¼ inch in diameter from entering the duct.

The mixing efficiency of the diffusers shall be such that an equal mass of room air is entrained and mixed with the discharge air at a distance of six (6) inches (152 mm) from the face of the diffusers. The maximum velocity of discharged air shall not be greater than 150 fpm at six (6) inches from the diffusers. Maximum air velocity throughout the car interior shall not exceed 100 fpm at 60 inches above the floor and 50 fpm at 48 inches above the floor.

8.7.1.2 Intermediate Levels

For the intermediate levels, a combination of linear slot diffusers (in the seating area) and six (6) inch trade size circular diffusers (in the quarter point door vestibule area) shall be utilized. The diffusers shall be arranged to comply with the temperature uniformity and air velocity requirements. Diffusers shall be aluminum and powder coated or anodized to match the adjacent ceiling panels.

Adjustable balancing dampers shall not be allowed. Balancing of circular diffusers shall be accomplished by fixed orifice nozzles at the diffuser inlet. The linear slotted diffuser shall be set in the same manner as those on the upper and lower levels.

The diffuser design shall not allow sufficient grip to allow the diffuser to be forcibly removed from the ceiling or damaged by vandals.

Maximum air velocity through the car interior shall not exceed 100 fpm at 60 inches above the floor and 50 fpm at 48 inches above the floor.
8.7.2 Cab Diffusers

Air shall be discharged into the operating compartment through an approved adjustable diffuser. The Operator shall be able to manually control airflow to the cab from full flow to no flow and control the direction of the air discharge. The volume of discharge shall not be less than 150 cfm.

The train Operator’s cab diffusers shall not be subject to velocity limitations; however, all passenger area interior noise requirements must be met with the cab diffuser set at any flow rate.

8.8 RETURN AIR GRILL

A return air grill or grills shall be provided in approved locations for each HVAC unit. The return air grill shall be of sturdy and rattle free construction and shall have a core and satin finished frame of anodized aluminum or powder coated aluminum, hinged on one of the short sides, and provided with approved captive fasteners and two (2) spring safety catches to hold the grill approximately four (4) inches down from the lock position. The recirculated air grill shall be designed to pass the required quantity of air with sound levels such that the requirements of TS 2.3 are met anywhere one (1) foot from the grill.

The grill design shall not allow a direct line of sight from the car interior to the mixed air plenum and shall prevent the introduction of small objects, such as cigarettes, pencils, etc., from entering the plenum.

8.9 FRESH AIR INTAKE AND WATER ELIMINATORS

The fresh air intake system shall be passive and not use motor driven blowers. Fresh air intake ducts shall be provided on the side of the carbody roof positioned for the best possible operation with bi-directional car movement. They shall be suitably placed so that supplemental shrouds or exterior ducting is not required to gain specified pressurization levels. The exterior portions of the fresh air ducts shall be built of stainless steel and shall use all stainless steel hardware. Their exterior appearance shall match adjacent areas of the carbody. The air intake shall face downward to minimize rain, snow, and dirt collection and shall have a perforated stainless steel intake screen with a multiple vee cross section, similar to the clean air system intake screen used on the SEPTA Silverliner IV cars. The vee section shall be parallel to car movement, and the intake screen shall be sized for a face velocity not to exceed 300 feet/minute. A water exclusion baffle and a fresh air filter (easily replaceable from the interior of the car) shall be included in each air intake duct. The ducts shall prevent the carryover of liquids or snow into the air distribution system, and the entrance screen shall not plug with ice or snow. Any ingested water shall drain from the duct to the outside. The fresh air shall be properly mixed with recirculated air such that there is no temperature difference in the air stream across the face of the evaporator or overhead heater. Fixed baffle plates, developed during the initial air balance qualification tests, shall be used to adjust the volumes of fresh and recirculated air. Baffle plates shall be located far enough upstream of the filters and thermostats such that the necessary uniformity of airflow through filters and airflow velocity over thermostats is achieved.
8.10 CFD MODEL AND ANALYSIS

Within 180 days of NTP, the Contractor shall submit to the Engineer a Finite Element Model, Computational Fluid Dynamics (CFD) model, and analysis of the cooling and air distribution system. [CDRL 08-017]

The model shall include, at a minimum, accurate representations of the following:

a. All carbody ductwork  
b. Diffusers  
c. Return air grills  
d. Exhaust grills  
e. Interior furnishings  
f. HVAC unit components in the fresh, return, mixed, and conditioned air streams

All internal and external loads may be modeled as sensible heat sources only, and the evaporator coil may be modeled as a sensible heat sink.

The analysis results shall demonstrate that the proposed air distribution system is capable of meeting the diffuser discharge velocity, interior air velocity, and temperature uniformity requirements of this Specification. Should the analysis not show compliance to these requirements, the design of the air distribution system shall be modified and the analysis repeated.

8.11 VENTILATION SYSTEM PROTOTYPE

Within ten (10) days of the completion of the first pilot car of each type, the Contractor shall conduct a ventilation system test of the air distribution system for the entire car. The test procedure and test report shall be submitted to the Engineer for review and approval. [CDRL 08-018] The HVAC units used for the test shall include complete evaporator blower sections including evaporator and heater coils and any other items in the air path such as turning vanes and associated insulators. The test shall confirm the following:

a. The accuracy of the CFD model and analysis  
b. The capability of the evaporator blower section to supply the design airflow  
c. Diffuser discharge velocity and mixing capability specified in TS 8.7.1  
d. Blower total static pressure  
e. Available duct static pressure  
f. Electrical power requirements of the blower motors  
g. Blower speed
h. The ability of the fresh air system to prevent the entrance of moisture into the carbody (worst case rain and snow simulation at the air inlets may be simulated on a separate test)

i. Preliminary air baffling requirements necessary to balance the specified ratio of fresh and recirculated air

j. Accessibility for maintenance of all filters

k. Absence of potential problems, such as excessive noise, pure tones, air turbulence, and blower instability

l. All necessary changes and adjustments shall be made during the prototype test such that the requirements of this Specification are met.

With the approval of the Engineer, the ventilation system prototype test may be conducted earlier in the program schedule on an approved mockup of a full car.

### 8.12 CONTRACT DELIVERABLE REQUIREMENTS LIST

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9 LIGHTING

9.1 GENERAL

Lighting shall be by means of an approved arrangement of lighting fixtures. All lighting shall operate from the 74 VDC power supplies. The lighting shall be as uniform as practical throughout the car. All interior lighting fixtures shall use LED modules, cool white in color, powered by the DC low voltage distribution network.

The vehicle lighting shall include the following:

a. Passenger area fixtures
b. Vestibule fixtures
c. Cab lights
d. Head and auxiliary lights (cab cars only)
e. Marker lights
f. Car number sign
g. Emergency lights (both battery powered and self-contained)
h. Platform and stairway illumination lights

The lighting system design and illumination requirements shall meet the Federal Regulations (49 CFR 27, 37, 38, 238, and 239) and APTA Standards and Recommended Practices (APTA-PR-E-S-013-99 Rev 1 and APTA-PR-E-RP-012-99) for car lighting. Where a conflict exists, the most restrictive condition shall apply.

The lighting system shall neither produce an objectionable glare nor deteriorate rapidly in effectiveness due to the collection of dirt on the fixtures. The fixtures shall permit easy cleaning and replacement of modules and shall be free of rattles and not generate noise during normal operation. Cleaning, maintenance, and parts’ replacement shall be accomplished without disassembly of interior panels.

Indirect lighting shall be provided for the passenger seating areas. Light fixtures shall be integrated into the car interior to provide light at the reading plane above each passenger seat to the specified intensity, while also illuminating adjacent ceiling panels, to assist in diffusing the light and in increasing the overall brightness level of the interior of the car. The details of the lighting design, arrangement, and installation shall be submitted to the Engineer for review and approval. [CDRL 09-001]
9.2 INTENSITY

The intensity of illumination at an elevation of 33 inches above all floor levels and on the upper surface of a transverse 45 degree plane at the front edge of each passenger seat shall be no less than 30 foot candles at rated voltage. It shall be uniform throughout the reading plane in the passenger seating area of the car and shall provide adequate illumination of surfaces such as aisles, doors, and advertising cards. The lighting intensity in the aisles one (1) inch above the floor shall be no less than five (5) foot candles. The illumination in all areas of the car shall comply with the minimum performance requirements of APTA-PR-E-RP-012-99. The illumination shall be directed downward so that there shall be a minimum of glare.

9.3 FIXTURE ARRANGEMENT

The lighting fixtures in the main passenger areas shall be ceiling mounted in two (2) parallel rows extending through in the lower, upper, and intermediate levels to provide indirect light. Alternative arrangements may be proposed. The lighting fixture arrangement shall be approved by the Engineer. [CDRL 09-002]

The fixtures shall be divided electrically into three (3) circuits. The fixtures on each of the three (3) circuits shall be connected in a manner to produce, as nearly as possible, uniform distribution of light throughout the car when only one (1) or two (2) circuits are activated. Each circuit shall have a separate circuit breaker. Adjacent fixtures shall not be on the same circuit.

LED drivers shall not draw power when the LED lamps are off. LED drivers shall operate reliably under conditions of the voltage levels and transients of the low voltage system. LEDs should be driven by a constant current circuit with a setting not in excess of 65 percent to 70 percent of the LED maximum current rating. Control of LED currents shall not cause any noticeable light flickering. The failure of a single LED shall not turn off the LED board/cluster and shall not reduce the life expectancy of the LED board/cluster. The minimum LED life shall be 100,000 hours of operation.

9.3.1 End of LED Life

The end of LED life shall be defined as:

a. The inability to meet the minimum required lighting levels as described in this Specification, FRA requirements, and APTA standards

b. Light output 50 percent or less compared to initial value of luminous flux

c. Color temperature shift

d. Failure of ten (10) percent or more LEDs in a cluster

e. Pulsating light

f. Complete LED failure
9.3.2 LED Design and Reliability Data

The design and reliability data for all fixtures and types of LEDs shall be submitted to the Engineer for review and approval during the design process. [CDRL 09-003] This shall include the following information:

a. The LED color’s temperature shall be such that the lighting looks natural. The temperature shall be approved by the Engineer.

b. The mean percentage of initial luminous flux available over the lighting system’s expected operating hours

c. Heat management design

d. Total system light output degradation curve

9.4 FIXTURE CONSTRUCTION

Sockets, if used, shall be of an approved heavy duty spring type with a circular configuration and edge wipe contacts and shall be designed to provide support to the end of the lamp. Supplementary support for the assemblies shall be provided to the underside of the reflector or approved equivalent. Sockets shall not be visible when viewing the fixture from seated positions. Easily accessible AMP MATE-N-Lok connectors, or approved equal, shall be provided on lighting fixtures for the connection of wiring so that the fixture may be electrically isolated for maintenance. The back of the fixture may be an aluminum extrusion. Continuous wireways separate from the fixture or an arrangement of thin wall steel conduit and junction boxes shall be provided to route wiring to each fixture. The access panel of the fixture shall be made with a concealed hinged extrusion and a closing screw extrusion. No wire splice shall be permitted in conduits or fittings connected to the lighting fixtures. The lighting fixtures shall provide indirect light in the passenger areas and shall be integrated into the interior arrangement such that the fixtures are not visible to seated passengers. The fixtures shall be arranged to be compatible with the color, pattern, and texture of the interior materials and provide the specified light intensity. Alternative fixtures may be proposed based on the requirements of the interior arrangement. The lighting fixture diffuser lens shall be translucent and shall provide a continuous lighting pattern. All fixtures shall have polycarbonate lenses and shall be arranged for replacement from the front. Fixtures shall be dust and moisture resistant using suitably designed solid neoprene rubber seals between the lens and fixture.

9.5 VESTIBULE LIGHTING

The LED light fixtures installed in the end of car vestibule shall be service proven for railway service and powered from the 74 VDC circuit. The fixtures shall be appropriately arranged and located so as to illuminate the steps and vestibule floor area. The minimum performance requirements of APTA-PR-E-RP-012-99 shall be met with the side passenger doorway arranged for either high platform operation (trap down) or low platform operation (trap up).

Light fixtures shall be installed to illuminate the quarter point doorway vestibule area. The fixtures shall be used for normal service and emergency operation and shall be powered from the 74 VDC system. The fixtures shall be aesthetically and functionally compatible with the interior of the car.
9.6 STAIRWAY AND STEPWELL LIGHTING

LED light fixtures shall be recessed in both the stairway walls and the passenger entrance stepwells and shall be directed downward to illuminate the stair tread. The lights shall be mounted below the floor level and shielded to protect the eyes of entering or exiting passengers. The fixtures shall be powered from the 74 VDC system to provide the required illumination for normal and emergency functions. The lighting intensity one (1) inch above the floor shall be no less than five (5) foot candles. The fixtures shall be service proven for railway service.

9.7 EMERGENCY LIGHTS

Each car shall be provided with emergency lights in both intermediate levels, the upper level, the lower level, in the vestibules/cabs, and in the stairways. Emergency lighting loads shall remain powered when the low voltage power supply output is momentarily or continuously lost. There shall be no load shedding of the emergency light circuit breaker. At least 50 percent of lighting fixtures shall remain powered for emergency lighting. The emergency lighting system shall comply with the minimum function and performance requirements of APTA-PR-E-S-013-99 Rev 1, 49 CFR 238 and 239, and APTA RT-VIM-S-020-10. Emergency lights shall be equipped with independent power sources utilizing super-capacitors with a minimum service life of 30 years.

Emergency lights shall be controlled by solid state sensing devices or relays, and the operation of the emergency lighting shall be coordinated with the load shedding function to ensure a smooth changeover of the lighting without loss of illumination. The control scheme shall so function that when the normal lighting power is interrupted, the emergency lights shall be managed in the following manner:

a. Upon interruption of the normal lighting power, the passenger lighting shall be powered at normal lighting levels for 90 seconds (delay to be adjustable by SEPTA).

b. With loss of normal lighting power for longer than 90 seconds (delay to be adjustable by SEPTA), the passenger lighting shall automatically switch to the emergency lighting mode with power being supplied by the car battery. Upon loss of car battery, the emergency lighting shall automatically switch to being powered by the independent power sources utilizing super capacitors without the loss of lighting.

c. While in the emergency lighting mode, the car battery shall provide power to the lighting until the battery voltage fall approaches 55 VDC at which time the emergency lighting shall automatically switch to an independent power source utilizing super-capacitors. The battery voltage shall not fall below 55 VDC and switch to the independent power source for a minimum of three (3) hours.
d. Emergency lighting shall remain operational for a period of 90 minutes (adjustable by SEPTA). After the 90 minute period (adjustable by SEPTA) has lapsed, the emergency lighting shall extinguish. Emergency lighting shall provide for independent power sources to back up the car battery that are located within a few feet of the light fixture preferably being located within the light fixtures. Independent power source modules shall be conveniently located and easily replaceable. The location shall be approved by the Engineer. The light system shall include an emergency lighting manual reset function that shall, when operated, allow the initiation of another 90 minute period (adjustable by SEPTA) at any time. One (1) momentary activated switch shall be provided on each car to reset the 90 minute (adjustable by SEPTA) timer. The switch with operating instructions shall be installed in an approved location accessible to the crew. The system shall allow for repeated use of the manual reset function.

e. When a 90 minute period has been initiated, if the car battery voltage drops to 55 volts, the emergency lighting shall be provided by the independent power sources. The emergency lights shall be energized for the remaining time to achieve the 90 minute period.

The emergency light independent power units shall provide for lighting during periods of total loss of DC power on the car. The emergency light independent power unit shall have sufficient capacity to provide a minimum of two (2) hours of operation from its own source (super-capacitors). The emergency light independent power unit shall be automatically recharged after the 74 VDC power is restored. The rate of charge will be such that the life of the emergency light independent power unit is maximized. The emergency light independent power sources shall be integrated into the general lighting scheme such that no differences in performance are noted when operating in the non-emergency mode. The emergency lighting shall be arranged such that a self-test can be performed by use of the manual reset switch. Each emergency light independent power unit shall incorporate an LED indicator that indicates the condition.

Operation in the emergency lighting mode shall not degrade the life of the LED.

Emergency lighting shall be evenly distributed throughout the car interior and include the car door areas and stairways. The illumination in emergency mode shall meet the requirements of 49 CFR Part 238.115.

The quantity and location of the emergency lights, emergency lighting arrangement, and operation shall be submitted to the Engineer for review and approval and demonstrated on the pilot cars. [CDRL 09-004]
9.8 LOW LOCATION EXIT PATH MARKING

Each car shall be equipped with a passive illumination, low location, and exit path marking system that complies with the requirements of APTA-PR-PS-S-004-99 Rev 2, 49 CFR 238, and 49 CFR 239. The system shall use HPPL marking material as provided by Kennco or approved equal. The system shall be arranged to provide visual guidance for evacuation of the car when overhead lighting and the emergency lighting system has failed or has been obscured. The low location exit path marking system shall clearly identify the primary path to be followed for exiting the car under emergency situations. The primary exit path shall be designed to evacuate the passengers to the next car and not onto the right of way. The Contractor shall propose the techniques and options for integration of HPPL elements into floor coverings, seat frames, door, exit path, stairways, and bulkhead elements to achieve the APTA standard requirements. The system shall be approved by the Engineer and demonstrated on the pilot cars. [CDRL 09-005]

9.9 POWER SOURCES

Lights shall operate from the battery circuit. Light fixtures shall not be wired in series. The system providing power for emergency lights shall be capable of operation in accordance with the requirements of 49 CFR Part 238.115 for a backup power system.

9.10 HEADLIGHTS

Dual headlights shall be installed at the cab end of each cab car. They shall be installed above the end of the car door opening on the center line of the car. They shall be designed to be aimed and relamped from the interior of the car. The headlight fixture shall be easily adjustable for horizontal and vertical alignment and shall be provided with a locking device. Bezel design shall assure correct rotational alignment. The procedure for access to and aiming of the lamp from the car interior shall be submitted to the Engineer during the car design review. [CDRL 09-006]

The headlights shall consist of two (2) sealed service proven 75 volt PAR 56 LED headlight assemblies with a 100,000 hour minimum life. The headlight fixture and wiring shall be capable of supporting standard 200 W bulb headlights. The lamps shall be mechanically adjustable with a locking device to permit proper alignment to comply with 49 CFR Part 229.125. The headlight fixture cover glass shall be Pyrex or approved equal. The headlights shall be designed to prevent snow and ice accumulation and shall operate under the environmental conditions specified in TS 2.2.5.
9.11 AUXILIARY LIGHTS

Two (2) external LED auxiliary lights complying with 49 CFR Part 229.125 shall be mounted on each side of the lower end sheet on the F-end of each cab car. The auxiliary lights shall have a minimum life expectancy of 100,000 hours. The auxiliary lights shall be recessed. The housing shall be of rugged corrosion resistant construction approved and suitable for railroad use. The auxiliary light fixture shall be easily adjustable for horizontal and vertical alignment and shall be provided with a locking device. The Bezel design shall assure correct rotational alignment. The auxiliary lights shall be controlled from the cab by a three (3) position selector switch to select “Manual”, “Off”, or “Automatic” modes. The auxiliary lights shall be “On” in the manual position. The auxiliary lights shall be activated and flash for twenty (20) seconds whenever the horn is blown or the bell is operated when in the “Automatic” position. The flashing rate shall be adjustable from 40 to 180 flashes per minute and shall be initially set to flash alternately at 60 flashes per minute. The power supply shall operate on 74 VDC and shall be capable of operating without damage within the voltage range specified in TS 2.2.7.2.

The auxiliary light fixture shall use a long life sealed LED array rated at 100,000 hours at 40-95 volts clear bulb. The fixture shall be constructed of the same metal as the car structure or have a gasket between the housing and mounting surface if made from a material different from the carbody.

9.12 MARKER LIGHTS

Two (2) red LED marker lights shall be installed on the end sheets at both ends of all trailer cars and the non-cab end of all cab cars and above the end windows at the cab end of cab cars. Marker lights shall comply with the requirements of 49 CFR 221 and shall be designed to be relamped from the interior of the car; at the F-end of the cab cars, they may be replaced from the exterior. The procedure for replacing shall be submitted to the Engineer during the car design review. [CDRL 09-007] The switches for the marker lights of all trailer cars shall be located in an approved location.

The marker light fixture shall use a long life sealed LED array rated at 100,000 hours at 40-95 volts clear bulb. The fixture shall be constructed of the same metal as the car structure or have a gasket between the housing and mounting surface if made from a material different from the carbody.

9.13 CAR NUMBER SIGNS

Two (2) illuminated car number signs shall be provided on each cab car. One (1) shall be located on each side as near to the cab end as possible at an approved location. The number signs shall have a four (4) digit number eight (8) inches high. They shall be located for access from the cab car’s electrical lockers for ease of servicing. Each sign shall use an LED backlight array for uniform illumination and shall be powered from the car battery. The LED array shall be designed such that the failure of one LED shall not darken the entire sign. The LED array design shall be approved by the Engineer. [CDRL 09-008]
9.14 PLATFORM LIGHTS

An LED platform light shall be provided at the car end side of each set of passenger entrance steps to illuminate the steps and the low level station platform. Lamps shall provide for a minimum of five (5) foot candles’ illumination at the most distant step tread and on the adjacent low level station platform. The platform light shall operate from the 74 VDC circuit. The platform lights shall comply with the requirements of 49 CFR 38.101. The LED light shall be a sealed unit inside of a protective fixture for dual protection from the elements with the fixture similar to Trans-Lite Part No FP-2450-9. The design shall be approved by the Engineer. [CDRL 09-009]

9.15 AIR GAUGE LIGHTS

LED gauge lights integral with the air gauges shall be supplied as part of the pneumatic system and be powered from the 74 VDC low voltage power supply through the headlight switch. All gauge lights shall be provided with dimming capability. A single rotary switch shall be provided for dimming the cab console gauge light LED which shall be easily replaceable and last a minimum of 100,000 hours.

9.16 CAB CONSOLE AND CEILING LIGHTS

The LED lights for the cab area shall be designed and arranged to comply with the requirements of 49 CFR 229.127. An LED cab console light shall be provided with a dimmer control. It shall provide lights for the console without reflecting on the windshield and for reading train orders, timetables, etc. LED cab ceiling lights shall be provided in accordance with TS 7.13. Enclosure and circuit breaker panel lighting shall be sufficient to allow for easy reading of all circuit breaker or switch identification at night with all other lighting turned off.

9.17 EXTERIOR INDICATOR LIGHTS

All system signal and indicator lights shall use long life high intensity LED array lamps having a rated life of at least 100,000 operating hours at 30 to 95 VDC. The LED array shall be arranged such that the failure of a single LED in the array does not affect the life of the remaining LEDs.

9.17.1 Door Lights

A red door open indicating light shall be provided on the exterior of each side of each car. It shall be in a low clearance corrosion resistant housing located within the car clearance line and of a design which shall not be damaged by car washing machines.

The light shall be visible from the front or rear of the train at a distance of 12 car lengths when lit in bright sunlight. Long life LED lamps in parallel with a 55-80 voltage input rating shall be used. They shall be energized from the 74 VDC low voltage power supply. The lenses shall be shaded to aid in meeting the visibility requirements. The door lights shall be located as approved by the Engineer. [CDRL 09-010]
9.17.2 Brake Lights

Three (3) indicator brake lights shall be provided in a corrosion resistant low clearance housing on the exterior of each side of each car within the car clearance line. The brake lights shall not be damaged by car washing machines and shall meet the visibility requirements of TS 9.17.1. Long life LED lamps in parallel with an input voltage of 55-80 volts shall be used on the 74 VDC. The indicators shall have a green lens for "Brake Release" at the top, a yellow lens for "Brake Applied" in the middle, and a blue lens for "Parking Brake Applied" at the bottom. The brake lights shall be located as approved by the Engineer. [CDRL 09-011]

9.18 SERVICE AREA LIGHTS

All service areas such as lockers and overhead equipment areas shall have LED 74 VDC circuit lights installed to aid in the maintenance and servicing of equipment. Lighting control shall be performed via micro switches that are engaged by the locker door or ceiling panel allowing the light to operate when the door/panel is open and automatically extinguish when closed. The style of light and location shall be submitted for approval by the Engineer. [CDRL 09-012]

9.19 LIGHT CONTROL

All lighting shall be protected by circuit breakers. The main passenger area lighting and platform lights shall be controlled by switches located in the switch locker. The emergency lights shall be automatically controlled as described in TS 9.7.

The number sign lights, cab lights, auxiliary lights, and headlights shall be controlled by switches on the Operator’s switch panel. A cab console light switch with dimmer shall be provided. The headlight switch shall have three positions: OFF, DIM, and BRIGHT, with indicators for the “Dim” and “Bright” positions.

The end vestibule lights and marker lights shall be controlled by switches located in the locker except at the cab end where the marker light switch will be on the cab console.

The light control arrangement and switch locations shall be approved by the Engineer. [CDRL 09-013]

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10 AUXILIARY POWER SUPPLIES AND ELECTRICAL APPARATUS

10.1 GENERAL

Power for the cars shall be supplied from a 480 VAC three phase HEP trainline that is energized from the 480 VAC source on the locomotive or from a wayside power supply system and from a 74 VDC storage battery on each car. The electrical system and apparatus shall comply with all relevant requirements of Title 49 of the Code of Federal Regulations, all relevant APTA recommended practices, IEC60077, IEEE 16 and IEEE 1476, latest issues, and all standards referenced therein except as otherwise indicated in this Specification. Details of the design, arrangement, and installation of the electrical system and apparatus shall be submitted to the Engineer for review and approval. [CDRL 10-001]

10.2 HEAD END POWER (HEP), TRAINLINES, AND VOLTAGES

The head end power (HEP) trainline voltage shall be 480 VAC 60 Hz three phase as described in TS 2.2.7.2.1. The HEP trainline cabling shall be able to support a continuous train HEP loading of at least 1000 kVA. No more than a five (5) percent deviation from a phase to phase current balance of the total load shall be permitted. Phase balance shall be assisted by rotation of phases from car to car. A power consumption analysis shall be provided to the Engineer for approval. [CDRL 10-002]

The HEP trainline voltage shall be used to operate the motors of the air conditioning compressors, condenser, and evaporator fans. It shall also furnish energy for the floor and overhead heat. The HEP trainline voltage shall be reduced by transformers on each car to 120 VAC as described in TS 2.2.7.2 for convenience outlets, air conditioning, and heating controls, etc.

A low voltage power supply/battery charging rectifier system operating from the 480 VAC HEP trainline and a 74 VDC battery shall provide low voltage power as described in TS 2.2.7.2. The low voltage system shall supply the marker, main and emergency lights, headlights, cab signal/ATC/PTC, communicating signal, PA, radio and intercom communication, wheel slide protection, door operators, etc.

10.2.1 HEP Trainline

The HEP trainline described in TS 5.5 shall be run under the car and shall be supported by suitable molded cleats at 16 to 24 inch intervals throughout the entire car. In the truck area, the cables shall be protected by a stainless steel conduit or duct and supported at intervals not greater than every 24 inches. The HEP trainline shall include four (4) power receptacles having three (3) power contacts and three (3) control contacts. The power trainline wire insulation shall be in accordance with AAR RP-585 (S-501) NEMA 133 percent insulation level. Connections between the power receptacle pigtail wiring and the underfloor wiring shall be made inside a suitably insulated watertight junction box. Details of the HEP trainline wiring and connections shall be submitted to the Engineer for review and approval. [CDRL 10-003]
10.2.2 Locomotive M. U. Trainline
The 27 conductor locomotive control trainline described in TS 5.5 shall supply 74 VDC from the locomotive for traction control, sanding, alarm signals, indicators, etc.

10.2.3 Door Control and Communication Trainline
The 27 conductor door control and communication trainline described in TS 5.5 shall supply 74 VDC for car control functions.

10.3 LOW VOLTAGE POWER SUPPLY

10.3.1 Battery
Each car shall be provided with a nickel cadmium battery which at a normal battery operating temperature of 77 degrees F shall have sufficient capacity to provide all 74 VDC car functions for not less than two (2) hours including 40 stops with a consist of one (1) cab and two (2) trailer cars. It shall have no less than a 100 ampere hour capacity at the five (5) hour rate. It shall be arranged in two (2) equally sized non-combustible trays.

The battery shall consist of a SAFT, Inc. type SRM, Hoppecke type FNC, or approved equal, nickel cadmium alkaline cells using sintered-type construction. All cells shall be treated to resist corrosion or be of non-corrosive material. All cells shall have a minimum of 2.6 inches of electrolyte above the plates, with a liquid surface area equal to that of the top of the plate area. However, lower values may be accepted for cell types that can be proven to have inherently lower water loss under identical conditions. Cells shall use an approved transparent fire-retardant plastic material suitable for transit service. It is desired that watering intervals be no less than every six (6) months. Cells shall have a flip-top vent cap to permit topping up and allow electrolyte levels to be measured. The vent cap shall be flame-arresting and shall incorporate an anti-spray device. Battery connectors and connection hardware shall be corrosion resistant. All battery cells shipped to the Contractor, or supplied to SEPTA as spare parts, shall be properly configured for long term storage in unheated conditions.

Battery loads on all cars shall be connected in parallel through the battery positive and battery negative trainlines. The battery construction, identification, test methods, and battery connectors shall comply with APTA-PR-E-RP-007-98, APTA-PR-E-RP-009-98, and 49 CFR 238, and all standards referenced therein, except as otherwise indicated in this Specification.

The battery in normal service shall require water no more frequently than once every 92 days.
10.3.2 Low Voltage Power Supply and Battery Charging System

10.3.2.1 Description

Each car shall be equipped with a low voltage power supply and battery charging (LVPS/BC) system supplied from the 480 VAC trainline power supply. The LVPS/BC system shall be rated to supply all DC loads and safely satisfy the charging requirements of the storage battery consistent with the anticipated frequency of the battery watering stated. The power factor including all frequency harmonics of the current shall be better than 0.95. The power supply shall have a balanced load among the phases. The unit shall be suitably weatherproofed and shall be protected from shock and vibration by shock mounting either the enclosure or the internal components as required. The unit shall be solid state and shall include the transient suppression and protective circuitry necessary to produce reliable performance in the electrical environment of the cars and, as a minimum, meet all relevant requirements of TS 17 and TS 18. Appropriate fault and operation LED status indicating lights and test switches shall be provided. Both status lights and digital voltage meters shall be provided at approved locations so that they can be easily read from the car side. Both meters and indicators shall meet the same shock, vibration, and temperature requirements as the LVPS/BC. The battery over temperature sensing switch circuitry shall be arranged to open the battery circuit breaker and to shut off battery charging. Monitoring and status information shall be integrated into the car monitoring and diagnostic system.

The LVPS/BC shall incorporate a modular design that provides functional separation of the two systems. The LVPS/BC shall consist of modular subassemblies allowing LRU replacement from within the car and be arranged to facilitate maintenance, replacement, and diagnostic tasks. The design and installation of the LVPS/BC shall not require removal of the LVPS/BC assembly to perform these tasks.

10.3.2.2 Charging System Operation

The battery charger portion of the system shall be either the constant voltage or constant voltage current limit type. If a constant voltage type charger is used, the nominal output voltage of the charger shall be 74 volts ± 1%. Control shall be provided to maintain the output voltage of the charger over the range from no load to 125 percent load over the input voltage range that the unit will be exposed to in service on the cars. The charging voltage shall be set as recommended by the battery manufacturer. The LVPS/BC shall not be damaged or indicate failure (except under fault conditions) when the input voltage is at any continuous voltage between 0 V and the maximum specified operating voltage.

A pushbutton switch shall be provided to allow maintenance personnel to reset a battery charger/LVPS fault. The switch shall be located inside the car in an area easily accessible to maintenance personnel.

If a constant voltage current limit type charger is used, the charger shall provide a constant current charge at a rate recommended by the battery manufacturer which shall continue until such time as the battery is fully charged. At this point, the charger shall automatically revert to a float charge condition.

Irrespective of the type charger used, the design shall be inherently current limited to restrict its output to a value that is safe for both the charger and the battery for continuous operation regardless of the level of the battery electrolyte. The current limit feature shall be such that no damage shall occur to the power supply when the output is short circuited or connected to a fully discharged battery.
In addition to the LVPS logic having control of the nominal charging voltage noted above, there shall also be a temperature-compensated charging feature employing a temperature sensor installed on a battery cell inside the battery box in an approved location. Temperature-compensated charging shall be the normal operational mode of the LVPS.

The LVPS control logic shall sense misoperation or failure of the temperature sensor, and when such is detected, the logic shall automatically revert to the mode of only maintaining the charging voltage at the nominal level noted above. Simultaneously, this change in operating mode shall be logged as a fault in the MDS for maintenance personnel.

Self-test features shall be provided to allow functional tests and tests of protective features. The protective features shall, as a minimum, include over voltage, over current, over temperature, and reverse polarity. The operation of the reverse polarity protective features shall not require the replacement of any components. Fuses or circuit breakers designed for the internal protection of the charger shall be mounted at accessible locations. External indication shall be provided to indicate blown fuses and/or tripped circuit breakers if such devices are located behind covers.

### 10.3.2.3 Charging System Capacity

The charger shall be capable of automatically charging a fully discharged zero volt battery. The output voltage from the power supply shall have a ripple of less than 0.7 Vp-p. The output voltage shall be unconditionally stable for all load conditions that include a disconnected battery and/or no loads. Under no circumstances shall the output voltage exceed 80 volts.

A filter network shall be applied to the DC charger system to provide adequate transient protection to 2800 Vp-p for 1.5 microseconds rise time with 20 microseconds width and to protect against switching noise and limit ripple. The power supply shall have internal shields that shall limit differential and common mode voltage pulses from being transmitted through the unit.

### 10.3.2.4 Emission Requirements

The battery charging system shall meet or exceed FCC Requirements, Part 15, Subpart B, Class A, for conducted and radiated emissions, and as required by this Specification including the requirements as laid out in IEEE 16.

### 10.3.2.5 Remote Status Indicator

The status of any abnormal charger operation shall be transmitted to the car monitoring system (TS 16). Such condition shall include, but not be limited to, high or low output, ground fault, current limit, and over temperatures.
10.3.3 Load Shedding

A load shedding contactor shall be provided to protect the battery from complete discharge and to retain vital loads such as emergency lighting, cab radio, cab signals, etc. The contactor shall be normally open and shall be designed to open at a nominal voltage of 50 VDC when the battery is off charge and close at a nominal voltage of 55 VDC when the battery is being charged. It shall shed the non-vital loads and provide an indication of the load shedding occurrence. A second normally open vital loads shedding contactor shall be provided to shed vital loads in order to protect the battery. The contactor shall be normally open and shall be designed to open at a nominal voltage of 45 VDC when the battery is off charge and close at a nominal voltage of 50 VDC when the battery is being charged. The supplier shall confirm that the voltages mentioned allow the vehicle to meet all FRA requirements for operation of vital loads and adjust the voltages as required to meet requirements. A plan for the vital loads and the loads to be shed shall be submitted to the Engineer for review and approval. [CDRL 10-004]

10.3.4 Battery Box

Weatherproof battery boxes shall be provided. The battery shall be housed in a rattle proof stainless steel battery box of adequate strength to support the battery with no deformation in any members of the box over the life of the car. Means shall be provided within the box to prevent battery movement. No combustible materials and no nylon material shall be used for either the battery blocking or box lining. The floor shall comprise a locking slide-out tray with stainless steel floor and means to drain liquids through a drain hole to the ground. The tray shall lock in the fully extended and retracted positions. Ventilation shall be provided through filtered holes in the box. The battery box shall have a minimum of five (5) inches of clear space above the top of each tray of cells in both the open and closed position. It shall be reasonably watertight to prevent water from entering in all areas during normal operation and maintenance activities. The battery box shall be constructed to accommodate the application of a nickel cadmium alkaline battery of the capacity defined in TS 10.3 as manufactured by Saft New Technology Design with bonded plates. The battery box construction shall comply with APTA-PR- E-RP-007-98, latest edition. The design shall ensure that the batteries are accessible from the exterior of the car and that servicing can be performed without the use of tools.

The battery box shall be ventilated to meet the requirements of Standard EN50272-2:2001 as appropriate for the selected battery. The Contractor shall submit a design report to the Engineer for the battery box that includes calculations for strength, mounting, and venting; identifies safety factors used; and includes an analysis comparing actual design with the requirements of Standard EN50272-2. The report shall be submitted with the battery protection system design review package. [CDRL 10-005]

10.3.5 Battery Disconnect

A battery disconnect shall consist of a circuit breaker of adequate capacity and approved design. The circuit breaker shall be mounted in an enclosure as close to the battery as possible on the side of the battery box and equipped with an LED panel indicating on/off/tripped status.
10.3.6 Battery Protection

A sensor to prevent overheating from overcharging shall be located in the battery box to disconnect the battery from the low voltage power supply whenever the battery temperature exceeds the temperature specified by the battery supplier but in no case greater than 160 degrees F (71 degrees C). An over temperature protection system shall disconnect the battery in the event of battery over temperature. All over temperature battery disconnect events shall be reported on the MDS and shall require a manual reset. The battery protection system shall be approved by the Engineer. [CDRL 10-006]

10.4 TRANSFORMERS

Three (3) single phase 480/120 volt transformers connected in delta shall be provided on each car. They shall have sufficient capacity to supply all of the required 120 VAC loads. The loads shall be evenly distributed among the three (3) phases. The transformers shall be encapsulated totally enclosed non-ventilated dry type distribution transformers built to the requirements of the latest revisions of ANSI, NEMA, and IEEE Standards for transformers and shall be Underwriters' Laboratories listed suitable for exposure to the environment as described in TS 2.2.5 and mounted in a protective frame. They shall include a shield between the primary and the secondary winding of the transformer for noise suppression. The shield shall be connected to the grounding stud of the transformer. The transformer’s location shall afford protection and proper ventilation to the enclosure. The Contractor shall provide data concerning transformers’ ratings, type of winding, and class of insulation, and the design and installation shall be approved by the Engineer. [CDRL 10-007]

10.5 CONVENIENCE OUTLETS

Convenience outlets shall be provided for both maintenance and customer convenience within the interior of the car. All convenience outlets shall be Underwriter’s Laboratories listed duplex grounded convenience outlets for a 120 VAC single phase 60 hertz electrical system. Ground fault protection shall be provided for all convenience outlets via GFCI technology. The overcurrent and ground fault protection for the convenience outlet system shall be provided to the Engineer for review. [CDRL 10-008] The following requirements shall be applied for each category:

a. Maintenance – The outlets shall be located in the lower bulkheads of both ends of the upper and lower levels and one (1) outlet on each intermediate level for a total of six (6) outlets within the passenger area s and one (1) receptacle in each equipment service compartment. In addition, one (1) duplex outlet shall be provided in the cab of each cab car. These outlets are intended for use by SEPTA’s maintenance personnel for cleaning, servicing, and troubleshooting the vehicle. Each outlet shall be rated for 20 amps, and the rating of the system shall be such that it is able to support a total load of 60 amps distributed between the outlets.

b. Passenger Convenience – The passenger convenience outlets shall consist of a flush style duplex receptacle. Installation shall be installed in the wall panel at all transverse seat locations and two (2) locations in each intermediate level, one (1) of which must be adjacent to mobility aid parking areas. The sidewall locations in the transverse seating area shall be on the sidewall below the window and 24 inches forward from the front of the seat back. The passenger convenience outlets shall be protected by four (4) separate power circuits each equipped with 20 amp GFCI breakers with test and reset buttons.
The location of the outlets shall be approved by the Engineer. [CDRL 10-009]

10.6 SWITCH AND BREAKER PANELS

10.6.1 General

Control and power circuit breakers shall be arranged and sized commensurate with the devices and wiring which they are intended to protect. All switches and circuit breakers shall be readily replaceable without the removal of bus bar assemblies. Test points shall be provided on all + and - DC circuits for troubleshooting. Details of the equipment, arrangement, and installation of all electric panels and lockers shall be submitted to the Engineer for approval during the design review process. [CDRL 10-010]

10.6.1.1 Panel Arrangement

Switch and breaker panels shall be located in the electric lockers and in underfloor boxes as necessary. All electric lockers and underfloor boxes shall be approved by the Engineer. [CDRL 10-011] These enclosures shall be lined with insulating panels of 1/8 inch Haysite, or approved equal, with dielectric proprieties, arc resistance, mechanical properties, moisture absorption, etc., sufficient for the apparatus mounted on the panel. The Haysite shall be tested and certified to meet the requirements of TS 17.

The dead front of the circuit breaker panel shall be of stainless steel brush finish with black engraved lettering for the identification of the breakers and switches. The switches and breakers of the Operator's compartment shall be readily accessible without the use of a standard coach key. The rows of breakers of that panel shall be protected by a hinged Plexiglas panel. The dead front of that switch panel shall also be painted white, and the switches and breakers shall be identified with riveted black engraved stainless steel plates. The identification on the nameplates shall reflect the actual name of the circuit being protected rather than the schematic identifier of the circuit breaker.

Each panel shall have the necessary apparatus arranged to be accessible for the connections and designed to prevent crew contact with energized parts when operating switches or circuit breakers. The electrical connections shall be accessible from the front of the individual devices with the dead front removed. All switches and breakers shall be provided with a nameplate attached with rivets or tamper proof screws on the "dead front" clearly identifying the circuit which each controls. Troubleshooting test points shall be provided on all DC circuits.

The lists of switches and circuit breakers given in TS 10.6 are not necessarily complete but are intended to identify the desired locations for the various items listed. The Contractor shall submit the proposed locations for all required switches and circuit breakers for review and approval by the Engineer. [CDRL 10-012]

10.6.1.2 Switches

Switches shall be of the heavy duty toggle action indicating type and suitable for railroad service.
### 10.6.1.3 Circuit Breakers
Circuit breakers shall be toggle action, trip free, shock resistant, properly sized, and rated to be suitable for railroad service. They shall be mounted vertically, “ON” in the up position and shall clearly indicate whether “ON” or “OFF”. The 480 VAC breakers shall be rated for 600 VAC service and mounted in appropriate enclosures accessible with the use of a standard SEPTA coach key. The circuit breakers shall be Heinemann type AM\$ or approved equal, for low voltage 120/240 VAC and 74 VDC circuits and type GH3, or approved equal, for 480 VAC. The circuit breakers shall be designed to meet MIL-C-55629 standards in moisture resistance, humidity, shock and vibration, operating temperatures, insulation resistance, and endurance tests. Plug in circuit breakers are not acceptable.

### 10.6.1.4 Ground Fault System
Each car shall be equipped with a ground fault detection system utilizing internal or external remote detection of faults in each carborne system (120 VAC and 74 VDC). LED indicators shall be provided to indicate faults and also to provide for manual system operation checks on all systems and trainlines for voltages up to and including 74 VDC. Ground faults shall be reported on the monitoring and diagnostic system (MDS). The ground fault system design and operation shall be submitted to the Engineer for review and approval. [CDRL 10-013]

### 10.6.1.5 Fuses
Circuit breakers shall be used for circuit protection wherever possible. Fuses may only be used, with the Engineer’s approval, where the use of circuit breakers is either impractical or inappropriate.

### 10.6.2 Lighting Control Panel
The car lighting switch panel shall be located in the electric locker in an approved location. This panel shall consist of three (3) pole single throw switches controlling the passenger area lighting circuits with one (1) of the poles being used to control the emergency lights through an emergency relay. The platform lights and the vestibule lights shall be controlled by switches located in the locker with separate switches for each end and each circuit.

### 10.6.3 Electric Locker
The following circuit breakers and switches with appropriate current rating shall be located in the electric locker of all cars:

- 3 - Main lighting - 2 pole, 74 VDC
- 1 - Emergency lighting - 2 pole, 74 VDC
- 1 - Marker lights - 2 pole, 74 VDC
- 1 - Public address system - 2 pole, 74 VDC
- 1 - Door control - 2 pole, 74 VDC
- 1 - Door operators - 2 pole, 74 VDC
- 1 - Battery - 2 pole, 74 VDC
- 1 - Wheel slide system - 2 pole, 74 VDC
- 2 - Platform lights - 2 pole, 74 VDC
2 - Body end door operator (1 per end) - 2 pole, 74 VDC
1 - Maintenance convenience outlet and cab heater fan (cab car)
3 - Passenger convenience outlets - 2 pole, 120 VAC, (20A GFCI)
1 - Protective heaters - 2 pole, 74 VDC
1 - Heating and air conditioning control - 2 pole, 120 VAC
2 - Door control zones - 74 VDC
2 - Marker lights - 74 VDC
1 - Electro-pneumatic brake - 2 or 3 pole, 74 VDC*

* Number of poles depends on the brake system chosen.

The electric locker door shall have a flush pull handle and lock operated by the SEPTA standard coach key.

In addition to the above, the following breakers with appropriate current rating shall be located in the F-end vestibule wall electric locker in the cab car only (the panel shall be located in the wall behind the Operator):

1 - Auxiliary lights - 2 pole, 74 VDC
1 - Headlight - 2 pole, 74 VDC
1 - Gauge lights and car number sign (ATC) - 2 pole, 74 VDC
1 - Cab signal - 2 pole, 74 VDC
1 - PTC - 2 pole, 74 VDC
1 - Roadway worker alerter system - 2 pole, 74 VDC
1 - Event recorder - 2 pole, 74 VDC
1 - Radio/PA amplifier - 2 pole, 74 VDC
1 - Cab air supply blower - 2 pole, 120 VAC
1 - Snow brake cab isolation - 2 pole, 74 VDC
1 - End door Bypass (EDBS) - 2 pole, 74 VDC (sealed)
1 - Quarter point door bypass (CDBS) - 2 pole, 74 VDC (sealed)
1 - Visual annunciation signs - 2 pole, 74 VDC

Test points shall be provided on both legs (+ and -) of all DC circuits on the switch panels above for troubleshooting.

10.6.4 Air Conditioning and Heating Breaker Panel

The following circuit breakers with appropriate current rating shall be located in a control box readily accessible from inside the car:

1 - Cab heat (cab car only) - 2 pole, 480 VAC
2 - Floor heat - 3 pole, 480 VAC
2 - Overhead heat - 3 pole, 480 VAC
2 - Air conditioning compressor - 3 pole, 480 VAC
2 - Air conditioning condenser fans - 3 pole, 480 VAC
2 - Air conditioning evaporator blower - 3 pole, 480 VAC
The following circuit breakers with appropriate current rating shall be located in a panel in the quarter point vestibule:

1 - Battery charger          -3 pole, 480 VAC
1 - Transformer input        -3 pole, 480 VAC
1 - Door track/heater        -2 pole, 120 VAC

The following circuit breaker with appropriate current rating shall be located in an underfloor box:

1 - Main                      -3 pole, 480 VAC

### 10.6.5 Cab Car Electric Locker

Each cab car shall have an electric locker at the cab F-end on the cab side in the passenger area. The locker shall contain as much of the following equipment as practical for access and maintenance:

a. Cab signal/PTC electronics and associated mobile communications package
b. Roadway worker alerter system controller
c. Speed recorder
d. Event recorder
e. Air brake pressure switches and control reservoirs
f. Various traction, door control, ATC, HVAC cutout, bypass, makeup switches, and relays
g. 480 VAC jumper cables (two (2)) and holders

The equipment and layouts shall be submitted to the Engineer for review and approval. [CDRL 10-014]

### 10.6.6 Vestibule Electric Lockers

Each car shall have additional electric lockers in the quarter point vestibule partitions. These lockers shall contain the following apparatus and shall have panel doors equipped with flush pull handles and barrel key locks apparatus:

a. Brake system electronics
b. Odometer
c. PA amplifier with AAR mounting rack
d. Operator’s display keyboard panel
e. Automatic equipment monitoring
f. Monitoring and diagnostic system screen (MDS) (The MDS shall include HVAC controller and door event recorder functions.)
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11 TRUCKS

11.1 GENERAL REQUIREMENTS

The Contractor shall, as a minimum, follow all of the guidelines provided in APTA-PR-M-RP-009-98 to demonstrate through design, analysis, and testing that the truck conforms to the requirements of this Specification. Details of the design, arrangement, installation, and testing of the truck components and assembly shall be submitted to the Engineer for review and approval. [CDRL 11-001]

Only trucks manufactured by a supplier with successful experience in railway passenger truck design and manufacture shall be acceptable. Trucks and components shall be only of a service proven design, meaning a design which has operated in similar service at speeds up to at least 110 mph with a design life of 30 years for operation in the United States. The Contractor shall submit the service history of the truck, noting any deviation for this application, to the Engineer for review and approval prior to the selection of the truck. [CDRL 11-002]

Each car shall be equipped with two (2) four (4)-wheel trucks with inboard or outboard roller journal bearings and a cast or fabricated HSLA steel frame. The trucks at each end shall be the same except for bolt-on components such as the parking brake, leveling valves and ATC speed sensor at the F-end and the single leveling valve at the B-end. The truck’s primary suspension shall be either radius arm or chevrons. The carbody shall rest on two (2) air springs at the extreme ends of the truck bolster which, in turn, shall rest on the truck frame. The truck bolster shall not pivot with respect to the carbody. The complete truck and each of the truck’s components shall be interchangeable between the ends (B-end and F-end) of each car and between cars.

Trucks shall be suitable for operation at speeds up to 110 mph with six (6) inches of cant deficiency with qualification at 115 mph with nine (9) inches of cant deficiency per 49 CFR 213.345. The truck design shall provide sufficient restraint to prevent “hunting” or "nosing" of the truck at all speeds while, at the same time, allowing the cars to negotiate curves specified in TS 2.2 without causing excessive flange or rail wear.

The truck weight shall be held to a minimum without sacrificing required strength, good performance, and low maintenance. Provision shall be made for a minimum of 1 1/2 inches adjustment, in at least three (3) equal steps, of the truck height to compensate for wheel wear. (This equates to three (3) inches reduction in wheel diameter.) The design and method of height adjustment shall allow for quick and easy adjustment without disassembly of truck or removal of the truck from the car and shall be approved by the Engineer. It is recognized that the carbody weight will need to be removed to make the adjustment. [CDRL 11-003] The method of adjustment shall be demonstrated on the Pilot Car.
Provision shall be made for the use of the SEPTA wheel truing machines to turn the wheels. Axle centers shall be accessible without requiring disassembly of the truck or its removal from the carbody. For outside bearing designs, the bearing end caps shall be designed to remain in place for truing. The truck shall be fully compatible with SEPTA’s wheel truing machines, practices including the currently used centers, and the safety tie down procedure. If compatibility is not possible, any required additional equipment (e.g. centers) or modifications to the machine shall be at the expense of the Contractor. This additional equipment shall be demonstrated to SEPTA before approval. No part of the truck assembly or car, including bolster anchor brackets, shall interfere with or foul any part of the wheel truing apparatus. If further clarification on wheel truing machine dimensions is required to meet clearance and/or compatibility, SEPTA will, upon request, provide access to the machine for the Contractor’s inspection.

The truck shall provide unobstructed access to all parts which require inspection, lubrication, removal, and/or replacement without requiring removal of any other components or equipment. Inspection covers, when removed, shall provide clear visibility to all apparatus that requires inspection and/or maintenance. All major bolted, threaded, keyed, or pinned connections, and structurally critical locations shall be readily accessible for visual inspection. Threaded fasteners shall be UNC or UNF standard types, 3/8 inch minimum nominal size, and considered safety related structural fasteners per TP 17.02(b)(3). All nuts and cap screws shall be retained by approved locking or prevailing torque devices. The fasteners shall be readily accessible without removal of truck components or the removal of the truck from the car and located to permit removal with standard hand tools.

The trucks shall be equipped with materials to prevent noise generation from direct metal to metal contact and minimize audible noise transmissions into the passenger and wayside areas.

11.2 RIDE QUALITY

Trucks shall be suitable for operation at all speeds up to 110 mph with six (6) inches of cant deficiency with qualification to 115 mph with nine (9) inches of cant deficiency and shall provide a comfortable ride at all speeds compliant with the ride quality and maximum safe operating speed test requirements of TS 18.2.8. The vehicle shall meet the requirements of 49 CFR 213.345 and APTA-PR-M-RP-009-98, Section 6. A mathematical model of the vehicle shall be developed and submitted to the Engineer prior to any vehicle testing to predict the dynamic performance and ride quality. [CDRL 11-004] This model shall serve, in part, as the basis for any decisions for correcting dynamic performance and ride quality deficiencies. The model shall be developed on an industry accepted program such as NUCARS™, Vampire, or other generally accepted vehicle dynamic program. Type testing of suspension components, as well as vehicle characterization, shall be done to validate model parameters. Once the model has been validated by comparing the predicted natural frequencies with those obtained from a vehicle characterization in lieu of an instrumented wheelset (IWS) test, it may be used to complete an MCAT dynamic analysis for the maximum design operating speed and cant deficiency.
Should the cars fail to satisfy the above mentioned requirements, a program for correcting the deficiencies shall be submitted to the Engineer for approval within ten (10) working days, together with a proposed schedule for completing the suggested correction. If, in the opinion of the Engineer, the program and/or schedule are inadequate, unsatisfactory or increase maintenance costs or otherwise affect the serviceability of the cars, the modifications will not be approved, and an acceptable program and schedule shall be resubmitted within five (5) working days. If the revised program and schedule are not submitted in time or are still unacceptable, SEPTA will return the cars to the Contractor's plant at the Contractor's expense.

Should the cars, after correction, still fail to produce the riding qualities specified, SEPTA will have the right to require the Contractor to make further modifications to bring performance to the required standards.

11.3 WEIGHTS AND DIMENSIONS

11.3.1 Load
Trucks shall be designed for AW3 loads, based on the heaviest car type, at an operating speed of 110 mph with six (6) inches of cant deficiency. The truck frame and all truck parts, including foundation brake gear, shall be capable of withstanding the maximum stresses imposed by the forces acting on the frame, including track shocks, brakes, maximum damper forces, and any possible combination of these forces. The truck frame and all components shall be retained to the truck bolster and to the carbody in accordance with 49 CFR 238.219 and applicable APTA Standards and Recommended Practices. Truck mounted components and equipment shall be capable, as a minimum, of withstanding without damage or degradation shock and vibration requirements of IEC 61373, 1999. Attachments for truck mounted components shall be designed to the requirements of Rail Group Standard GM/RT 2100 Section 15.

The ultimate strength of the truck and the truck-to-carbody connection shall be sufficient to secure the entire truck to the carbody to prevent truck/carbody separation during derailments, collisions, or other untoward events in which a horizontal load of 250,000 lbs. is applied in any direction at any point on the truck frame with the truck frame at any point between the upper and lower vertical stops. This load may be transmitted from the truck frame through structural members, positive stops, or other rigid mechanical safety devices, and/or combinations thereof, to the carbody bolster. The bolster locating radius rods shall not be used to provide any part of this strength. The carbody bolster shall be designed to resist this load without damage.

Each component of the truck, including but not limited to wheelsets and the truck frame, shall remain attached when a force equivalent to two (2)g acting on the mass of the component is applied at any point and in any direction on that component.

A means shall be provided for retaining the bolster and truck frame with the carbody during vertical jacking or lifting of the carbody. This lifting arrangement shall be designed to provide a safety factor of two, based on the yield strength of the material. They shall be designed and located in a manner which shall minimize damage during derailments at speeds below 15 miles/hour. Truck mounted brackets shall also be provided to engage safety lugs on the gear units in the event of failure of the motor support arrangement. Additional safety hangers and safety stops shall be provided where necessary.
11.3.2 Clearances

Trucks shall be so designed that the maximum vertical and lateral vehicle deflection and roll are within limits specified in the construction limit outline and clearance diagrams specified in TS 2.2 with any combination of new and worn suspension components and any one (1) failed suspension component. The completely assembled trucks, with brakes and other equipment, shall not exceed the clearance limits required between truck and carbody in TS 2.2.3 or between truck and roadway for safe operation with maximum wear and load, over limiting lateral and vertical curves in TS 2.2, as well as tangent track. The truck outline shall not exceed the limits shown in the maximum equipment diagram. Clearance will be confirmed for the vehicle stopped on a track with a uniform six (6) inch superelevation. In no case shall any part of the truck, except wheels, come within 2 3/4 inches of the top of the rail under any combination of worn or failed suspension components. A minimum clearance of 1.5 inches (including construction tolerances) shall be maintained between moving truck parts and carbody parts, including wiring, hoses, cables, wheels and chains, under the most unfavorable combinations of vertical and horizontal track curvature, wheel wear, lateral and vertical motion, roll, and failed springs. The method of meeting these requirements shall be submitted to the Engineer for approval before the truck design is finalized. [CDRL 11-005]

11.3.3 Weight Transfer

It is intended that the car be capable of high instantaneous deceleration rates during emergency braking of over three (3) mphps. The truck design shall minimize the likelihood of wheel slide by minimizing weight transfer between axles, accomplished through the design geometry. The amount of actual weight transfer produced by the proposed truck shall be submitted for qualification of the design during Design Review.

11.4 DESIGN FEATURES

11.4.1 Truck Frame and Bolster Requirements

Truck frames and bolsters shall be of a service proven cast and/or welded steel manufacture suitable for the vehicle design. Materials shall conform to the requirements of TS 17.5 and TS 17.4. All welding shall be in accordance with TS 17.5 and TS 17.22.

Where pockets or partially enclosed spaces exist, adequate drainage shall be provided so that no moisture collects. All pockets and spaces shall be arranged such that debris, leaves, trash, etc., cannot accumulate.

Highly loaded welds shall be identified by the truck manufacturer and approved by the Engineer [CDRL 11-006]. These welds shall include, as a minimum, all welds or portions of welds which, based on the results of the stress analysis and/or truck tests, are expected to have a fatigue stress range exceeding 60% of the F_{TH} stress in Table 2.5 of AWS D1.1, 2008.
Critically loaded welds shall be as identified by the truck manufacturer and approved by the Engineer [CDRL 11-007]. These welds shall include, as a minimum, all welds or portions of welds which if a failure occurs, the truck and/or its accessory components will not be able to perform their function.

As part of the design approval, the Contractor shall provide the Engineer with drawings showing all areas of the truck that require radiography, ultrasonic, magnetic particle, or dye penetrant inspections when trucks are manufactured according to TS 17.5 and TS 17.22. [CDRL 11-008]

All truck frames shall have tram marks above and below, where applicable, each journal bearing location, located within 0.005 inches (0.13 mm) of the true position. Additionally, the truck frame assembly, when loaded through normal paths, shall maintain the longitudinally opposed bearing locations such that the difference in the distance between them shall not exceed 0.060 inches (1.52 mm) and shall maintain the diagonally opposed bearing locations such that the difference in the distance between them shall not exceed 0.100 inches (2.54 mm). These limits shall apply both at the AW0 load and a load condition of 120% of AW3 load.

11.4.2 Bolster Requirements

The truck bolster shall support the carbody by means of two (2) air springs, located one (1) at each end of the bolster. The bolster may also act as an air reservoir, connected through orifices to the air springs. Whether a separate reservoir is provided or the interior of the bolster is used as the reservoir, the interior shall be thoroughly cleaned to remove scale, weld flux, sand, and all other potential contaminants.

The carbody shall be arranged to move laterally by distortion of the air springs, but hydraulic shock absorbers shall dampen and a combination of elastomeric and metal stops shall limit this motion. The bolster shall be prevented from moving longitudinally and from swiveling by radius rods between the ends of the bolster and the carbody.

Loads shall be transmitted from the bolster to the truck frame through side or central bearings. Rotation between the truck bolster and the truck frame shall be through a vertical wear sleeve which shall also transmit all horizontal loads and not require lubrication. The truck frame shall be attached to the bolster with a locking center pin.

11.4.3 Equalization

The truck shall equalize such that the lifting of any one wheel in a truck a height of two (2) inches shall not unload any other wheel in the truck by more than 25 percent when the truck is under the carbody with air springs deflated, which is a value SEPTA considers necessary for its existing track conditions and has been achieved on its present equipment. An alternate value may be proposed in the Technical Proposal if the benefits of the revised value can be documented. The vehicle shall safely negotiate all classes of FRA track at the speed specified for that class of track. Equalization shall also meet the requirements of the equalization test in TS 18.2.2.11.
11.4.4 Center and Side Bearings

Center and side bearings, when used, shall be designed to permit rotation of the truck and to transmit vertical loads from the bolster to the truck frames. Load-carrying side bearings shall be designed to dampen truck swiveling and prevent truck nosing and hunting, and shall not require lubrication. Effective sound damping shall be achieved and measured per TS 2.3. Wear limit grooves shall be inscribed in the material, and all bearing material shall have a minimum life of ten (10) years. Center bearing material shall be non-metallic with no lubrication required. The Contractor shall submit the design data for the center and side bearings to the Engineer as part of the truck design review submittal.

11.4.5 Wearing Parts

All wearing parts of the truck, including pedestal liners and pinned assemblies, shall be provided with renewable liners, Teflon, or other suitable materials as approved by the Engineer.

11.4.6 Equalizers

Equalizer beams, if considered necessary or compliance with the specified requirements as required by the design, shall be used between the journal boxes. The equalizer beams shall either be plate steel as provided by the Buckeye Steel Castings Company, or steel forgings as provided by the Canton Drop Forge Company. The selected equalizer beam material and design shall be consistent with the truck design and specified loading conditions. The centerline of the equalizers and primary springs shall coincide with the centerline of the journal bearings. Either single or double equalizers may be used.

The equalizer coil spring seats shall be made of cast steel to AAR Specification M-201, Grade “B”. The springs shall be mounted on insulation pads in the spring seats. Steel shims may be used under the insulation pads for initial carbody leveling. Removable cast steel equalizer seats shall be used between the equalizer beams and the journal boxes. These seats shall be furnished in three (3) thicknesses to provide adjustment for wheel wear in 0.5 inch thick increments. All cars shall be delivered with the minimum thickness seat installed. The Contractor shall ship to SEPTA prior to the delivery of the pilot cars a quantity of three hundred (300) of each alternate thickness seat.

11.4.7 Inspection

The Contractor shall prepare and submit to the Engineer for review and approval a process and procedure to accurately and positively identify the work of each welder. [CDRL 11-009] Upon approval of the methodology, the Contractor shall submit this information monthly throughout the course of the production schedule.

The Contractor shall submit for approval an inspection and acceptance plan which includes, as a minimum, the requirements of TS 17.5 and TS 17.22. [CDRL 11-010] Production of trucks, prior to the Engineer’s approval of the required inspection plan, shall be at the Contractor’s risk.

If the first truck fails the radiographic or ultrasonic inspection, the second shall be inspected. This process shall continue until a truck passes the inspection. Production variables shall duplicate those for the truck which passes the inspection. There shall be no less than three (3) etched sections at each critical area, and the location of each shall be approved by the Engineer. [CDRL 11-011]
After qualification in accordance with the preceding paragraph, all welds shall be subjected to magnetic particle or dye penetrant inspection. In addition, welds, that are both highly loaded and critical as defined in TS 11.4.1, shall continue to be inspected by radiography or ultrasound. Magnetic particle inspection shall be performed in accordance with ASTM E 709. Dye penetrant inspection shall be performed in accordance with ASTM E 165. Ultrasonic inspection shall be performed in accordance with AWS D1.1-2008, Section 6.

Truck frames and bolsters shall not be considered complete and shall not be run in service on SEPTA until the Contractor completes, to the satisfaction of the Engineer, all inspection requirements specified in TS 17.5 and TS 17.22. Where grouping or lots are to be accepted by random sampling, all tests must be completed and the grouping or lot accepted before any of the units in their grouping or lot are considered complete or run in service. A complete quality control/plan for the truck and bolster assemblies shall be provided to the Engineer upon request.

### 11.4.8 Truck Curving

The truck shall be designed to develop an angle of attack of the lead wheelset of no more than 1.25 mrad per degree of curvature for curves up to and including four (4) degrees, and no more than 1.50 mrad per degree of curvature for curves from four (4) through ten (10) degrees. Additionally, the truck shall be designed to have a truck swiveling index (TSI) between 0.040 and 0.074. Service proven trucks that vary from these requirements shall be submitted for review. TSI is calculated as (refer to Koffman’s Formula in Rail Engineering International, September 1973):

\[
\text{TSI} = \frac{T}{2xQxD}
\]

Where:
- \(T\) = truck turning torque in foot-pounds
- \(Q\) = wheel load in pounds
- \(D\) = truck wheel base in feet

TSI shall be calculated for:

1. New vehicle, AW0 wheel load
2. New vehicle, AW3 wheel load
3. Fully worn truck/carbody interface, AW0 wheel load
4. Fully worn truck/carbody interface, AW3 wheel load

### 11.4.9 Truck Stress Analysis

The Contractor shall submit a stress analysis of the truck structure using the methodology and details as described in TS 3.8 and using the loads in TS 18.2.1 prior to commencing manufacture of truck parts. [CDRL 11-012]
Maximum stresses at any location recorded in the truck tests specified in TS 18.2 shall not exceed 55 percent of the yield strength for the base material; for welds, the maximum stresses shall not exceed the allowable stresses in AWS D1.1, 2008, Section 2, Part B, in Test 1, Nominal. For Test Number 2, Overload, the yield strength of the material shall not be exceeded. For Test Number 3, Fatigue, the base material stress is limited to the smallest of 100% of the appropriate endurance limit when plotted on the modified Goodman diagram as shown below or the $F_{TH}$ value in Table 2.5 of AWS D1.1:2008. For welds in Test Number 3, stress will not exceed the $F_{TH}$ value in Table 2.5 of AWS D1.1:2008. If stresses exceed the specified limits for any of the preceding tests, the design shall be corrected to bring the stresses within the allowable limits, the truck shall be reanalyzed and retested, and all trucks supplied under this Contract shall be corrected in accordance with the modified design.

**11.5 AXLES**

**11.5.1 General**

Axles shall be forged carbon steel furnished to AAR Specification M-101, latest revision, Grade "F", double normalized and tempered, or Grade H, normalized, quenched, and tempered, and given a subcritical quench heat treatment. The final material properties will conform to M-101. Each axle shall be marked by the manufacturer in accordance with M-101, latest revision.
The Contractor shall ensure the maximum fatigue resistance of all axle grooves and machine surfaces through the use of acceptable design and analysis. All grooves shall be cold rolled per AAR S-658, using a 3/16 inch roller and 1,200 pounds force. If a Grade H axle or other parameters are used, a representative sample groove must be tested using ASTM E-937 to show that the residual subsurface compressive stress is greater than that produced with the aforementioned parameters. Axles will be designed to EN13103 or other recognized standard. Overhung wheel seats will be used to improve fatigue resistance. The AAR fatigue allowables for axle material in AAR +Report MR-390, Table 1, will be used in lieu of other authoritative data specific to axle fatigue. Higher fatigue values will also be considered if supported by fatigue tests of the actual material or a minimum of 15 years’ service life of other axles in similar high speed service using the same design method and stress limits. The Contractor’s manufacturing process and quality assurance plan shall incorporate sufficient controls, inspections, and tests to ensure the axle provides the fatigue resistance required by the design. In all cases, the design of any grooves or other machine surfaces shall be subject to review and approval by the Engineer. [CDRL 11-013]

All axles shall be thoroughly inspected by the Contractor. The car history book for each car shall contain all inspection documents for the axles on that car. A list of these documents shall be proposed to SEPTA for review and approval prior to shipment of the first car. As a minimum, these documents shall include all inspection forms (visual, ultrasonic, magnetic particle, etc.), subcritical quench forms (include temperature, time, quench orientation, quenching medium, etc.), serial numbers, heat lot numbers, and other appropriate forms. [CDRL 11-014]

11.5.2 Mounting

The wheels, axles, brakes, discs, gears, and roller bearings shall be mounted using pressures and fits specified in the AAR Wheel and Axle Manual with the following exceptions: the back-to-back wheel dimension shall be 53 3/8 inches, +0, -1/8 inch; completed wheelsets shall have a static imbalance of 83.3 ounce inches or less. More restrictive conditions shall apply if recommended by the truck manufacturer.

The bearing interference fit parameters shall be provided by the bearing manufacturer and approved by the Engineer. [CDRL 11-015] At a minimum, bearing cone diameters and the corresponding diameters of the bearing seats shall be measured at three (3) locations on their length and at 120 degrees on the diameter, and the interference fit shall be within limits at all measured locations. For cones, nine (9) measurements are to be recorded, three (3) at each location; 3/8 inch inside from each face and at the midpoint. For seats, nine (9) measurements are to be recorded; their locations shall correspond to locations for the cone measurements when seated. Alternately, bearing cones may be measured using a dial bore gauge to locate and record the maximum and minimum diameters. The dial bore gauge is to be inserted into the cone and moved 180 degrees around and along the inside of the bearing cone. For seats using a snap gauge, the maximum and minimum diameters are to be located and recorded. The snap gauge is moved 180 degrees around and along the bearing seat locations that shall correspond to the locations for the cone measurements when seated. Measurement shall be strictly monitored and enforced; there shall be 100% surveillance of the entire bearing assembly process including mounting.

The pressure “spike” parameters for mounting the bearings shall be provided by the bearing manufacturer and approved by the Engineer. [CDRL 11-016]
All mounting work shall be performed in an AAR certified facility, and a copy of the AAR certification shall be submitted to the Engineer for review during the design review and shall be subject to verification at any time. [CDRL 11-017] Any change in the status of the facility’s AAR certified status, during the course of wheelset production, shall be immediately brought to the attention of the Engineer.

Mounted wheels shall be concentric between the bearing seat diameters and tread at the plane of the taping line within 0.007 inch total indicated run out and shall not exceed 0.015 inch out of parallel to each other or to a plane perpendicular to the center line of the axle.

Pressure graphs and inspection sheets of mounting wheels, disc hubs, and journal bearings shall be available to SEPTA for inspection, prior to installation on the trucks, for all wheel and axle assemblies. [CDRL 11-018] The hub and bore diameters of all fits shall be recorded and included on the inspection sheets and provided with all other pertinent information, as required by the Engineer, as part of the car history book.

### 11.6 JOURNAL BEARINGS

#### 11.6.1 General

Journal bearings shall be fully enclosed NFL (no field lubrication) roller bearings completely lubricated when assembled by the bearing manufacturer. The journal size shall be in accordance with AAR requirements for cars operating at speeds in excess of 85 mph, based upon the AW3 loaded weight of the car, and shall be not less than 6 1/2 inches x 12 inches, type AP, Class F. The journal bearing manufacturer must specifically approve the associated bearing end caps that will be used with the bearings. Additionally, the bearing end caps, if used, must comply with the structural requirements of AAR M-934C.

Under normal operating conditions, bearings shall not require inspection more than once every 500,000 miles. Journal bearings shall be designed for an ANSI/AFBMA L_{10} of 1,000,000 miles of service at the AW3 passenger load. The bearing type shall have had previous successful service application in railway passenger car use.

#### 11.6.2 Journal Box Numbers

Journal boxes shall be numbered, beginning at the F-end of the car, as follows: boxes on the right side shall be numbered R1, R2, R3, and R4; boxes on the left side shall be numbered L1, L2, L3, and L4. The numbers shall be steel stamped on stainless steel plates, riveted with stainless steel rivets, at the same location on all truck frames. The stainless steel plates shall be interchangeable among all trucks.

### 11.7 WHEELS
### 11.7.1 Design

Wheels shall be 32 inches in diameter, multiple-wear type, manufactured according to APTA-PR-M-S-012-99 Rev 1, with a 1/40 tapered tread and a reverse dish or "S" plate design. The existing SEPTA wheel profile, which is detailed in SEPTA Drawing C-4335, shall be supplied unless otherwise approved by the Engineer. Wheels shall be designed to provide three (3) inches of diametrical wear, plus an additional 3/16 inch radial tread thickness safety margin. Wheels shall be machined all over, removing mill scale and decarburized material from the plates, to specified dimensions and tolerances. The plates shall be shot peened per APTA-PR-M-S-012-99 Rev 1 following machining. Reference grooves will be provided in accordance with AAR RP-619.

The entire wheel shall be inspected and tested by NDT ultrasound equipment and certified before application to an axle. When assembling the wheels and axles, the wheel pairs shall be matched with respect to tape size in accordance with AAR Standards. All wheels shall be of a proven design with the lowest possible mechanical and thermal stresses available. The FEA of the wheel design selected shall be submitted to the Engineer for review and approval. [CDRL 11-019] Tread braking shall be limited to prevent the formation of thermal checks or cracks under full friction braking of a train of four (4) vehicles and one (1) locomotive with full passenger loading in local service. A thermal analysis to AAR S-660, plus route braking profiles as provided by SEPTA, shall be performed to demonstrate that the wheel thermal input will not produce thermal checks or cracks. [CDRL 11-020]

### 11.7.2 Material

Wheels shall be of wrought steel manufactured to APTA-PR-M-S-012-99 Rev 1, Class B, with a fracture toughness (K\text{IC}) of 57 ksi square root inch minimum for any single sample and 62 ksi square root inch minimum lot average. Fracture toughness testing shall be performed on each heat lot number, and each test shall be performed in strict accordance with the procedures set forth in ASTM E-399, latest revision, or an approved notch test. In the event that the test sample size, which can be extracted from a wheel, invalidates the K\text{IC} value for high toughness samples, the K\text{Q} value shall be used for Specification compliance.

### 11.7.3 Certification

Each and every wheel provided for this application shall have the following data available to SEPTA for inspection prior to mounting on axles: serial number; Brinell hardness; test data (per lot); fracture toughness test data (per lot); ultrasound test certification; and ladle analysis (per lot). This information shall also be included in the car history book.

### 11.8 SUSPENSION

#### 11.8.1 Primary Suspension

The primary suspension shall be either radius arm type or chevrons. If coil springs are used with the radius arm, they shall be nested pairs of alloy steel in accordance with AAR M-114-81. Coil springs will have a 50 percent working height reserve when subjected to the AW3 working load. Pedestal tie bars, if used, shall be attached to the truck frame with a positive metal in bearing path for loads.
Rubber elements of the primary suspension shall be designed to have a minimum 8 1/2 year life in the SEPTA environment. SEPTA may require life testing of the rubber elements to demonstrate durability, using data obtained from pilot car testing, if suitable performance history of the particular component is not available.

Retainers must be provided to prevent an axle from leaving the truck when the car is lifted with the trucks attached or in the event of a derailment. Retainers shall also prevent any primary suspension element from leaving its proper position when the axle is carried by its retainers, as will occur in order to spin motors and axles.

### 11.8.2 Secondary Suspension

The truck shall utilize an air spring secondary suspension system with a truck bolster, in conjunction with vertical and lateral dampers. The suspension system shall be so designed that buffers (TS 3.10.1) cannot pass one another with air springs fully overinflated on one car and fully deflated on the adjacent car with new wheels on the overinflated car and fully worn wheels on the deflated air spring car. Cars must also comply with this requirement when coupled to existing cars in the SEPTA fleet.

#### 11.8.2.1 Air Springs

A double convolution air spring shall be provided at each end of the truck bolsters. The air spring assembly shall be Firestone #207C closed Airide Assembly or approved equal. A rolling diaphragm type air spring may be submitted to the Engineer for approval as an alternative to the specified air spring. Safe operation of the car shall be ensured at all speeds when any one, any combination, or all air springs are inoperative or damaged.

Each air spring shall be connected through a damping orifice to a reservoir that may be contained in the truck bolster and forming part of the suspension system. Orifice resistance to the transfer of air between the air spring and reservoir shall be provided. Leakage of the air spring will be minimized, and no more than 0.10 psi/60 seconds when tested at 50 psig or the operating pressure which will produce the greatest pressure drop over time.

Means shall be provided so that when one air spring on a truck is deflated for any reason, the other is also deflated, regardless of whether or not they are controlled by the same leveling valve. A cut-out cock, in an approved location, shall be provided in air supply line to the air springs on each truck. The cut-out cock shall be accessible from the side of the car.

Air springs shall be fabricated of natural rubber or polychloropene, with a wear resistant outer covering, and shall be capable of easy replacement and maintenance. An elastomeric stop shall be provided in each air spring housing to limit bolster, vertical down motion, and to support the carbody in the event of an air spring failure. The stop shall be designed with a progressive rate to produce a low force at initial contact and a build up as the stop is compressed. The auxiliary spring system (elastomeric stop) shall permit operation at maximum speed without discomfort to the passengers in accordance with TS 18.2.
11.8.2.2 Leveling (Height Control) Valves

Three (3) leveling valves, two (2) at the F/A-end truck and one (1) at the B-end truck connected between the carbody and truck bolster, shall detect variations in height between the carbody and bolsters due to increased passenger load, and each shall admit air to or exhaust air from the air springs to maintain the carbody at a constant height and level above the truck. A four (4) leveling valve system, meeting the requirements of this Section, may be proposed, subject to review and approval by the Engineer. The leveling valves shall control the air suspension system to maintain the intermediate floor height at 51 inches (+1/2 inch, -0 inch) and within the required clearance envelope at all times. Each leveling valve on the B-end shall control one (1) air spring, and the single one (1) leveling valve on the A-end shall control both air springs on that end. The valves shall not be damaged by any possible normal movement of the truck. The normal failure mode of the valves shall cause deflation of the air springs. The leveling valves shall be as manufactured by Westcode, model WD-12155/005, or approved equal.

The leveling valve action shall be controlled through a mechanical linkage. The total lap range distance or deadband shall be no more than six (6) degrees (+/- three (3) degrees) movement of the leveling valve arm. The leveling valve arm and operation shall ensure that the specified floor height is maintained.

A choke and cut-out cock shall be provided in the leveling valve air line to both trucks to prevent rapid air loss from the car and a consequent brake application in the event of air spring ruptures. Cut-out cocks shall be safety wired in the open position. Accessible and suitable test fittings shall be provided at each leveling valve to monitor and calibrate air spring pressure. The location shall be approved by the Engineer. [CDRL 11-021]

The Contractor shall submit, for the Engineer’s approval, a comprehensive detailed procedure for leveling the cars. [CDRL 11-022] This procedure shall contain tolerances and all tools required to adequately perform the task. Air spring pressures on a truck must be adjusted to within one (1) psi of the nominal value during car body leveling. In order to provide an expedient method for future adjustments and inspections, the carbody bolster centerline, at each end of each bolster, shall be marked with a permanent plate showing the as built centerline.

Bosses shall be provided on the members above and below the air spring so that a go/no-go gauge may be inserted to verify proper spring height. White painted metal indicator pointers, which align when the air spring is at the proper height, shall be provided for purposes of yard inspection. They shall be mechanically fastened for ease of replacement.

11.8.2.3 Anti-Roll Bar

If the truck is designed with an anti-roll bar, the bar and bar levers shall be designed for an infinite life under SEPTA operating conditions. The connecting components, such as articulations, shall be designed for a minimum 20 year life. The anti-roll bar, and all connecting components including articulations and bearings, shall be submitted to a life test per TS 18.2.1.10 to demonstrate compliance with the Specification. [CDRL 11-023]
11.8.3 Dampers

Mechanical friction dampers will not be permitted in any application. The mountings for all shock dampers shall be sufficiently resilient to provide sound and vibration isolation between the connected components. All hydraulic dampers will be tested per TS 18.2.1.11. Dampers, including end mountings, shall be designed to operate without failure for 8 1/2 years of normal service. All dampers will be permanently sealed, provide suitable protection of the seal and rod from contamination including abrasive dusts, and not require any periodic maintenance during the service life. Damper force, velocity, length, strength, etc., will be specified by the car builder and be commensurate with the vehicle design and the railroad requirements. The dampers shall not prevent the recentering of the damped component.

All dampers will be equipped with a data plate with the following information:

a. Design damping rate (Newton-sec per meter (lb-sec per ft))
b. Nominal damping velocity (Newton per sec (lb per sec))
c. Maximum output force (Newtons (pounds))
d. Date of manufacture
e. Lot identification

11.8.3.1 Vertical Dampers

A hydraulic damper will be provided at each wheel location to control vertical wheel motion relative to the truck frame, unless a chevron suspension is used.

A hydraulic damper shall be installed between each end of the truck bolster and the carbody to provide vertical damping and to ensure that the specified ride quality is attained. The truck and carbody bolsters shall be provided with vertical shock absorber attachment points. Mountings for the shock absorbers shall be sufficiently resilient to provide sound and vibration isolation between the truck and the carbody.

11.8.3.2 Lateral Dampers

Two (2) hydraulic dampers shall be mounted between the truck bolster and the carbody to dampen lateral movement and ensure that specified ride quality is attained. The dampers shall be bolted to the brackets on the bolster and carbody, with an offset bolt pattern, so that the damper cannot be mounted upside down. Alternative means to prevent the damper from being mounted upside down may be proposed subject to approval by the Engineer. Mountings for the shock absorbers shall be sufficiently resilient to provide sound and vibration isolation between the truck and the carbody.
11.8.3.3 Yaw Dampers

The truck shall be equipped with yaw dampers, if analysis, tests, or operation indicates that yaw dampers are required. If yaw dampers are required, they shall be bolted to brackets on the truck frame and carbody, with an offset bolt pattern, so that the damper cannot be mounted upside down. Alternative means to prevent the damper from being mounted upside down may be proposed subject to approval by the Engineer. The initial truck design will include a plan for the yaw damper attachment. If yaw dampers are required per the above, the analysis shall be included in a revised ride quality model submittal package.

11.8.4 Stops

Lateral and vertical stops shall be designed with a progressive rate to produce a low force at initial contact which shall build up as the stop is compressed. Stops shall develop sufficient force to limit motion but shall not be compressed solid under any conditions that can be developed in the truck during normal operation. Truck parts contacted by elastomeric cushions shall be provided with stainless steel wearing surfaces. A wear resistant surface shall be provided on the contact surface of the elastomer cushion. Solid mechanical stops shall prevent lateral and vertical displacement in excess of the allowable motion stipulated on the construction limit outline. The Contractor shall submit designs and data for all stops to the Engineer for review and approval. [CDRL 11-024]

11.8.5 Safety Straps

A means shall be provided for retaining the bolster and truck frame with the carbody during vertical jacking or lifting of the carbody. These safety straps shall be designed to provide a safety factor of two (2), based on the yield strength of the material. They shall be designed and located in a manner which shall minimize damage during derailments at speeds below fifteen (15) mph. Additional safety hangers and safety stops shall be provided where necessary.

11.9 ELECTRICAL GROUNDING AND INSULATION

No current shall be returned to the running rail through journal bearings. This shall include both normal current and overload current due to insulation failures in car borne equipment and ground return current from an electric locomotive. A ground strap shall be installed between the car and ground brush assemblies mounted to each journal bearing housing (one (1) ground brush per axle). The housing shall be equipped with two (2) insulated brush holders. The assembly housing shall allow removal without dismounting of any wheels or bearings. A constant pressure spring assembly shall hold each ground brush in uniform contact with the ground ring from a new to worn brush configuration. The brushes shall be easily removable from the holders without disassembling or removal of the brush holders from the housing. Each assembly shall be capable of a continuous rating of 250 amps with a peak current capability of 1000 amps. Ground return connections shall meet APTA-PR-E-S-005-98 requirements. Brush life will be 500,000 miles minimum in SEPTA service. Ground returns shall be provided to specifically designated ground pads. The truck grounding system shall be sized to allow operation with up to two (2) shunt paths per car disconnected without exceeding the current ratings of the remaining electrical grounding apparatus. The design and ratings for the ground brush assembly and a block diagram of the grounding system shall be submitted to the Engineer during the design review of the car. [CDRL 11-025]
11.10 BOLSTER ANCHOR RODS (RADIUS RODS)

Two (2) bolster anchor rods shall be provided on each truck, connecting the carbody to the bolster. The rods shall extend horizontally from brackets attached to the side sills to brackets attached to the ends of the truck bolster. Elastomeric pads shall be installed between the radius rod assembly and anchor brackets to permit vertical movement.

Bolster anchor rods shall be designed and located to eliminate longitudinal vibration from the car. The design and location shall be approved by the Engineer. [CDRL 11-026]

Each of the rods shall, as a minimum, withstand a longitudinal load equal to two (2) times the weight of the complete truck, including brakes and other apparatus mounted thereon, without exceeding the yield strength of the materials used. Each of the brackets, by which the bolster anchor rods are attached to the truck, the truck bolster, and/or the carbody, and the members to which these brackets are attached, shall, as a minimum, withstand a longitudinal load equal to three (3) times the weight of the complete truck assembly without exceeding the yield strength of the material used. Furthermore, both radius rods together must also support, without deformation, the load that can occur if the maximum main reservoir pressure is applied to the brake cylinders assuming perfect wheel/rail adhesion. Perfect wheel/rail adhesion is defined as that condition where the wheels continue to roll (sufficient adhesion to prevent the wheels from sliding) with the brakes applied at maximum main reservoir pressure. This may be more or less than a coefficient of friction of 1.0.

11.11 AIR PIPING

Truck air piping shall use welded fittings in accordance with the requirements of this Specification. Hose connections to specific equipment shall be made with flange fittings. Threaded pipe fittings shall not be used. Piping shall be securely supported by pipe clamps clear of the frame, shall not cause interference, contact or rubbing with equipment or cables, and shall be arranged to avoid the formation of water pockets. Installation of all piping shall be approved by the Engineer. [CDRL 11-027]

All flexible hoses shall be of a type approved by the Engineer. [CDRL 11-028] All hoses shall be arranged to avoid chafing and undue stresses in all operating positions.

All pipes and hoses shall be routed in such a manner to utilize the minimum length of pipe or hose possible and to ensure the maximum clearance possible at all dynamic conditions. All hoses between the truck frame and carbody shall incorporate a walking loop design to minimize kinking and/or stretching.

11.12 VEHICLE/TRACK SYSTEM QUALIFICATION

For vehicles which have been previously qualified, the Contractor shall submit a copy of the full report on the testing and a copy of the letter from the FRA approving operation up to 110 mph or higher with up to 6 inches of cant deficiency. Vehicle types not previously qualified shall be qualified in accordance with the following requirements [CDRL 11-029]:
a. Simulations or Measurement of Wheel/Rail Forces

For vehicle types intended to operate at track Class 6 speeds, simulations, or measurement of wheel/rail forces during qualification testing shall demonstrate that the vehicle type will not exceed the wheel/rail force safety limits specified in 49 CFR Part 213.333. Simulations, if conducted, shall be in accordance with paragraph b, Simulations. Measurement of wheel/rail forces, if conducted, shall be performed over a representative segment of the full route on which the vehicle type is intended to operate.

b. Simulations

For vehicle types intended to operate at track Class 7 speeds or above or at any curving speed producing more than six (6) inches of cant deficiency, analysis of vehicle/track performance (computer simulations) shall be conducted using an industry recognized methodology on:

1) An analytically defined track segment representative of minimally compliant track conditions (MCAT – Minimally Compliant Analytical Track) for the respective track class(es) as specified in 49 CFR Part 213, Appendix D, to this part; and

2) A track segment representative of the full route on which the vehicle type is intended to operate. Both simulations and physical examinations of the route’s track geometry shall be used to determine a track segment representative of the route.

c. Instrumented Wheelsets (Optional)

Two (2) instrumented wheelsets and associated data acquisition software and hardware shall be used to acquire continuous longitudinal, lateral, and vertical wheel/rail forces. The primary use of the wheelsets shall be to determine the safe operating envelope of the vehicles by verifying high speed stability, safety of high cant deficiency operation, and measuring operating wheel/rail forces per TS 11.2. The maximum operating speed of the wheelsets shall be 115 mph, and the minimum life including strain gauge attachment and protective coating shall exceed the duration of the test program including all testing required to achieve full FRA operating approval for the design speed. As a minimum, wheelsets must meet the requirements of Appendix B, AAR Specification for Instrumented Wheelsets for Chapter XI (M-1001) Testing. Data acquisition shall be done with a high speed digital system using commercially available computers and related components for data acquisition storage and display.

As part of the current contract, it is the Contractor’s responsibility to provide all associated support equipment and operating personnel to show that the truck and vehicle meet the requirements for operation at 110 mph with six (6) inches of cant deficiency and qualification at 115 mph with six (6) inches of cant deficiency. Initial testing per 19.02(c)(11) may be accomplished on portions of SEPTA or Amtrak trackage deemed appropriate for the testing.

The wheelsets shall be the same size, material, and tread profile as the wheels supplied on the vehicles. Milling of the wheelsets, to improve sensitivity, shall be allowed as long as the final dimensions remain within AAR limits for passenger service.
The lateral and vertical wheel forces shall be measured with the measurements processed through a low pass filter with a minimum cut off frequency of 25 Hz. The sample rate for the wheel force data shall be at least 250 samples/sec. The operating ambient air temperature range shall be no less than 0 to 110 degrees Fahrenheit. The actual operating temperature range shall be noted as well as any temperature restrictions. All raw data channels shall be preamplified to a minimum of one (1) volt peak to peak at a nominal 80 percent load on the wheel side of the slip rings.

The longitudinal, lateral, and vertical outputs shall be within 4 percent of the actual applied load or within 250 pounds, whichever is greater. This accuracy shall be over the entire range of applied loads, over the range of lateral to vertical (L/V) and traction to vertical (T/V) values, and around the full 360 degrees of rotation. This accuracy shall be maintained under conditions of high angles of attack and during two-point wheel/rail contact. This accuracy shall be demonstrated in an approved loading fixture or fixtures. Testing and documentation in support of this accuracy shall conform to Sections 3 and 4 of Appendix B, AAR Specification for Instrumented Wheelsets for Chapter XI (M-1001) Testing, and submitted to the Engineer for approval.

11.13 **ELASTOMERIC AND NON-METALLIC ELEMENTS**

Due to previous difficulties experienced by SEPTA in material procurement, all elastomeric and non-metallic elements used in the truck shall be supplied by a domestic US supplier or manufacturer, unless approved otherwise by SEPTA. Complete design and purchasing information shall be provided in the as built drawings (see TS 1.18), including material composition, spring rate, hardness, process details, dimensions, tolerances, coefficient of friction, etc., to enable SEPTA to specify and purchase replacement parts during the life of the car.

11.14 **CONTRACT DELIVERABLE REQUIREMENTS LIST**

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12 ELECTRO-PNEUMATIC FRICTION BRAKE SYSTEM

12.1 GENERAL

A 26C-CS-2 compatible electro-pneumatic brake system shall be provided on all multi-level cars. The brake system shall comply in all respects with the latest applicable requirements of both the FRA regulations and the APTA Standards and Recommended Practices. The air brake system shall be a microprocessor based brake control design such as Wabtec Fastbrake or Knorr-NYAB CCBIIP. All parts necessary to cause the efficient operation of this equipment shall be supplied, installed, and tested to ensure proper and safe operation of the brake system as integrated into the cars.

The brake system and the individual components other than generic standard materials shall be supplied by an experienced air brake equipment supplier who has confirmable previous satisfactory operating experience on North American commuter railroad passenger systems. The Contractor shall receive certification from the brake system subcontractor that the application and method of installation and connection of the system have been reviewed and approved by the brake system supplier. A copy of this certification shall be submitted to the Engineer. [CDRL 12-001]

The normal control of braking shall function through electrical trainline circuits providing quick and accurate response in both application and release (holding). The status of the electrical brake control trainlines shall be reported to the digital trainline network (DTN). The brake system shall also permit the cars to be handled by a locomotive, which is not equipped with an electro-pneumatic braking system, through full pneumatic control of braking by means of the brake pipe trainline pressure regulation. The details of the design arrangement and installation of the brake system shall be submitted to the Engineer for review and approval. [CDRL 12-002]

Thermal capacity shall be separately validated at design operating speeds and duty profiles. Both the thermal and friction capabilities of the friction brake system shall be subject to critical review at design operating speeds and duty profiles. The brake equipment arrangement shall have adequate thermal capacity to meet the requirements of TS 2.2.7.5 and shall not produce any thermal damage to the wheels, discs, and brake shoes/pads at train speeds up to 110 miles/hour under any operating condition. The thermal distribution shall be determined by the brake equipment supplier and approved by the Engineer. [CDRL 12-003] Thermal braking simulations using AW3 loads, SEPTA route profiles, and full service braking distances shall be submitted to the Engineer for review and approval. [CDRL 12-004] Dynamometer testing using Contractor proposed brake equipment including shoes and pads shall be performed to determine the thermal limits. The brake disc and brake pad and wheel and brake shoe temperatures shall not exceed the limits specified by the manufacturer(s). These limits shall be included in the test procedure for the dynamometer tests.

A diagnostics and monitoring system shall be provided which shall perform the following functions as a minimum:
a. The system shall record all faults that require maintenance and/or limit the function of the system by logging date of fault, time, type of fault, and identification of faulty/defective components as well as fault applicable air pressures.

The system shall perform system tests through the cab driver display unit by means of user friendly instructions. The tests shall be manually activated to allow the user to initiate functional testing of each part of the system and verify that the lowest replaceable unit is functioning properly. The system shall provide visual and recorded messages indicating whether or not the component is functioning, reporting, and recording specific malfunctions.

b. The system shall be connected to the monitoring and diagnostic system (MDS) via the data car network (DCN).

c. The brake system diagnostics and monitoring system design and functionality shall be approved by the Engineer. [CDRL 12-005] The system performance shall be demonstrated on the pilot cars.

12.2 CONTROL

The normal operation of the brake system shall be controlled from the locomotive or cab car by means of an electronic brake controller and associated equipment which shall exhaust or charge the brake pipe and energize “SERVICE” or “RELEASE” trainline wires to apply or release (hold) brakes through magnet valves installed on each car. The brake control shall be designed for pneumatic graduated release with the capability for easy conversion to pneumatic direct release when needed. The pneumatic graduated release function shall retain corresponding brake cylinder pressure control throughout the entire control range down to within five (5) psi of the full release brake pipe pressure. The control hysteresis between the brake pipe pressure and precontrol pressure shall be no more than two (2) psi for the application and release. The brake control may facilitate the transmission of quick service and quick action through local exhaust of the brake pipe.

All cars shall be equipped with microprocessor based controls such as Knorr CCBII or Wabtec Fastbrake. On cab cars, each Operator’s cab shall be equipped with a brake controller located on the right side of the cab console and arranged for ease of use by the Operator’s right hand. The cab brake controller shall be a console style unit with a non-removable handle. The handle movement shall be in a longitudinal front and back direction with the release position closest to the Operator. The controller shall be a combination pneumatic and electrical unit and shall generate electrical signals to the brake pipe control manifold unit. In addition, it shall include a vent valve for redundant venting to the outside of the vehicle during an emergency brake application.

Mounted on the brake controller housing shall be a control device to permit the Operator to activate or deactivate, CUT-IN/CUT-OUT, the controller. The device shall prevent the controller handle from moving or responding except between the handle off and emergency positions. The emergency position shall be functional at all times.

The controller handle shall have the following positions from front to back:
The electro-pneumatic brake control shall be self-lapping CS-2 based. An electric HOLD functionality shall be provided by lateral movement of the handle to the right in any position between full service to release inclusive. Each of these lateral positions shall have a detent and shall cause the brake pipe control unit to provide the trainline commands. The design of the handle shall make it impossible to place the unit in the handle off position without initiating an emergency brake application. No independent brake control for the locomotive shall be provided.

The time required to initiate brake cylinder blow down electrically (pressure release) from a “FULL-SERVICE” application on a 12 car train shall not exceed one (1) second from the instant of movement of the brake handle from “holding” to “release” after all cars are recharged. Sound attenuation shall be incorporated into the design and installation to preclude transmission of noises into the passenger compartments from the operation of the brake system. The brake valve shall be exhausted to the outside of the cab.

A failure of the electric trainline control shall require no action by the Operator in “SERVICE,” “EMERGENCY,” or “RELEASE.”

The brake system shall provide a pneumatic brake backup with direct release set to AW0 load weight. The pneumatic backup brake shall be available at all times.

A load weigh system using air spring pressure shall adjust the brake cylinder pressure in both “SERVICE” and “EMERGENCY” braking to maintain a consistent deceleration rate for a given command as car load varies and to ensure that the adhesion limit is not exceeded over the range from empty to crush load. The failure of any portion of the load weigh system shall result in not less than empty car brake cylinder pressure.

Sufficient brake cylinder pressure shall be maintained on a standing train to prevent any train movement when all cabs are inoperative while an Operator is “changing ends”.

A brake pipe pressure reduction of six (6) psig shall result in brake cylinder pressure of at least ten (10) psig. Thereafter, the brake cylinder pressure shall increase linearly in proportion to continued brake pipe reduction to maximum brake cylinder pressure. The system shall be designed such that the brake pipe pressure is maintained during multiple brake applications, and the commanded brake cylinder pressure is maintained.

The Contractor shall provide a brake system that is fully compatible with the air brake systems on SEPTA’s single level cars and electric locomotive fleets over the full range of service and emergency braking. Cars shall have improved release times and drop off rates over the existing SEPTA cars.
The Contractor shall submit to the Engineer for review and approval all brake performance data and other information concerning the apparatus proposed for meeting the compatibility requirements. This data shall be provided during the design review process and shall be updated throughout the project. [CDRL 12-006]

### 12.3 BRAKE RESPONSE TIMES

The air brake system shall provide rapid "SERVICE" and "EMERGENCY" response at all times and shall permit quick recharge of the brake pipe after an "EMERGENCY" application, after the vent valves have closed.

The response times shall be as follows:

a. **Full Service Application**

   With the brake pipe fully charged at 110 psi, the time for brake pipe pressure reduction from initiation of brake controller handle movement to 85 psi shall be 4.5 seconds maximum using pneumatic control and 3.0 seconds maximum using electro-pneumatic control. The brake cylinder pressure build up time from the brake controller handle movement to 90 percent of full application pressure shall be a maximum of 4.0 seconds.

b. **Full Service Release**

   The time for brake cylinder pressure release from initiation of brake controller handle movement to five (5) psi shall be a maximum of 3.5 seconds.

c. **Emergency Application**

   The time for brake pipe pressure reduction from initiation of brake handle movement to 85 psig shall be less than 0.5 second. The time for brake cylinder pressure build up from brake controller handle movement to 90% of full application shall be less than 1.0 second.

d. **Deceleration Rates**

   The performance requirements for the “FULL SERVICE” and EMERGENCY” deceleration rates shall be met as required in TS 2.2.7.3.

### 12.4 EMERGENCY BRAKE

An emergency brake application initiated from any car in the train shall promptly operate the brakes on all cars in the train at the emergency rate. The emergency brake application shall bypass the electric brake control and apply the brake through pneumatic means. The emergency brake shall be timed so as to assure that the train is stopped before the brakes can be released (Stop-Insured). An emergency brake application shall be possible at any time or at any stage of brake application or release regardless of the degree of “service” application provided that the brake pipe pressure is not lower than 50 psig. An emergency brake application shall cause all sanders to apply sand. The brake cylinder pressure shall be determined by the load weigh system.
An emergency brake application shall be initiated from the electronic brake controller. In addition, an emergency brake application shall be initiated from a valve located in the control cab, a Conductor’s emergency valve located on cab and trailer cars, a passenger compartment emergency brake valve, or by rapid reduction of brake pipe pressure from any point in the train. Specific locations and design detail of the emergency valves shall be approved by the Engineer. [CDRL 12-007]

Wheel slide correction shall be deactivated in the emergency brake but means shall be provided to activate the wheel slide correction in the emergency brake at the Operator’s option using the emergency brake trainline where deenergized provides no wheel slide correction and energized provides wheel slide correction.

### 12.5 DEAD HAUL

Apparatus shall be provided to haul each vehicle in a completely shut down condition in both passenger and freight consists and by a lone locomotive. The apparatus shall consist of equipment allowing the main reservoirs to be charged from the brake pipe. The apparatus shall allow the friction brakes to operate in the consist at a brake cylinder pressure that avoids over braking and wheel flats. The apparatus shall also allow the charging of the secondary air suspension to the proper car ride height. The vehicles shall not require additional valves or other equipment to be replaced or installed in order to allow dead haul.

### 12.6 DISC BRAKE UNITS (DBU)

Individually actuated air pressure applied disc brake units shall be installed on each axle of each car. The disc friction ring assembly shall consist of a hub and a split friction ring to allow removal of the friction ring from the hub without removing the wheel from the axle. The split friction ring shall be demonstrated to have the necessary thermal characteristics and strength to resist warping and cracking due to thermal stress. The friction ring arrangement shall permit replacement without the removal of any components or equipment other than the caliper assembly. Wear indicating marks shall be provided to indicate the condemning limits of each surface. The hub and friction ring design shall be submitted to the Engineer for review and approval during the design review. [CDRL 12-008]

The disc brake actuators shall include an automatic slack adjustment feature which shall adjust for brake pad wear as well as assure drag free running. The disc brake actuator and caliper assembly shall be designed to function in normal service for not less than eight (8) years between overhauls. The disc brake pads and holders shall be designed for quick replacement without disassembly of the actuator unit or use of wrenches. The brake actuator, brake pad retaining latch, and locking pin arrangement shall be submitted to the Engineer for review and approval. [CDRL 12-009]

Each disc brake actuator shall be pneumatically connected with an individual hose from the truck frame piping. Connections shall utilize fittings which permit quick disconnection and facilitate brake actuator removal. The hoses shall be AAR M-618 compliant, single wire braid reinforced with reusable fittings. The hoses shall be protected from debris damage. Brake actuator assemblies shall be resiliently mounted on the truck frame. The equipment shall be installed and located to provide for safe inspection and observation of brake application and release from both high and low platforms. Bushings, pins, and other components that require periodic lubrication shall be supplied with protected lubrication fittings.
A system shall be provided to prevent brake cylinder pressure drop in case of main reservoir pressure loss.

### 12.7 TREAD BRAKE UNITS (TBU)

Individually actuated tread brake units (TBU) shall be installed at each wheel of each car. Brake cylinders and automatic slack adjusters shall be furnished as part of the truck mounted brake units. Positive clearance shall be provided between the brake shoe and wheel during brake release. Manual adjusters shall be provided to allow for manual adjustment of the shoe position when replacing shoes. The adjuster mechanism shall not require special action to engage or disengage the adjuster during routine maintenance to prevent subsequent damage to the adjuster or the unit.

The geometry of the brake unit and its installation shall minimize any self-energization effect. The design of brake units shall permit the use of unflanged high friction composition brake shoes. Units shall be installed on the truck in a manner to provide for ease of removal and replacement of brake shoes. Each tread brake unit shall be installed and located to provide for safe inspection and observation of brake applications and releases from both high and low platforms.

The air connection to each TBU shall be with AAR M-618 compliant, single wire braid reinforced hose with reusable fittings. The hoses shall be protected from debris damage.

Bushings, pins, and other components that require periodic lubrication shall be supplied with protected grease fittings. The tread brake unit shall be designed to function in service for not less than eight (8) years between overhauls.

### 12.8 SNOW BRAKE

The brake system shall include a snow brake system described herein. All cars shall have a snow brake trainline. On cab cars, the snow brake function shall be provided through the brake control computer to retain a constant brake cylinder pressure by reacting to the snow brake trainline state. The snow brake shall be activated when the snow brake switch located in the Operator's switch panel is closed.

The snow brake system shall provide automatic periodic release to allow for slack adjustment while the snow brake system is in use. The method and frequency of the automatic periodic release system must be designed to assure that full braking effort is maintained assuming continuous use of the snow brake feature. Details of the snow brake system shall be submitted to the Engineer for review and approval. [CDRL 12-010]
12.9 LOAD WEIGH CONTROL

Brake cylinder pressure in service and emergency braking shall be limited in proportion to the weight of the passenger load. Failure of any component of the load weigh control shall result in no less than an empty car service brake cylinder pressure when a full service brake is requested, or no less than an empty car emergency brake cylinder pressure when an emergency brake is initiated. The design criteria, component reliability, failure history, and analysis of how this shall be achieved shall be submitted to the Engineer for review and approval during the design review of the car. [CDRL 12-011]

12.10 MANIFOLD AND VALVE COMPONENTS

All air brake components shall be mounted on common manifolds (pipe brackets) to minimize excessive interconnections and to simplify the removal, replacement, and servicing of individual components. The number of manifolds shall be minimized by taking the commonality of function and physical arrangement constraints into consideration. Single side manifolds are acceptable. Air brake apparatus shall be so located in an interior compartment as to permit full accessibility from the interior of the vehicle. The location of the brake apparatus shall allow removal of valves and devices from pipe brackets for inspection, cleaning, and repairs without removal of interior panels. The area where the brake apparatus compartment is located shall be lit upon the opening of the access panel. The access panel shall be lockable with key access.

All brake valves/components subject to scheduled regulated maintenance shall be serialized unless specifically approved by the Engineer.

12.11 DUPLEX AIR GAUGES

Two (2) duplex air gauges at least 3 1/2 inches in diameter shall be provided in each Operator’s cab. The gauges shall have an illuminated black dial. The two (2) gauges shall be graduated from 0-200 psig. One (1) gauge shall indicate the main reservoir and equalizing reservoir pressures, and the other gauge shall indicate the brake cylinder and brake pipe pressures. Gauge hand identification shall be shown on the gauge panel not on the gauge face. The air gauges shall be interchangeable. The air gauges shall be equipped with gauge test fittings and be arranged for testing in place. Gauges shall be internally illuminated. Gauges shall be easily visible to the Operator from a normal seated position angled to squarely face the Operator and located even in height with the plane of forward vision of a 50th percentile male Operator. Alternative configurations compatible with the cab design may be submitted for consideration as options to the base configuration.

12.12 PRESSURE TEST FITTINGS

Salem or SEPTA approved equivalent pressure test fittings shall be provided for all pneumatic transducers, pressure switches, air gauges, or other equipment requiring periodic routine calibration and function checks.
The fittings shall allow for simple and effective accuracy and calibration testing without removing the item being tested from the car. It shall be possible to perform testing while the system is fully charged through the use of an automatic shut off valve integral with the test fitting. The valve shall upon insertion of the test apparatus close off the normal supply line to the component being tested. Fittings shall be close coupled to the device which they serve and shall be mounted in accessible locations.

Separate test gauge fittings shall be installed in the brake system piping to facilitate testing and troubleshooting the brake system.

### 12.13 CUT-OUT COCKS

A vented cut-out cock with a locking handle shall be provided in the brake cylinder line for each truck to cut out the truck's brakes.

Other cut-out cocks with locking handles shall be installed in the air supply and brake system piping in approved locations to isolate the air supply to system components and equipment to permit their removal and replacement and to allow for service, repair, maintenance, and trouble shooting of the pneumatic equipment.

All cut-out cocks shall be identified with a permanently fixed nameplate visible from the side of the car. The design details, location, and installation of all cut-out cocks shall be submitted to the Engineer for review and approval. [CDRL 12-012]

### 12.14 BRAKE PIPE AND MAIN RESERVOIR PIPE

#### 12.14.1 General

The brake pipe trainline diameter shall be 1.25 inches. The main reservoir trainline diameter shall be 1.0 inch. All pipe work shall comply with TS 17.14. Final pipe work design, fittings, and pipe locations shall be approved by the Engineer. [CDRL 12-013]

Locking type straight angle cocks shall be provided for the brake pipe, and locking type cut-out cocks shall be provided for the main reservoir equalizing pipe at both ends of the car. Straight cocks at the ends of the cars shall be accessible and located in accordance with the latest AAR recommendations and SEPTA requirements. Flow indication shall be included on the handle. Dummy couplings and chain assemblies for air connections are to be provided at each end of the car.

The air hoses shall be located to avoid fouling when cars are coupled on straight or curved track. The Contractor shall ensure that pipe and hose locations are consistent among all cars. Hose supports approved by the Engineer shall be applied to prevent coupled or uncoupled hose ends from dropping below 2 3/4 inches above top of rail.

The main reservoir equalizing pipe shall have a slope from the center of the car into two (2) small condensate accumulating reservoirs equipped with manual drain valves located at each end of the lower underframe. From each reservoir, the pipe shall rise to the end of car level. Each manual valve shall be operable by an extension lever from the track side. Each drain valve shall have a guard to prevent damage from debris.
12.14.2 Charging
Charging of the brake pipe shall be initiated from a brake controller in an active cab. In order to initiate charging, the brake controller must be in the Full Service position and the train must be at rest (No Motion is true). The brake controller and brake pipe control unit shall have a delivery that is as rapid as possible, but insufficient to recharge against the open position of any of the venting apparatus.

12.14.3 Maintaining
Brake pipe pressure shall be maintained at the level commanded by the brake controller in the active cab by a combination of the trainline control unit on the car with the active cab, and application magnet valves on each FBCU. Pneumatic components shall be provided to maintain the brake pipe pressure at the desired pressure, provided that the brake pipe is not vented, and also to cut off brake pipe charging during an emergency brake application. The maintaining feature shall become active once the brake pipe has been charged to a specified minimum pressure, and shall be cancelled upon initiation of an emergency brake application.

12.15 CUT-OUT HANDLE POSITIONS
All cut-out cock handles except brake pipe angle cocks shall be arranged to be parallel with the pipe in the closed position and perpendicular to the pipe in the open position. Cut-out cocks shall be oriented so that valve handles cannot vibrate to the opposite position in service.

12.16 BRAKE INDICATORS
Air pressure brake indicators conforming to the requirements of 49 CFR 238 shall be provided at each truck to indicate the applied or release status. The details of the brake indicator design and installation shall be submitted during design reviews.

12.17 CONDUCTOR’S VALVE
A Conductor’s valve shall be provided at each end of each car inside the passenger section and adjacent to the body end door for a total of four (4) per car. The cab car shall have an additional valve located in the passenger area adjacent the Operator’s control station that is also accessible for the operation when the cab area is closed off. They shall when actuated cause a pneumatic emergency brake application.

12.18 VIGILANCE MONITOR
The cab car brake system shall have a vital penalty module which shall interface with the alerter, ATC, and PTC vigilance monitoring systems as defined in TS 14.3 to cause penalty brake applications in accordance with the design of that system. The brake system shall report valid temporary and permanent suppression signals in accordance with TS 14.
12.19 ELECTRO-PNEUMATIC (EP) BRAKE TRAINLINES

Electro-pneumatic (EP) brake trainlines shall be provided through each car. For intercar connections, the brake trainline wires shall utilize conductors in the door control and communication trainline jumpers as described in TS 5.5. Through the car, the brake trainline shall be carried in a separate conduit.

12.20 RESERVOIRS

Reservoirs shall be of adequate capacity on all cars. On cab cars, compressed air for the horn, bell, and sanders shall be recognized and additional main reservoir capacity shall be provided for this purpose and to permit fast recharge of the brake pipe. The capacity of the additional main reservoirs shall be no less than 49,000 cu. in. Horn and auxiliary air supplies shall be taken from the No. 2 main reservoir.

All reservoirs on all cars shall be designed and manufactured with drilled "telltale" holes in compliance with the requirements of 49 CFR 229. Air reservoirs shall meet the requirements of Section VIII for ASME Pressure Vessels and shall comply with all applicable FRA requirements. Reservoirs shall be supplied with permanently affixed stainless steel identification plates with engraved lettering. The plates shall identify the part number and test certification data, and such information shall be included in the car history books.

Reservoirs shall be sloped to drain to one end where a manual drain valve shall be installed. A drain valve guard shall be provided to protect each drain valve from damage from the ballast and other debris. The details of the size and installation of all reservoirs shall be approved by the Engineer. [CDRL 12-014]

12.21 WHEEL SLIDE DETECTION/CORRECTION CONTROL

A wheel-slide protective system shall be provided.

The microprocessor controlled wheel slide control system shall detect random, back to back, and synchronous wheel slides at all four (4) axles by means of inductive speed sensors at axle mounted toothed wheels. Slide correction shall be made on a per truck basis by a wheel slide control valve located as close as possible to the brake cylinder piping to the truck. The wheel slide system controlled braking shall not exceed the maximum jerk rate. Wheel slide protection shall be effective from any car speed down to five (5) mph.

The detection and control system shall be powered from the low voltage DC power system. An indicator and audio alert located on the Operator’s control cab console shall provide the status of the wheel slide correction.

12.21.1 Fail Safe

The slide system shall be fail safe such that any system’s failure mode shall render the slide system ineffective and shall not prevent the application of brakes at any rate less than desired. A separate fail safe timing and override of friction brake release on each truck shall also be provided. The dump valves shall be energized to dump and energized to lap. If an unsuccessful slide correction lasting five (5) seconds is detected, the system shall deenergize the dump valves.
The system shall operate over the full range of service braking and during emergency braking. During emergency braking as detected by a drop of brake pipe pressure below 50 psi, the dump valves shall be deenergized and remain deenergized until the car has come to a complete stop if an unsuccessful slide correction lasting longer than five (5) seconds is detected.

12.21.2 Wheel Size

The wheel-slide correction system shall function properly with differences in wheel diameter up to two (2) inches among the wheels of a vehicle but not on the same axle. The equipment shall be self-calibrating requiring no manual adjustment to compensate for wheel diameter variations.

12.21.3 WSS Speed Sensor

The axle speed sensors shall be of an approved service proven design for direct application to the bearing housing sensor basket. The sensor shall be fitted with an appropriate length lead terminated in a protective and waterproof potted connection at the sensor body.

12.21.4 Self-Test

The wheel slide system shall be equipped with a self-test feature for internal and external fault diagnosis. The wheel slide system shall report faults or defects that would prevent complete function.

The wheel slide system and component installation shall be submitted to the Engineer for review and approval. [CDRL 12-015]

12.22 PARKING BRAKE

A spring applied air released parking brake shall be provided using a sufficient number of truck mounted disc brake units capable of holding the worst case load of either an AW3 loaded cab car or AW3 trailer car indefinitely on a three (3) percent grade. Testing to verify this requirement shall be conducted using new brake shoes and pads. A manual mechanical release for each truck's parking brake shall also be provided. The mechanism shall be protected from damage by debris. The released state of the manual mechanical release shall be visible and verifiable from either side of the vehicle. Operation of the mechanical release shall not require the use of a tool and shall not require more than 15 pounds force to operate. Access for the manual release mechanism shall be from both sides of the vehicle. The brake shall automatically reset to the normal operating condition when air brakes are reapplied after use of the mechanical release feature. Moving the unit dead in tow shall not require any special operation other than moving the parking brake control to the release position assuming the air system is charged.

The parking brake function shall be activated and deactivated at each car by means of a switch in a locker at the B-end. A SEPTA approved method of cutting out individual parking brakes on the vehicle shall also be provided from the exterior. The cut-out state of a truck parking brake shall be visible from either side of the vehicle.
A parking brake applied indicator light shall be provided on each side of each car and in the B-end vestibule. The design and operation of the parking brake system shall be submitted to the Engineer for review and approval. [CDRL 12-016]

### 12.23 BRAKE TEST RACK

The Contractor shall provide a railroad industry standard AB type test rack for testing the brake equipment. The Contractor shall also provide three (3) sets of any cables, hoses, adapters, fittings, and any other necessary test equipment to perform testing of the pneumatic components as well as electro-pneumatic and logic driven components. The design and operation of such test equipment shall be suitable for SEPTA’s use. Test procedures shall be provided by the Contractor to SEPTA for testing and maintaining each vehicle type’s brake equipment. [CDRL 12-017]

### 12.24 CONTRACT DELIVERABLE REQUIREMENTS LIST

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13 COMMUNICATION SYSTEM

13.1 GENERAL

The Contractor shall provide a complete and functional communication package for each car. Each communication package shall be comprised of the following units:

a. Public Address System (PA)
b. Crew Intercom System (IC)
c. Communicating Buzzer System
d. Passenger Emergency Intercom System (PEI)
e. Train Radio System (TR) – cab cars only
f. Destination Sign System
g. Paging System
h. Train to Wayside Communication Equipment (TWC)
i. LCD Graphical Displays
j. Onboard Video Surveillance System (VSS)
k. Automatic Passenger Counting System (APC)
l. Dynamic Advertisement System
m. Automatic Vehicle Location System
n. Passenger WiFi System
o. Audio Frequency Induction Loop System

Details of the design, equipment, arrangement, and installation of the complete communication package shall be submitted to the Engineer for approval during the design review process. [CDRL 13-001]
The communication system shall permit the train crew to make announcements and to page the passengers and other train crew members by use of the speakers in the passenger areas of the cars. It shall permit two-way radio communication between the train crew/Operator and other trains and wayside installations. It shall permit private two-way intercommunication between any two (2) or more communication control panels within the train, e.g. between train crew and Operator. It shall also accommodate recorded or digitized human speech messages for announcements or other passenger information in accordance with the requirements of 49 CFR 38 and enable announcements to be interfaced with the interior destination sign for visual broadcasting. Passengers shall have the capability to communicate with the train crew members via the passenger emergency intercom system. In addition, the system shall be capable of receiving and displaying on the interior signs arbitrary text messages addressed to the passengers and/or crew (paging system). Each cab car shall include capabilities to record all PA announcements. The communication system shall also provide for transfer of data between the train and wayside installations using an LTE modem and/or via an IEEE 802.11ac wireless LAN or the latest available technology based on IEEE 802.11 at Notice to Proceed. Trainline audio communication shall be backwards compatible with existing SEPTA cars. The PA/IC functions shall be included in the door and communication trainline system and implemented in the digital train network (DTN). All cabling shall be shielded twisted pairs capable of digital communication transmission. The communication package components, which comprise the PA, IC, PEI, destination sign system, paging system, LCD graphical display, onboard video surveillance system, automatic passenger counter, and TWC equipment, shall communicate via the car and train Ethernet network.

The communication system shall utilize audio for trainline transmission of voice signals along with conventional baseband audio trainlines for backward compatibility with older SEPTA rolling stock.

The communication system described herein shall be powered from the 74 VDC low voltage power supply directly through the communication system circuit breakers and shall be capable of operation within the voltage range specified in TS 2.2.7.2.3. The PA, radio, and TWC equipment shall be provided with separate circuit breakers. Apparatus requiring power conversion devices because of voltage range requirements shall have those devices designed integral to the apparatus. Power conversion devices external to the apparatus shall not be acceptable. Power conversion devices shall not be damaged or operate improperly at voltages below 55 VDC.

Suppliers of the communication system shall have proven experience in the successful design and manufacture of apparatus of this type for similar railcar application, and the Contractor shall follow the manufacturer’s recommendations for its installation.

All apparatus furnished under this Section shall be capable of operation without damage in the environment as specified in TS 2.2.5 with the car heating and air conditioning systems inoperative.

The functionality of the communication system described in this Section shall be exposed for future system modifications and upgrades through a defined and verified open application programming interface (API). Functions to be exposed by the API include control and monitoring of all system components.
The variety of audio and visual messaging possible through the communication system shall be prioritized. The system shall be capable of the preemption of higher priority announcements and allow depending on the situation the repetition or cancelation of certain announcements. The message priority and system function when conflicts occur shall be submitted to the Engineer for approval. [CDRL 13-002]

At a minimum, the following message types shall be considered in the prioritization structure:

a. Manual announcements by crew  
b. Announcement of PEI activation  
c. Public address paging from the wayside  
d. Automatic announcements  
e. Triggered train wide and public announcements

13.2 PA SYSTEM

13.2.1 General

The PA system shall allow one way communication between the train crew and the passengers via interior and exterior speakers. The PA system shall provide clear intelligible audio with a constant audio level regardless of the position of the audio source within the train. It shall incorporate an automatic volume adjustment feature to compensate for ambient noise conditions. The amplifier shall allow announcements as internal only, external only, external single sided, or all. Announcements shall be trainlined to all cars in the train to be routed to interior or exterior speakers as appropriate.

The PA system shall include microphones, amplifiers, speakers, associated wiring and other circuits, and, when operating shall have the following performance characteristics:

a. Frequency response: +/-5 dB minimum from 250 Hz to 8,000 Hz  
b. Total harmonic distortion (THD): less than one (1) percent over the entire frequency range  
c. Signal to noise ratio: > 40 dB

The PA amplifier shall include a three band equalizer adjusted during the PA system qualification test to qualitatively adjust the PA system frequency response. The center frequencies of the three bands of the equalizer shall be 250 Hz, 1000 Hz, and 3500 Hz. Each band would have a Q factor of 1.5 and an adjustable gain of $\pm 12 \text{ dB}$. The PA system (from the input of the microphone to the output of the interior speakers) shall have a 90 percent intelligibility rating when tested according to ANSI S3.2-1989 (R1999), Method for Measuring the Intelligibility of Speech over Communication System.

Each PA announcement made by a crew member shall be recorded and stored digitally in the cab car and/or locomotive. The announcements shall be digitally recorded, vox controlled, and stored in non-volatile memory. The storage memory shall have sufficient capacity to store not less than eight (8) hours of PA announcements with memory organized on a “first in first out” basis. The information shall be capable of being accessed using the methods described in TS 16. The system shall permit the downloading of announcement information to a PC by USB flash memory device or by the TWC system defined in TS 13.10. The TLDS shall maintain the following information for each PA announcement:
Southeastern Pennsylvania Transportation Authority  
Multi-Level Car Technical Specification  
Section 13  
Communication

13.2.2 Amplifier

The public address amplifier and spike suppression filters shall be mounted in an approved location in each car. The unit shall be completely solid state with modular construction.

The unit shall have a minimum output of 25 watts. The gain controls shall be adjustable and installed in a well-defined location with restricted access in the amplifier enclosure. The amplifier unit shall be complete with transient filtering capable of withstanding 2.5 kV peak pulse with total energy of 50 watt seconds.

The amplifier shall produce a minimum compression range in the microphone and circuits of 18 dB with a maximum output level variation of two (2) dB and a maximum total harmonic distortion of three (3) percent at the compressor output. The amplifiers shall be designed such that the audio output to the trainlines and speakers shall have a consistent level when the Operator's mouth is between two (2) and 12 inches from the microphone. The line amplifier shall be capable of delivering a minimum of +20 dBm into an impedance of from 200 to 600 ohms with less than one (1) percent total harmonic distortion.

The PA amplifier shall incorporate an automatic output level adjustment to ensure that the messages are heard by the passengers over the ambient noise level within the car. The automatic output level adjustment shall be capable of maintaining an audio output at a configurable value initially set at ten (10) dB higher than the ambient noise level for all car operating conditions. The automatic output level adjustment shall make use of sensing microphones located within in the passenger compartments. Use of the interior speakers as ambient noise sensors shall be prohibited. As a minimum, the system shall include four (4) sensing microphones: one (1) on each intermediate level, one (1) on the upper level, and one (1) on the lower level. The ambient noise level shall be sampled immediately before each PA announcement is initiated. The sampling method and location of sensing microphones shall be subject to the approval of the Engineer. [CDRL 13-004]

The design, material, and workmanship of the amplifier and its application shall be subject to approval of the Engineer. All terminals and wires shall be properly identified. With speech input, the amplifier shall operate continuously with full output at rated input voltage without damage to components.
13.2.3 Speakers

A minimum of eight (8) speakers shall be installed in each ceiling of the upper and lower passenger levels, and four (4) in each intermediate level area of each car. They shall be evenly spaced longitudinally and alternately mounted on opposite sides of the ceiling. The location and number of the speakers shall be such as to provide a uniform audio level throughout each passenger compartment. A minimum of two (2) external speakers shall be provided on each side of the car. The location and number of speakers shall be subject to the approval of the Engineer. [CDRL 13-005] A minimum of one (1) speaker shall also be installed in each end vestibule. All speakers shall be arranged in such a manner as to eliminate feedback as a result of an active microphone.

The speakers shall be connected in parallel with uniform polarity (in phase) to a pair of wires from their respective amplifiers.

Each speaker shall be mounted behind a flush baffle in the car ceiling by means of screws and hinge fittings or screws only. The speaker installation shall be arranged such that speakers can be removed and replaced by removing the baffle without disturbing ceiling panels. The baffle shall be integrally colored to match the decorative treatment of the car. Speakers shall be secured with tamperproof screws.

Wiring for the speaker system shall conform to the requirements of TS 17.18 and TS 17.19. Fusing of the speaker distribution system shall not be allowed.

The speaker shall be of the direct radiating permanent magnet field type capable of handling up to ten (10) watts of audio power. The nominal axial sensitivity shall be at least 92 dB at four (4) feet with one (1) watt input. The speaker shall have a wide dispersion characteristic.

All speaker assemblies shall consist of a low profile speaker and a 70 volt line matching transformer rated at four (4) watts with taps at one (1), two (2), and four (4) watts. The secondary of the transformer shall properly match the voice coil of the speaker. The primary of the matching transformer shall be connected to the speaker distribution wires by means of a two (2) conductor lead which shall be provided at one end with a keyed connector or approved equal which shall plug into a matching connector in the speaker distribution circuit mounted in the ceiling. The transformer end of the lead shall be arranged to permit connection or reconnection of the conductors to any taps.

The speakers shall be phased so that when the primary is connected to the distribution line according to the labeling, all speaker cones will move in the same direction at the same time. The speaker shall have a one (1) piece stamped steel frame with an outside diameter of approximately six (6) inches and shall mount to a flat baffle with four (4) equally spaced slots or holes. The overall depth shall not exceed 4 inches. The cone, voice coil assembly, and suspension shall be moisture resistant. All ferrous metal parts shall be made rust resistant by plating.
Speakers located adjacent to the communication control panels or the control head shall be disconnected during PA transmission to prevent feedback. The speaker shall be protected by a metal or plastic enclosure. The enclosure shall adequately protect the speaker from the effects of dust, moisture, magnetic materials such as steel filings, or other foreign objects. The protective enclosure shall be rustproof. It shall mount on the speaker baffle completely enclosing the speaker from the rear. The enclosure shall include knockouts and gaskets for the dust tight entrance of the speaker connection leads. The enclosures shall be so constructed that no mechanical resonance or vibration occurs.

The speaker baffle and enclosure shall be supplied by the same manufacturer.

Each interior speaker shall be protected by a stainless steel or plastic enclosure designed to adequately protect the speaker from the effects of dust, moisture, ferrous materials or other foreign objects. The enclosure shall include knockouts and gaskets for the dust tight entrance of the speaker connection leads and shall prevent mechanical resonances or vibrations from occurring. The speakers shall be mounted behind an approved flush baffle of stainless steel satin finished metal or integrally colored plastic material, matching the decorative treatment of the car. Matching tamper-resistant stainless steel mounting hardware shall be used. The mounting of the interior speakers shall be aesthetically pleasing and allow easy removal of the speaker for repair or replacement.

The exterior speakers shall be mounted behind a strong stainless steel grille resistant to thrown objects. There shall be waterproof, dynamic reflex horn, or engineer approved alternative, designed for extreme outdoor environmental conditions, and the front surface of the horn shall have a gasketed flange for flush mounting into the carbody. The mounting of the external speakers shall not allow water to leak into the carbody, shall be aesthetically pleasing and allow easy removal of the speaker for repair or replacement. The speaker locations and grilles shall not violate the outline limits defined in this Specification. The exterior speakers shall be immune to the chemicals and detergents normally used during vehicle washing and shall not interfere with or damage the mechanical car wash components.

13.3 COMMUNICATING BUZZER SYSTEM

A communicating signal buzzer shall be provided in the operating compartment of each cab car, one (1) at each door control panel on each side of each end of car vestibule, one (1) on the ceiling of each side of each quarter point door vestibule, and one (1) on the exterior of each side of each end of car vestibule near the stepwell. The buzzers shall be trainlined, and all locations shall be connected through a car relay which is connected to the trainline. The signal buzzer trainline shall include surge suppression to prevent the generation of any electrical noise in the trainline. The communicating signal buzzer shall be operated by any of the communicating signal buzzer push buttons anywhere in the train consist without the use of a key.
In order for the crew to ascertain that the signal buzzer button has functioned properly and to communicate with other members of the crew, an electronic buzzer shall be located near each buzzer button. All buzzers shall have tone and volume sufficient (approximately 88 to 92 dBA) to be readily audible under high noise level conditions such as a passing freight train. Buzzers shall be an electronic static type with an input voltage of 55-90 volts and with parts floated to isolate grounds and potted to resist moisture. Voltage below 55 volts shall not degrade or damage the communicating signal buzzer. The tone of the signal buzzer shall be different from that of the trainline door closing auditory warning described in TS 6.11.3 and any other tone and shall sound like the existing mechanical buzzer used on SEPTA’s Silverliner V cars.

13.4 PASSENGER EMERGENCY INTERCOM SYSTEM

Each car shall have a passenger emergency intercom (PEI) system to allow two way communication between passengers and train crew. There shall be a PEI panel located in each level of the car.

When a passenger activates the PEI, a visual indicator on the PEI shall flash in the active cab and on the Communication Control Panel (CCP) until the crew acknowledges the call at which time the annunciator on the PEI shall constantly illuminate. The annunciator shall be large enough for crew members to easily identify an active PEI station. Activating the PEI station shall notify the crew of the car number audibly in all cars via the PA system and the location of the active PEI station visually on the communication control panel in all cabs.

Each cab and CCP shall be equipped with two (2) passenger emergency intercom system momentary contact pushbuttons or rocker switches identified as "Passenger Intercom Push-to-Talk" and "Passenger Intercom Reset". The reset switch shall also be illuminated. When a passenger presses the pushbutton on the passenger emergency intercom, it shall cause all "reset" switches to illuminate and also sound a distinct chime signal to alert the crew. It shall also cause the passenger intercom station to latch on allowing the passenger to both speak to and hear the crew without having to continue to depress the pushbutton. The crew shall use the "Press-To-Talk" button in the console area in conjunction with either the crew communication panel’s internal condenser microphone or the external lapel microphone to talk to the passenger and shall hear the passenger over the monitor speaker. Simultaneous activation of all passenger intercom stations of a train shall be possible. When communication with the passenger has concluded, the crew shall depress the "Reset" pushbutton to reset (unlatch) all energized passenger emergency intercom stations; when this occurs, the indicator within the "Reset" pushbutton shall be extinguished.

Details of the design, installation, arrangement, and location of the PEI panels shall be submitted to the Engineer for approval during the design review process. [CDRL 13-006]

The PEI panel shall be vandal proof and shall include:

a. A flush mounted microphone and intercom speaker behind a perforated vandal proof grille
b. A push to call push button – When the PEI panel's push button is depressed, the PEI lights on all communication panels in the consist shall flash, the audible signal shall be activated, and an annunciation of the PEI request and car number be made through the PA system. A distinctive tone shall be sounded in the cab when a signal is initiated from the PEI system. The push to call push button should be of a design which is recessed to avoid accidental engagement.

c. An LED to indicate to the passenger that a call has been placed. The LED shall flash when the push button is pressed and shall change to steady illumination after the call is answered by a crew member.

d. Operating instructions and car number shall be provided adjacent to the panel in photo luminescent material per APTA-PR-PS-S-001-98 and TS 4.11.2.1.1.

13.5 CONTROL PANELS

13.5.1 General

Each trailer car shall be equipped with two (2) communication control panels: one (1) located recessed into each end of car vestibule partition. Each cab car shall be equipped with three (3) communication control panels: one (1) located recessed into the end of car vestibule at the B-end, one (1) located on the Operator's cab console per TS 13.5.3, and one (1) located at the F-end intermediate area near the door control panel.

Components, which do not require the attention of the Operator, shall be mounted in the equipment locker adjacent to the cab and shall be accessible for maintenance and servicing.

The microphone shall be designed to assure low feedback and attenuate background noise. The speaker or speakers closest to each control panel shall be muted as necessary to limit the available feedback.

The installation and protection of the wiring to the control panel shall be approved by the Engineer.

13.5.2 Non-Cab Communication Control Panel

Each non-cab communication control panel shall be located at an approved height above the floor. Each communication control panel shall include:

a. A flush microphone and intercom speaker mounted behind a vandal proof perforated grille

b. A flush mounted coach key operated selector switch with four (4) positions

c. “PUBLIC ADDRESS”, “INTERCOM”, “PASSENGER EMERGENCY”, and “OFF”. The key shall be removable in the "OFF" position only.

d. A “PEI Activated” light
The key switches shall be activated by SEPTA’s standard coach key. Wherever a switch is operated by SEPTA’s standard coach key, the tumbler shall be set back at least 0.5 inch from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver or similar device.

13.5.3 Cab Communication Control Panel

The cab car shall have a communication control panel in the cab located on the Operator’s left vertical indicator and switch panel. It shall be within easy reach of the seated Operator. The cab communication panel shall include:

a. A flush mounted microphone for radio/PA/intercom/PEI mounted behind a vandal proof perforated grille

b. A 12 channel control head conforming to AAR part 12-10, Figure 1210-5, with LED display corresponding to a selected channel and channel bank

c. Radio speaker volume control (25 percent to 100 percent of full volume)

d. LED indicator showing in system activated and mode in use

e. Radio/PA/intercom/PEI push buttons (When held in radio, PA, PEI, or intercom position, it shall allow the Operator to talk over the radio, PA, PEI, or intercom system respectively.)

f. A “PEI Activated” light

The cab communication control panel shall be energized by insertion of a standard coach key in the cab communication control panel. It shall also be energized when the key is inserted into the master controller in the operating cab. The intercom shall function without a key in both active and non-active cabs.

The train radio communication mode shall be the highest priority in the event of a communication system failure. The cab communication control panel shall directly connect the microphone, PTT button, speaker, and any other required components directly to the radio in such an event.

13.6 TRAIN RADIO

13.6.1 Description

Each cab car shall be equipped with a Ritron RCCR-151 “Clean Cab Radio” radio meeting AAR 12-10 Standards with PA/IC interface or approved equal. Radio units shall be shipped separately from the cars. Instructions regarding shipment will be furnished by SEPTA. The radio shall be interchangeable with SEPTA’s existing locomotives and cab cars and shall embody the following requirements:
a. The radio shall meet or exceed all applicable FCC and AAR requirements and be designed for AAR tray mounting (including all captive wingnuts to fix the radio to its mounting base). All electrical tests shall be either referenced to a specific test procedure or shall be described in full by the manufacturer. The equipment shall be capable of operation without significant degradation when subject to the applicable temperature, shock, humidity, and vibration tests set forth in EIA Standards RS-152-B and RS-204 and AAR Specification 12-10.

b. The radio unit shall be designed to operate from the 74 VDC low voltage power supply. The power source shall not be dependent on the proper functioning of any other communication system component and shall be powered from a dedicated independent circuit breaker.

c. Radio circuitry shall include a time out feature to prevent inadvertent lockout of the transmitter and receiver.

d. Transient filter protection shall be designed as an integral part of the radio and shall provide adequate protection from transients of the type encountered in commuter car and locomotive applications.

e. The radio unit shall be fully synthesized and capable of utilizing all AAR frequencies.

The radio’s channel selection and operating modes shall be programmable by a laptop computer. Radio disassembly shall not be required to connect the computer to the radio unit for programming.

A cab car radio shall be energized by two (2) distinct ways otherwise the radio is powered down:

1) Activation of the cab with a master controller key
2) Activation of the cab MDCP communication crew key switch

The incoming radio message shall always be heard from a dedicated radio speaker while the radio is energized. The IC and PEI incoming message shall be heard from the cab CCP. The CCP speaker monitor mode shall be enabled at the same time the radio is energized. Gain control independent of gain control related to PA, IC, and PEI functionality shall be provided for the interface between the radio and the radio speaker.

f. It intended that the integrated radio transceiver be flush mounted at the base of the left side cab console panel, using a slide-out mounting. Sufficient cable slack shall be provided for ease of servicing or replacement. The radio transmit control shall be by means of a dedicated pushbutton located on the right side of the cab center console outboard of the brake controller, arranged for ease of Operator use by the right hand. All other control over the radio transceiver shall be performed by use of the radio faceplate controls and indicators. If possible, the radio faceplate transmit pushbutton should also be kept functional, for redundant/left hand operation.
13.6.2 Performance Specification
The radio shall meet the design criteria as given in the AAR Communication Manual (12-10), reaffirmed in 1991, pages 1-20.

13.7 ANTENNA
A GE 25 AN-1 "Sinclair" Model Excaliber ST221 low profile type antenna including Times Microwave Systems LMR-400 FR solid core conductor for VHF radio antenna coaxial cable application running from the antenna to the adjacent radio shall be provided. No angle connectors shall be used. A voltage standing wave ratio (VSWR) of 1.5 or better shall be required after installation. The antenna shall be mechanically grounded to the carbody through a copper or similar conductive metal between the antenna and its mounting. The antenna lead shall pass through the roof by means of a one (1) inch pipe of the same material as the roof. The pipe shall extend up to the antenna base and be welded completely to both the roof and the base of the antenna. No air or moisture shall enter or escape through the antennae lead roof penetration.

13.8 DESTINATION SIGN SYSTEM

13.8.1 Equipment Description
An electronic destination sign system shall be installed on each car. It shall comply with all of the requirements of 49 CFR 238, IEEE P1477, Draft Standard for Passenger Information System for Rail Transit Vehicles or latest revision, and referenced IEEE Standards IEEE 100-1996, IEEE P1473, and IEEE P1482. The character height shall be three (3) inches – four (4) inches. The system shall meet or exceed all ADA requirements.

The exterior signs shall display route type (Express, Limited, etc.) and destination information as well as public relations messages all under the control of the Operator or train crew. The technology use shall be backlit full color LCD (using high intensity LED backlighting to be visible in bright sunlight), RGB high intensity LED, or other Engineer approved equivalent full color display.

The exterior destination sign message shall be sufficiently sized (minimum height of 3 inches) to allow a person with normal vision to identify the destination and route type text on the front exterior sign at a minimum distance of 150 feet and each side exterior sign at 50 feet. All signs shall have readability at a 65 degree angle on either side of a line perpendicular to the center of the mean plane of the display. Cycling of input power to the destination signs shall not cause the sign to display a fault mode or self-test mode. The sign shall automatically resume normal display without Operator intervention. Each destination sign assembly shall be placed in dustproof water resistant housing. The housing shall allow easy access to all routine maintenance functions including the cleaning of the display face(s) of the unit.

Cab cars only shall have one (1) 20 character (minimum) external front destination sign.

All cars shall have four (4) 20 character side destination signs with three (3) inch character height for viewing from the exterior of the cars.
All cars shall have six (6) 15 character full color LED signs with three inch character height for viewing from the interior of the cars. If a three inch character height cannot be accommodated because of space limitations, an alternative character height sign may be used if approved by the Engineer. The Contractor shall demonstrate that the signs are visible from the different interior locations of the cars.

All cars shall have eight (8) graphical display interior message signs in each car. Due to anticipated placement constraints, two (2) sizes shall be utilized. Four (4) of the interior graphical display message signs shall be 19 inches measured diagonally or larger. The remaining four (4) screens shall be 30 inches measured diagonally or larger. Both sizes shall use a backlit full color LCD (using high intensity LED backlighting) or other Engineer approved equivalent full color display and shall have the capability of displaying graphics, images, and text with Engineer approved character size. Alternate sign arrangements may be proposed. The interior signs shall have the capacity when desired to scroll large messages such as preprogrammed emergency or public relations messages. In addition, the interior destination sign system shall be configured (including preinstalled low loss carbody wiring) to permit connection to the existing wayside active messaging system for advertisements, current news, and other information as per TS 13.16. Details shall be submitted to the Engineer for approval during design review. [CDRL 13-007]

Maintenance personnel shall be able to command an LED test pattern to be displayed on any sign from the MDS.

### 13.8.2 Location of Equipment

The externally viewed side signs shall be located as approved by the Engineer: two (2) on the right side and two (2) on the left side of each car. The opening shall be glazed, and the glazing shall be secured with a neoprene glazing strip. A housing compatible with the interior design with a hinged cover shall be provided on the interior of the car. Approved fasteners shall be provided to secure the access door. The hinged cover shall be large enough to allow troubleshooting and removal of the sign assembly without disturbing or removing the glazing assembly.

The externally viewed front sign shall be located above the Operator’s cab as approved by the Engineer.

The internally viewed full color LED text signs shall be installed in wall panels at an approved location for each passenger compartment. There shall be one (1) sign on each intermediate level, two (2) signs on the upper level, and two (2) signs on the lower level.

The sign control unit on cab cars and trailer cars shall be incorporated into the MDS system as approved by the Engineer. The Operator’s display keyboard functionality for the destination signs shall be integral to the MDS located in the locker adjacent to the quarter point doors on all cars. The system shall be arranged and integrated to permit authorized personnel only to access the Operator’s display keyboard functions for programming, troubleshooting, or reviewing messages, and the message data base. The keyboard shall be placed at a suitable height for easy operation.

A connector shall be provided adjacent to the CCU and behind the access door to facilitate the connection of a portable memory transfer unit.
13.8.3 System Operation

The system shall be operated from any MDS display unit of any car in a train. The control of the message display throughout the train shall be accomplished over a digital trainline network. It shall be possible for only one (1) MDS display unit on the train to be in use at any given time to select messages. It shall be possible to program all side signs, interior signs, and front signs with different messages from any MDS display unit. It shall be possible to command all destination sign screens in a consist to enter a timed “test pattern” mode as a way of validating screen operation outside of revenue service when requested from the MDS. Provision shall be made to enable the system to be automatically operated from a remote source such as central control, radio, or automatic vehicle location system. The same provision shall allow simultaneous activation of a pre-recorded voice message over the PA system as described in TS 13.2. In order to change messages, an access code shall be required. The sign system shall be operational whenever the 480 VAC trainline is energized. The design of the destination sign system including location and operation and interface control documents shall be submitted to the Engineer for review and approval during design review process.

The Contractor shall provide all details of the hardware, firmware, software, and interfaces for all system, system components, and system equipment to allow SEPTA to replace the destination sign system and any of its components in the future without any changes to its operation with the MDS. [CDRL 13-008]

13.8.4 Memory Transfer Unit

A standard PC shall be used to update the message listing and all memory devices in the sign control units in each car through the use of a USB flash memory card. It shall also be possible to update the system through the TWC system and the DTN/DCN.

Software programs shall be provided which shall enable authorized SEPTA personnel to change the message and voice databases using a standard PC. The software shall be capable of creating special graphic characters. The message listing created in the computer shall be transferred directly to each sign control unit via a USB flash memory card or the TWC system as described above.

13.8.5 System Components and Wiring

All components and wiring shall meet the requirements of TS 17.18 and TS 17.19. Where required to prevent interference, shielded twisted pairs of wires shall be used. The power supply shall be capable of operating within the voltage range specified in TS 2.2.7.2.3. All antennas shall be mounted per the requirements of TS 13.7.

13.9 Paging System

A paging system shall be provided to permit wayside personnel to transmit arbitrary text messages to the train for display to the passengers or crew. The paging system shall use the TWC equipment to receive the page messages. Page messages shall be transmitted to all cars via a digital trainline network.
13.10 TRAIN TO WAYSIDE COMMUNICATION

Train to wayside communication (TWC) equipment shall be provided on all cab cars. The TWC equipment shall provide the following functions as a minimum:

a. Transfer of consist monitoring and diagnostic data from the train to the wayside
b. Transfer of train status information from the train to the wayside
c. Remote troubleshooting of the locomotive and car systems
d. Transfer of sign database updates from the wayside to the train
e. Transfer of software updates from the wayside to the train
f. Transfer of paging system messages from the wayside to the train
g. Transfer the trigger of train wide public and special messages to the communication system
h. Transfer of onboard dynamic advertising content

Communication among locomotives and cars and the TWC equipment shall be by means of the onboard Gigabit Ethernet DTN. Communication between the train and wayside installations shall use one (1) of the two (2) vehicle borne TWC “channels”, i.e. LTE communication or wireless LAN depending on service availability. Wireless LAN shall be the preferred communication medium. LTE shall be used in areas where wireless LAN communication is not available. It shall be possible to send and receive all data on either of the two (2) TWC channels.

Within each car, the system shall interface with the onboard Gigabit network (see TS 15) to achieve the specified functionality. A TWC gateway apparatus shall provide the interface between the onboard Gigabit network and the wireless bridge that will be cabled to the appropriate antenna assembly (e.g., MIMO) offering optimum performance for communicating with the wayside WLAN access points and the WWAN network. The TWC gateway shall be extensible providing an interface which will allow systems, which may be integrated into the Gigabit network, the ability to communicate via the WWAN and WLAN.

The TWC equipment shall be implemented using an approved operating system suitable for the application and environment. The wireless LAN shall conform to IEEE Standard 802.11ac or latest WiFi variant at NTP. Both the wireless LAN channel and the LTE channel shall implement end to end security in all connections to the wayside installation by means of an IPSec VPN. Both TWC channels shall use a mobile IP client. The Contractor shall provide the wireless LTE data subscription for all equipped cars throughout the full term of the Contract (last car out of warranty). The proposed carrier and network coverage shall be submitted to the Engineer for review and approval. [CDRL 13-009] The implementation of the two (2) TWC channels and the security implementation must be approved by Engineer to assure compatibility with its wayside installation including the wayside installation and service provider of the LTE cellular network. [CDRL 13-010]

13.11 RADIO AND COMMUNICATION INTERFERENCE

The Contractor shall submit a communication system design plan that describes the communication system and the criteria used for each system to mitigate potential interference problems during:
a. Concept development  
b. Design development  
c. System qualification testing  
d. Systems integration into the vehicle  
e. Integration of the vehicle into the SEPTA system

The Contractor shall ensure that the communication equipment including, but not limited to, train radios, hand held radios, and public address and intercommunication systems are free from onboard and external caused interference. For intercommunication, SEPTA uses a car borne intercom, car borne radios, handheld radios, and cellular telephones. The application of control components such as filtering, shielding, and bonding shall conform to sound engineering practices and industry standards and shall be an integral part of the car system. Potential interference sources such as electric buzzers and other trainline signals shall be considered and adequately suppressed.

The Contractor shall develop the plan in conjunction with the EMC plan and shall submit the plan within 120 days following the Notice to Proceed. [CDRL 13-011]

The Contractor shall perform and interoperability study to ensure that no antennas interfere with each other. [CDRL 13-012]

13.12 AUTOMATIC VEHICLE LOCATION SYSTEM

The Contractor shall supply a complete system to have the interior destination signs display information identifying the next regular stop on the selected route. This shall consist of the interior signs giving visual identification of the next stop (using several screens if necessary) with a simultaneous automatic public address announcement using the interior speakers of the next stop along with connecting transit routes and points of interest. Upon arrival at the stop, the exterior speakers shall announce the vehicle route and destination, and the interior speaker shall announce the stop. The system shall also allow the additional display without voice announcement of up to 50 supplementary emergency or public relations messages. The signs shall alternate between display of the supplemental message and station stop information. Selection of all automatic announcements and supplementary messages shall be under the control of the Operator and train crew. All interior and exterior voice announcements shall simultaneously announce on all cars of the train through the PA. The current local time shall be displayed on the interior signs at least once between each station stop.

A switch to disable exterior announcements during the trip shall be provided. In addition, the system shall be capable of being programmed by SEPTA personnel to reduce volume and/or disable exterior announcements at select stations or during selected hours of the day.
In order to synchronize the sign displays and voice announcements to the proper location, the Contractor shall provide an automatic vehicle location system (AVL) system. The system shall use a global positioning satellite system (GPS) enhanced by utilizing the wide area augmentation system (WAAS) and a dead reckoning system for operation within the 1.5 mile Center City Commuter Connector Tunnel plus other short highway overpass sections which will provide the geographical location of the vehicle. The system shall use satellite ranging to determine position on a geographic coordinate system. The position information shall be correlated to a database containing the various routes, location triggers, announcements, and other required information. The SEPTA Railroad Division operation has 300 end to end one way route miles.

The system shall include a vehicle location control panel as well as provisions for the entry of an employee I.D. number. When the Operator activates the train, the Conductor or Operator will enter the route number and train number into the vehicle location control panel. The system shall use this information for next stop announcements and to determine schedule adherence. The vehicle location control panel shall include a small display. The route and current location in SEPTA's Railroad Division terminology shall be displayed along with the train speed, current local time, estimated time to the destination, estimated arrival time at the destination or downtown terminals, and schedule adherence information. The system shall be configured to recognize various types of triggers to be used for vehicle location, stop, next stop, and public relations announcements along the route.

A method to disable GPS synchronization of the destination signs and automatic announcements shall be provided. This shall allow for the manual operation of the destination sign displays during out of service conditions (test trains, dead heads, etc.).

Updates to the location database and system software shall be by the use of a Microsoft Windows laptop computer with an approved PTE port, and updates to the database shall also be made using the wireless local area network and wireless wide area network. The system shall support partial updates and allow update resumption if WiFi or WLAN connectivity is interrupted. Updates shall be possible to be scheduled for either the WLAN or the WWAN or first available. Updates shall include an effectivity date allowing schedule updates to be preloaded for automatic activation at a later time. The system shall be capable of using the existing SEPTA sign and location database utilized for the SEPTA Silverliner V communication system. Alternative approaches to maintaining a singular sign and location database shall be submitted to the Engineer for approval. [CDRL 13-013]

Application software and hardware shall be supplied so that updates and changes can be made to the automatic vehicle location database including audio and visual announcements and graphics. Changes to the voice announcements made along the routes shall be by converting text to speech to form a voice message that can be saved to a new database for eventual downloading to each car. The sound quality of the converted message shall be the same as a prerecorded voice message. The software shall have adjustable sound parameters and characteristics to adjust the sound quality; all messages shall sound as if from the same voice. The system shall allow the addition of new location triggers with the accompanying voice announcement and sign displays. Updates to the database shall also allow independent updates to and the addition of new interior and exterior sign displays. The system for updating the data base and system software shall be user friendly and intuitive. The Contractor shall be responsible for developing the initial set of audio and graphic files for all SEPTA Regional Rail lines.
The system shall include a simulator mode which shall make it possible to view and enter routes or locations and simulate the operation of the train along the route via the laptop computer or the control panel. It shall be possible to play any voice message or display any sign message.

The Engineer in defining certain features shall permit the Contractor to offer various plans and/or methods of achieving the overall outcome and specific configuration of the system. The approval process shall be systems oriented.

The Engineer shall provide to the Contractor listings of all station stops for all routes in the SEPTA Railroad Division system. The Contractor shall prepare all mapping and survey work (location database) necessary to establish trigger points for all announcements, and prepare all software for complete operation. All mapping and survey work performed pursuant to this Contract shall be the property of SEPTA and shall be delivered to SEPTA in a format that is transportable and/or convertible in furtherance of SEPTA’s interests. The Contractor shall supply all required software and special equipment to SEPTA by a site license agreement as part of this Contract. The Contractor shall provide all source codes, mapping software and hardware to SEPTA which is required to make initial and future announcement changes, shall prepare and install all updates and revisions to the cars for the basic warranty period for each car, and shall disclose to SEPTA all required proprietary methods, software, tools, and associated equipment necessary to ensure the successful operation of the system. All required licenses required to permit SEPTA to operate, maintain, and modify the system for the lifetime of the car shall be included at no additional cost to SEPTA. There shall be no additional or reoccurring costs incurred by SEPTA for any software, documentation, or special equipment required to operate, program, update, change displays and/or announcements, and maintain the system as delivered. This shall include all software and hardware necessary to incorporate future changes and revisions in routes, destination displays, announcements, public relations messages, and so forth.

The system in all operating modes shall indicate vehicle location to within three (3) meters horizontally at 95 percent probability, and the WAAS enabled GPS system shall provide accuracy sufficient for track identification. The system and components shall be designed to permit integration with current digital and analog type radio systems and cell phone networks. The Contractor shall provide all source codes, mapping software, and hardware to SEPTA along with a complete bill of material. The Contractor shall disclose to SEPTA all required proprietary methods, software, tools, and associated equipment necessary to ensure the successful operation of the system. All aspects of the system shall be in compliance with the Americans with Disabilities Act as amended.

The system shall include a digital crystal controlled clock which shall permit periodic synchronization from the Global Positioning System used for the vehicle location and automatic passenger announcement system. The GPS obtained time shall be used for all system clocks on the train in UTC and shall be automatically adjusted to the local time for all train crew, passengers, or Operator displays and shall be displayed on the vehicle location control panel or moving map display.
13.13 AVL EXPANSION PROVISIONS

An automatic vehicle location (AVL) and announcement system utilizing an open architecture shall be supplied to provide for future expansions and upgrades to the system. The system shall be designed to easily add new functions and upgrades from different equipment manufacturers/suppliers. All input/output modules and control and data transfer protocols shall not be proprietary information and shall be provided to SEPTA at no additional cost or to other communication suppliers upon request to add expanded functionality. The protocol shall fully describe all parameters for control and usage of the data. There shall be no additional cost to SEPTA to fully utilize this information on the currently planned system and on future expansions. The system and components shall be designed to permit integration with current digital and analog radio and cell phone based data transmission systems.

Future expansions shall include, but are not limited to, the following:

a. Transmit train number, head end car number, consist configuration, location, direction, speed, date, time, and schedule adherence information to the SEPTA Control Center. This information will then be disseminated to a wayside passenger information system with displays at each station as well as being available to Control Center personnel. Information will be updated on a timed almost real time basis. Schedule adherence information shall also be available to the public via their personal cell phone and over the Internet and at stations on passenger information display signs. Data transmitted shall also include dead reckoning distance traveled from last known GPS position for continued position information in the tunnel or in case of GPS failure.

b. The system shall transmit different types of automatic alarms upon the bypassing or cut out of a system or the detection of certain failures. These alarms shall be stored and transmitted via the WLAN and WWAN systems. Alarm types shall be functional and shall include, but not limited to, an emergency alarm, ATC cutout and fire detected with the others as spares. When the proper circuit becomes bypassed or a failure is detected, the required alarm shall be transmitted without any actions being required by the Operator.

As an example, whenever an Operator uses the automatic train control (ATC) manual cutout switch, the radio shall transmit an alarm signal indicating ATC cutout and car number to the SEPTA Control Center.

The Contractor shall provide all source codes, mapping software, and hardware required to make initial and future changes to SEPTA and shall disclose to SEPTA all required proprietary methods, software, tools, and associated equipment necessary to ensure the successful operation of the system. All required licenses required to permit SEPTA to operate, maintain, and modify the system for the lifetime of the car shall be included at no additional cost to SEPTA including the above listed expansion plans.

13.14 AUTOMATIC PASSENGER COUNTING SYSTEM

The Contractor shall furnish and install an infrared motion analyzer based automatic passenger counting data collection system that shall collect, route, and export collected data to SEPTA’s computer network. It shall be the Contractor’s responsibility to integrate this system into the rail vehicle while adhering to the existing Specification and its intent unless approved otherwise by the Engineer.
The system shall be the InfoDev Series 400 Gateway Counting System or approved equal. The system shall be backwards compatible with SEPTA’s existing UTA Model 20 and UTA SmartSensor Systems unless approved otherwise by the Engineer. All export functions, end user interfaces, and reports shall function seamlessly among SEPTA’s existing wayside APC infrastructure.

Sensors shall be flush mounted with no exposed cables or wiring and must meet the 32 inches minimum clearance ADA requirement. The sensors shall accommodate both high and low station platforms. The sensors shall be arranged to obtain proper operation, and their location shall not reduce the door aspect/clear opening requirements of this Specification. The sensor arrangement shall prevent obstruction and accommodate routine maintenance and replacement.

The system shall store, organize, date and time stamp passenger counting events. To ensure timing accuracy, the system shall synchronize with the GPS clock. The carborne APC system shall store two (2) weeks of passenger counts at a minimum. Data transmissions are to occur via the WLAN and WWAN networks when available.

Authorized SEPTA personnel shall have the ability to access all data online and download all data to wayside PC based systems without the loss of storage and quality of data.

13.15  ONBOARD VIDEO SURVEILLANCE SYSTEM (VSS)

An onboard crash and fire protected digital video recording system (DVR) shall be provided to meet the requirements of the SEPTA video surveillance system (VSS). The video data acquisition system shall monitor and record data acquired from multiple onboard camera sources that shall be arranged to maximize the coverage of the vehicle and its operations. The onboard camera system shall have day and night vision/infrared capabilities and provide high quality color video. The system shall be compatible with SEPTA’s existing wayside video systems, and the Contractor shall be responsible for integration. To ensure timing accuracy, the system shall synchronize with the GPS clock.

13.15.1 Equipment Description

The system in operation shall provide adjustable frame rates necessary to avoid latency and/or frame loss that would cause discontinuity of motion and loss of apparent causal circumstance. SEPTA currently requires ten (10) frames per second.

All acquired data shall be written, stored, and encrypted. All data shall reside on the rail vehicle on a solid state drive (SSD) or hard disk drive (HDD) device that is designed and applied for the purpose of mobile data acquisition and storage.

Data acquired in this mode shall be high quality to allow monitoring personnel to view data that equals the quality of data written on the vehicle’s SDD/HDD device. Authorized SEPTA personnel shall have the ability to access all data online and download all data to wayside PC based systems without the loss of storage and quality of data stored on the vehicle’s HDD system.
13.15.2 Video Cameras

The quantity and location of video cameras shall be as follows:

a. One (1) outward facing camera shall be installed in the cab of each cab car

b. One (1) inward facing camera, having audio capability, shall be trained on the Engineer’s operating position in the cab

c. A minimum of eight (8) cameras throughout the passenger compartment to provide complete coverage of all passenger areas of the vehicle

d. One (1) camera trained on each door to be in addition to the cameras located throughout the passenger compartment

e. Installation and location of all cameras are subject to SEPTA’s approval

f. The Contractor shall be responsible for submitting to the Engineer for approval a coverage plan identifying the location, viewing angle, and details of the camera arrangement [CDRL 13-014]

13.15.3 Wireless Download

Wireless download shall be at 802.16 WiMax protocols. The transmission distance shall be a minimum of 1500 feet to be compatible with SEPTA’s existing WiMax infrastructure.

13.16 ONBOARD DYNAMIC ADVERTISING SYSTEM

The vehicle graphical interior messaging signs shall include dynamic advertising capabilities and integrate in with existing digital signage servers used for the SEPTA Silverliner V fleet. When the train is not displaying next stop information in full screen mode, a mixture of advertising and editorial/information messages will be displayed. The onboard system shall function in the same manner and have the same capabilities as the existing dynamic advertising system installed on the SEPTA Silverliner V fleet. The following provides a general overview of the system features:

13.16.1 Advertising Content Playback

a. Content Loop – the vehicle graphical message signs shall be capable of playing a content loop to be provided by the wayside digital signage server. When the station arrival information/system information messages need to play, playback of advertising and editorial content provided via the content loop should be paused. Ad/editorial content should playback from the beginning of the last message interrupted or continue playback with the next item if no interruption was required.

b. Content loop shall be based on playlists.

c. Content items shall have start times and end time attributes.
d. Content items shall be able to be played at specific times and time intervals.

e. The content loop shall be able to play a playlist:

1) In order
2) Random

f. Messages should be able to incorporate dynamic data.

### 13.16.2 Content Type

The onboard dynamic advertising capabilities shall be able to play a variety of content including: mpeg2, mpeg4, Flash, AVI, WMA, QuickTime movies, as well as JPG, PNG, BMP, and other standard graphics formats.

### 13.16.3 Dynamic Data

The onboard dynamic advertising system shall include the ability to connect to external sources via the train wireless networks to provide “fresh” data. The capabilities shall include:

a. News/Sports/Other Feeds – various types of data feeds employing RSS or other sources. Data shall be able to flow into premade templates. If data is stale or unavailable, the message should not play. If the data source is inaccessible, an alert should be raised.

b. Ability to connect to and display external content such as sports scores and weather reports through RSS feeds, XML, or flat file manipulation

### 13.16.4 Logging

The onboard dynamic advertising system shall include the ability to track system operation and ad execution:

a. General – logs shall be recorded in flat files, CSV, or other format that is easily digestible in a database based server environment.

b. Play – player will report log play activity. Play log will include date and time as well as asset played.

c. Status – player will log system status for the following:

1) Current settings
2) Link health
3) Uptime
4) Transfer status
5) Software/firmware versions
13.16.5 Player Communication

The onboard dynamic advertising system shall communicate with the digital signage server utilizing the onboard WiFi wireless system and the existing SEPTA wayside WiFi wireless network.

The following key tasks shall be performed:

1. Move content to players
2. Move advertising schedules
3. Move data to players
4. Fetch/modify player attributes
5. Transmit logs to server

The onboard dynamic advertising system shall implement the data encryption methods utilized by the wayside dynamic advertising server.

13.17 PASSENGER WIRELESS INTERNET (WIFI)

The Contractor shall furnish a complete Passenger Wireless LAN system on each vehicle to provide on train wireless Internet access. The passenger wireless Internet system and its installation shall be designed in a modular fashion to allow upgrades of all components throughout the anticipated service life of the vehicle. The proposed expected passenger bandwidth requirements, design, layout, and system capabilities of the passenger wireless Internet system shall be submitted to SEPTA for review and approval. [CDRL 13-015] The wireless LAN system shall be comprised minimally of the following components:

13.17.1 Wireless Aggregation Device

The passenger wireless Internet backhaul and management is to be provided by a wireless aggregation device selected by SEPTA during design review for Contractor purchase and installation. It is anticipated that this device will aggregate a variety of technologies (WiFi, WWAN) and/or carriers (e.g., Verizon, AT&T, T-Mobile, Sprint) to provide uninterrupted high quality Internet access throughout SEPTA’s right of way.

The wireless aggregation device shall be located in a locker in close proximity to the roof mounted antenna array with conduit leading to the roof location of the antenna array.

13.17.2 Roof Mounted Antenna Array System

The antenna array shall provide multiple elements for both cellular (LTE, CDMA EVDO, GSM HSPA+, etc., at the frequencies offered by carriers in SEPTA’s service area) and WiFi (for both 2.4 GHz and 5 GHz bands, all channels) to be connected to the wireless aggregation device for Internet backhaul.
The antenna array shall system include multiple elements capable of providing sufficient Internet backhaul for the growing bandwidth demand of passengers. At a minimum, it is expected that the antenna will include 3x3 MIMO antenna for WiFi and several LTE/cellular antenna elements to supply multiple cellular cards located within the wireless aggregation device. Required RF cabling and equipment (e.g., diplexers) to support diversity requirements of the wireless aggregation device manufacturer shall be provided and installed by the Contractor.

The mounting arrangement of the antenna array shall be of a waterproof design with conduit leading directly to the locker location of the wireless aggregation device.

The antenna array shall include a minimal lead length into the carbody with quick disconnect RF connectors to assist in replacement.

Coaxial cables of a type approved by the aggregation device manufacturer and compliant with relevant Sections of this Specification shall be provided to route the antenna elements to the locker area.

The antenna array shall be suitable for use in a rail environment which includes exposure to overhead catenary, harsh weather conditions, and debris strikes.

The roof mounted antenna array manufacturer and part number shall be submitted to SEPTA for review and approval.

13.17.3 Passenger Compartment WiFi Antenna and Access Points

A passenger facing WiFi network shall be provided by one (1) or more passenger compartment WiFi systems comprised of interior antennas paired with an access point.

These devices shall support the full capabilities of IEEE 802.11 a/b/g/n/ac and shall be arranged in the passenger compartment to provide full WiFi coverage throughout all areas of the car.

Two (2) Category 7 cables shall be routed in a dedicated conduit from the area containing the wireless aggregation device to each access point location to supply power (PoE) and network connectivity.

The passenger facing WiFi network hardware will be selected by SEPTA during design review for the Contractor’s purchase and installation.

13.18 AUDIO FREQUENCY INDUCTION LOOP SYSTEM

The Contractor shall provide a complete audio frequency induction loop system (hearing loop) assistive listening. The hearing loop system shall comply with IEC 60118-4:2006. The hearing loop shall broadcast all Public Address announcements (including manual, automatic, and wayside to train) throughout all passenger areas of the vehicle for passengers with TeleCoil or T-Coil equipped hearing aids. The design of the system shall incorporate techniques and technologies which eliminate potential interference, cross talk, or signal bleed such that the signal is not transmitted to passengers located in adjacent vehicles or otherwise outside the vehicle equipped with the broadcasting hearing loop. The Contractor shall incorporate appropriate signage indicating the vehicle is equipped with hearing loop technology. Alternate technology that offers the same level of accessibility may be used as approved by SEPTA.
The Contractor shall supply all diagnostic test equipment necessary to test and maintain the assistive listening system. This shall include a quantity of ten (10) field strength meters which meet the relevant commissioning requirements of IEC 60118-4:2006 as well as a quantity of ten (10) hearing loop receivers to allow SEPTA maintenance personnel to verify the performance of the assistive listening system. Appropriate methods shall be provided to properly test the hearing loop system (such as playing test announcements over the hearing loop system while muting the PA system).

The Contractor shall demonstrate that the signal levels required by IEC 60118-4 are met at all seats of the vehicle during the typical operation of the vehicle. The Contractor shall demonstrate that the magnetic spill from the hearing loop system is less than -32 dB peak in areas outside the vehicle (including station platforms and vehicles on adjacent platforms).

The Contractor shall submit the design of the hearing loop system to the Engineer for review and approval. [CDRL 13-016] The design submission shall include:

- Details of the hearing loop driver
- Methods used to adequately address crosstalk and signal bleed
- Methods used to compensate for the effects of metal within the carbody structure
- Identification of the expected background magnetic noise in the loop coverage area based on similar vehicles in service in similar environments, and its affect on the audio quality of the completed loop system.
- Design details of hearing loop
- Hearing loop diagnostic test equipment to be supplied

### 13.19 WAYSIDE ACCESS POINTS

The Contractor shall design, supply, and install all necessary wireless local area networks (WLAN) including hardware, software, extranet, and monitoring equipment as follows:

- Individual WLAN locations shall be installed at each of SEPTA’s Railroad Division’s five (5) yards and shops along with SEPTA’s Suburban Station for the primary purpose of data exchange between wayside equipment and all WiFi equipped cars. The facility based WLAN’s shall also accommodate other maintenance management and information software used by SEPTA so they are accessible via the WLAN networks.

- All WLAN location data systems in conjunction with the wayside diagnostic system described in TS 16.6 shall be configured to automatically capture the car number, fault, and status information from each vehicle as it enters within any WLAN area.

- SEPTA’s Suburban Station’s WLAN system shall be capable of communicating and fully recording data from all equipped vehicles passing through the designated location at any time.
d. Yard WLAN applications shall be designed to allow full area reception to all cars in the track areas and shop work zones of each local yard. Sufficient apparatus shall allow for communication with each car to be achievable from the SEPTA network. The signal strength shall be adequate to allow communication with a WLAN equipped laptop computer from inside the cars at a speed acceptable to the Engineer for accessing additional SEPTA maintenance information.

e. The Contractor shall design the topography of the networks as applicable for each location and supply and install all needed hardware and software. The IEEE 802.11 WiFi technology chosen for the WLAN shall be the latest commercially available variant at the time of NTP, 802.11ac or newer. The design and installation of the network shall be based on the site surveys for network coverage concerning reception such as signal to noise ratios, EMI interferences, speed potential, and estimated car and user bandwidth loads. An adequate number of wireless access points and associated antennas shall be provided to accommodate efficient speed and access based on the use of the proposed automated data transfer system, estimated data transfer assuming a fully occupied and equipped yard, as well as data available on SEPTA's Vehicle Maintenance Information System (VMIS) and Vehicle Technical Information Library (VTIL) system. Site surveys, network design, installation, and testing shall occur not more immediately prior to the delivery of the first equipped vehicles. Network design shall be extensible and take into account the challenging and changing RF environment found throughout SEPTA’s yards and in Suburban Station.

f. Security of the WLAN system to exclude unauthorized users and potential hackers will be paramount. Security protocols implemented are to be industry best practices at the time of the WLAN system design.

g. All vehicle WLAN systems, the SEPTA Control Center, and selected management departments shall be connected via a secure extranet or attached to the existing SEPTA computer network. Associated servers and networking software shall be supplied by the Contractor. Extranet fees shall be borne by the Contractor for the full term of the Contract (last car out of warranty). If the Contractor proposes to use the SEPTA existing network(s) for WLAN wayside communication instead of extranet, the Contractor shall supply all required equipment and devices determined to be required by the SEPTA network Engineer to accommodate increased traffic on the SEPTA networks (routers, switches, cards, etc.), and extranet fees will not be applicable. All hardware and software shall be approved by the Engineer. [CDRL 13-017]

h. The Contractor shall also provide the following complete WLAN computer systems for use on the WLAN and associated monitoring stations:

1) Two (2) WLAN desktop computers per yard location

2) Two (2) additional WLAN laptop computers per yard location

3) One (1) desktop computer installed for monitoring the status system at SEPTA's Control Center
4) One (1) desktop computer installed for monitoring the status system at management location (to be determined)

   i. The system shall have the ability to update the database in part or in whole. Partial updates shall allow longer upload times to occur over different times of vehicle availability in the yard. The system shall record where it left off and continue the update without having to start at the beginning. Partially updated vehicle databases shall be fully functional in the AVL system using existing information until the latest updated information is fully downloaded and ready for use, at which time the system will make use of the latest updated information. The system shall automatically update any and all vehicles in the WLAN that require the database update, and shall record the car number and percentage of the database updated. Cars that leave a yard or shop before completion of the update shall have the upload continue sequentially at any other yard or shop that it next enters, until the percentage of update is fully completed.

### 13.20 CONTRACT DELIVERABLE REQUIREMENTS LIST

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<tr>
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<th>Car Type</th>
<th>Reference Paragraph</th>
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<td>13-001</td>
<td>Complete Communication Package Details</td>
<td>All</td>
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<td>------------------------------------------------------</td>
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<td>All</td>
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<td>13.15.2</td>
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<td>All</td>
<td>13.19.g</td>
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14 OPERATIONAL SAFETY SYSTEMS

14.1 GENERAL

This Section describes the operational safety systems and subsystems to be provided on each cab car in accordance with the Specification. Each operator cab shall be fully equipped.

14.1.1 Regulatory Requirements

In general, all systems specified here shall comply with the current FRA regulation, FRA mandated PTC requirements, APTA standards, IEEE standards, and requirements of the AREMA communication and signal manuals.

All systems shall fully comply with 49 CFR 238.105, Software Safety Requirements.

At a minimum, the following regulations shall apply:

a. 49 CFR 236 for the advanced speed enforcement system
b. 49 CFR 229 for the event recorder system
c. IEEE Standard 1482.1.1999 for the event recorder system
d. 49 CFR 238 for the alerter system

Any proposed deviations from this Specification shall be submitted to the Engineer for discussion, resolution, and approval. No deviation will be accepted without formal written approval from the Engineer.

Train operation safety shall be the prime consideration in the design and selection of components.

As part of the system safety plan, including interface with other systems, each system shall be analyzed in a systematic manner to determine all possible failure modes and their effects on the overall safety of the train operation based on the preliminary hazard analysis provided by the Contractor.

14.1.2 General System Requirement

For the safety and normal operation of the train, each of the major systems specified in this Section shall provide safety and normal functionality independent of each other. The shared input and output signals shall be isolated in such a manner that any failure within any one system shall not affect the operation of the other systems. Each system shall be capable of communicating over the car and wayside network systems.

14.1.3 Submittal Requirements

The following shall be submitted to the Engineer for review and approval:
a. Design of the operational safety systems [CDRL 14-001]
b. Hardware configuration of the operational safety systems [CDRL 14-002]
c. Software configuration of the operational safety systems [CDRL 14-003]
d. Installation of the operational safety systems [CDRL 14-004]

### 14.2 EQUIPMENT REQUIREMENTS

Due to FRA mandated rules and regulations and the safety critical nature of the ATC/PTC system, the Contractor shall supply equipment that is identical to SEPTA’s current ATC/PTC system. Listed below are the part numbers of the Ansaldo STS (ASTS) ATC/PTC system as used by SEPTA:

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP-System-3</td>
<td>Complete Mobile Communications Package:</td>
<td>STI-CO</td>
</tr>
<tr>
<td>MCP-SEPTA</td>
<td>Mobile Communication Package including Digi Modem, Power-One Power Supply, GE PTC Radio, Filters, and Cabling</td>
<td>STI-CO</td>
</tr>
<tr>
<td>MCP-PWR</td>
<td>Optional External Power and Serial Bracket</td>
<td>STI-CO</td>
</tr>
<tr>
<td>HDLP-MB-PLL25-SEPTA</td>
<td>Antenna System, SEPTA Configuration PTC/CEL/CEL/Wi-Fi</td>
<td>STI-CO</td>
</tr>
<tr>
<td>HDLP-GPS</td>
<td>Optional GPS Sensor for Antenna System</td>
<td>STI-CO</td>
</tr>
<tr>
<td>HDLP-RDM</td>
<td>Optional Radome for SEPTA Antenna System</td>
<td>STI-CO</td>
</tr>
<tr>
<td>PKIT-LMR-240-UF-FR-SEPTA</td>
<td>Cable Kit Antenna to MCP, SEPTA Configuration, Fire Rated</td>
<td>STI-CO</td>
</tr>
<tr>
<td>370-3100-ant-sep</td>
<td>Roadway Worker Alert Systems (RWAS) Antenna Assembly</td>
<td>ProTran</td>
</tr>
<tr>
<td>370-3100ND-SEP</td>
<td>Vehicle Mounted Controller</td>
<td>ProTran</td>
</tr>
<tr>
<td>D604218-A01</td>
<td>ATC/PTC Kit for Electric locomotive</td>
<td>Siemens</td>
</tr>
<tr>
<td>C070G230</td>
<td>CTV Cable</td>
<td>Siemens</td>
</tr>
<tr>
<td>C070G293R2</td>
<td>CTV Coax Cable</td>
<td>Siemens</td>
</tr>
<tr>
<td>C070G294R2</td>
<td>CTV Twin Axial Cable</td>
<td>Siemens</td>
</tr>
<tr>
<td>D5664H61R0</td>
<td>Vehicle ID Module</td>
<td>Siemens</td>
</tr>
<tr>
<td>2RBS2A1</td>
<td>RedBOX Star Event Recorder</td>
<td>Deuta Werke</td>
</tr>
</tbody>
</table>

The supplied ATC/PTC equipment shall meet all functional requirements as outlined in the Ansaldo PTC System Functional Description, document number S820661-01300-2100, latest revision. The equipment supplied shall be designed for F-end and B-end operation, even though in this application the equipment shall be utilized in the F-end configuration only.
As part of this Contract, the Contractor shall also provide to SEPTA upgraded software and upgraded portable test equipment software for SEPTA’s existing ATC, PTC, MCP, and event recorder systems. The software will include a new vehicle type for multi-level cab cars to allow the vehicle ID module to communicate the appropriate vehicle type to the OBC and for each of the systems to recognize the vehicle type. SEPTA will, at its discretion, install the upgraded software on all legacy ASTS equipment. The new software supplied shall be designed such that all Contractor supplied ATC/PTC, MCP and Event Recorder System (ERS) components are interchangeable with SEPTA’s existing ATC/PTC devices.

14.3 GENERAL SYSTEM DESCRIPTION

The automatic train control (ATC) and positive train control (PTC) systems shall enforce the safe operation of the train primarily through forced acknowledgement and overspeed protection. Each system can initiate a penalty brake application in order to stop the train if the operator is unable or unwilling to do so.

The combined equipment shall provide the function of traditional cab signal and modern positive train control (PTC) with civil speed enforcement. The cab signal portion shall be based on a NORAC 9-aspect system with overspeed protection. The PTC portion shall be a SEPTA PTC system which will provide the civil speed enforcement. The ATC/PTC equipment shall be designed for use on SEPTA property and shall be compatible with the northeast corridor (NEC)/Amtrak operation. It shall be designed utilizing fail safe techniques to provide a vital platform that can be relied upon to perform safety critical functions.

The ATC equipment shall use track receivers to continuously monitor coded carrier signals in the rail. Coded carrier information is translated to signal aspect information, which is used for traffic control.

The PTC equipment shall be transponder based system that enforces civil speed restrictions for fixed locations such as curves, bridges, stations, etc., as well as temporary speed restrictions and a positive train stop. While cab signal equipment shall enforce vehicle operation based on speed and time; the PTC equipment shall enforce operation based on speed and distance (position).

A single ATC/PTC system shall be located on board. User input to the system shall come from devices within the Operator’s cab. Normally, input can only be produced from an activated cab which occurs when the cab is made up as the lead cab in the consist. In order to accomplish its control tasks, the equipment interacts with other systems on the vehicle, such as the air brake, diagnostic, and the vehicle control systems.

The ATC/PTC system shall have an integrated alerter system which shall be responsible for monitoring the train operator vigilance. The ATC/PTC system shall interface with an FRA compliant standalone event recorder. All FRA required ATC and PTC system inputs, outputs, and messages will be communicated and stored within the event recorder.

The ATC and PTC equipment shall be installed at an accessible location in each car (refer to TS 10). The equipment of each of these systems shall be designed to be packaged in one (1) equipment cubicle. The equipment enclosure shall be fitted with a restricted access key lock. The key to unlock this enclosure shall be an Illinois Lock Co. model G341 key.
The Contractor shall supply all necessary auxiliary devices, pressure transducers/switches, cutouts, brake system interfaces, etc., to provide a complete functional system.

14.4 ATC/PTC System Requirements

The ATC/PTC system shall conform to all FRA rules and regulations and conform to all Northeast Operating Rules Advisory Committee (NORAC) rules and regulations. As part of the system design, either the ATC or PTC will be capable of operation as an individual system. If the ATC system is cut out, the PTC system shall stay active. If the PTC system is cut out, the ATC system shall stay active.

14.4.1 ATC System Functions

The ATC system shall perform the following functions:

- a. Vitally detect, at all times, block signal information transmitted from the running rail into the active cab of the train and shall enforce the speed limits associated with the signal information received
- b. Measure vehicle speed using a dedicated speed sensor
- c. Incorporate one (1) aspect display unit (ADU), in each cab
- d. Perform ATC protection in the form of forced acknowledgement in response to signal aspect downgrades
- e. Allow operation in non-cab signaled territory at speeds up to 79 MPH
- f. Enforce a positive train stop (PTS) as defined by the SEPTA PTC System
- g. Perform an automated departure test when activated by the ADU key switch. This onboard test feature shall be capable of testing the cab signal, ATC, and alerter systems. The cab signal test function shall operate in the presence of 25 Hz or 60 Hz traction power, constant or sporadic 100 Hz and/or 250 Hz carrier, and with a valid cab signal (coded 100 Hz with or without 250 Hz) coded rate within the rails.
- h. Report all FRA and SEPTA specified real time data to an external FRA compliant event recorder
- i. Record system operation within an internal data logger. Access to this information shall be available by portable test equipment (PTE), the vehicle WiFi network, and over a car’s cellular network.
- j. Perform real time event monitoring. Access to this information shall be available by portable test equipment (PTE), the vehicle WiFi network, and over a car’s cellular network.

14.4.2 PTC System Functions

The PTC system shall perform the following functions:
a. Acquire wayside transponder data and translate it into civil speed restrictions (permanent speed restrictions (PSR))

b. Acquire wayside data over SEPTA’s 220 MHz data radio and translate this data into a PSR

c. Acquire temporary speed restriction (TSR) package data (via transponders or data radio) and apply corresponding speed restrictions

d. Measure vehicle speed and distance traveled using a dedicated speed sensor

e. Automatically compensate for wheel wear. The ATC system shall receive and incorporate the updated wheel diameter in all speed calculations.

f. Report maximum authorized speed (MAS), vehicle speed, and PTC operating status to the operator via the aspect display unit (ADU)

g. Enforce civil speed requirements as required by the onboard computer (OBC)

h. Enforce positive train stop (PTS) as defined by the PTC system

i. When activated by the ADU key switch, perform an automated onboard departure test. This onboard test feature shall be capable of testing the PTC system including the transponder antenna, MCP, and OBC. The cab signal test function shall operate in the presence of a 25 Hz or 60 Hz traction power, a constant or sporadic 100 Hz and/or 250 Hz carrier, or with a valid cab signal (coded 100 Hz with or without 250 Hz) coded rate within the rails.

j. Report real time data to an external FRA compliant event recorder

k. Record system operation within an internal data logger. Access to this information shall be available by the portable test equipment (PTE), the vehicle’s WI-FI network, and over the car’s cellular network.

l. Perform real time event monitoring. Access to this information shall be available by portable test equipment (PTE), the vehicle’s WI-FI network, and over the car’s cellular network

14.5 ATC System Operation

14.5.1 Cab Signal Decoding

Cab signal aspect information is communicated to a vehicle using coded carrier signals in the rail. The onboard cab signal equipment inductively receives this information through track receiver antennas mounted over the rails ahead of the lead axle.
The SEPTA ATC system uses dual carrier frequencies (100 and 250 Hz) modulated to represent unique signal aspects. The signal aspect, enforced by the onboard cab signal equipment, is derived from the decoded carrier signals received. In dual carrier operation (100 Hz and 250 Hz), either only the modulated 100 Hz carrier is utilized in the rail, or both the 100 Hz and 250 Hz carriers are used. When both carriers are used, the 250 Hz signal is present only during the off time of the 100Hz signal.

### 14.5.2 Aspects, Indications, and Authorized Speeds – NEC

Listed below are the carrier code rates, aspects, and permitted speeds:

<table>
<thead>
<tr>
<th>F1 Code Rate (91.67/100 Hz)</th>
<th>F2 Code Rate (250 Hz)</th>
<th>Cab Signal Aspect</th>
<th>Speed Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>180</td>
<td>Clear</td>
<td>100 MPH/MAS</td>
</tr>
<tr>
<td>180</td>
<td>No code</td>
<td>Clear</td>
<td>100 MPH/MAS</td>
</tr>
<tr>
<td>270</td>
<td>270</td>
<td>Clear</td>
<td>100 MPH/MAS</td>
</tr>
<tr>
<td>120</td>
<td>120</td>
<td>Cab speed 80</td>
<td>80 MPH</td>
</tr>
<tr>
<td>270</td>
<td>No code</td>
<td>Cab speed 60</td>
<td>60 MPH</td>
</tr>
<tr>
<td>120</td>
<td>No code</td>
<td>Approach medium</td>
<td>45 MPH</td>
</tr>
<tr>
<td>75</td>
<td>75</td>
<td>Approach</td>
<td>30 MPH</td>
</tr>
<tr>
<td>75</td>
<td>No code</td>
<td>Approach</td>
<td>30 MPH</td>
</tr>
<tr>
<td>No code</td>
<td>No code</td>
<td>Restricted</td>
<td>20 MPH</td>
</tr>
<tr>
<td>No code</td>
<td>No code</td>
<td>Non-cab signal territory</td>
<td>79 MPH</td>
</tr>
</tbody>
</table>

### 14.5.3 Departure Test Required Mode

When the power is removed from the ATC system, the system will restart in a departure test required mode. This mode shall stay active until a departure test has been completed successfully. While in departure test required mode, all cab signal aspect displays are dark. The system shall enforce a 10 mph speed limit while in this mode. The ADU shall display an “ATC DEPT TESTREQD” message while in this mode. A momentary bypass switch shall be provided within the equipment enclosure. To initiate a bypass, the switch must be pressed each time after the equipment is reset or powered up.

### 14.5.4 Speed Sensing Requirements

The system shall monitor the wheel rotation via gear mounted magnetic sensors. The configured vehicle type and wheel size data shall be incorporated within the vehicle I.D. module for use by the ATC/PTC systems.
14.5.5 Non-Cab Signal Territory

Provision shall be made to permit operation in territory without cab signals. When an input is provided to the cab signal/speed control system indicating entry to non-cab signal territory, the system shall darken all cab signal aspects and impose a 79 mph speed limit. The input shall be manual from a SEPTA approved non-cab signal territory momentary pushbutton located within the cab. While in non-cab signal territory mode, a valid input from the non-cab signal territory pushbutton will toggle the system back to cab signal territory mode.

Upon entering cab signal equipped coded territory, any code received shall cancel the non-cab signal territory condition and cause the cab signal to be displayed. At this time, it shall be necessary to acknowledge the change in operating mode. The 79 mph speed limit shall be removed, and the speed limit shall be as determined by the cab signal.

14.5.6 Signal Carriers

The cab signal equipment shall operate using two carrier frequencies: F-1, range a nominal 100 Hz and F-2, a nominal 250 Hz.

Operation shall be such that the equipment shall interpret the F-1 carrier as specific speed commands for each coding rate and shall interpret the same F-1 coding rates as separate and distinct higher speed commands when the F-2 carrier is present during the "off" coding periods of the F-1 carrier.

The cab signal equipment shall respond to and operate successfully with the following carrier frequencies and tolerances:

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Operating Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-1 100 Hz</td>
<td>90 Hz to 102 Hz</td>
</tr>
<tr>
<td>F-2 250 Hz</td>
<td>247 Hz to 253 Hz</td>
</tr>
</tbody>
</table>

The rail current threshold detection point is 1.65 ±0.5 amps for F1 and 0.80 ±1.0 amps for F2.

The cab signal equipment installed on the car will operate in Amtrak and SEPTA territories. As such, the equipment shall be capable of operating in the presence of up to 0.5 amperes of in band noise for the 91.67 Hz/100 Hz system and up to 0.25 amperes for the 250 Hz system, as defined on the Amtrak EMI limit curve A-60-7659.

14.5.7 Codes

The cab signal/ATC equipment shall respond to and operate successfully within the following tolerances:

<table>
<thead>
<tr>
<th>Signal</th>
<th>Operating Range</th>
<th>Signal Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 Hertz carrier</td>
<td>247 Hz – 253 Hz</td>
<td></td>
</tr>
<tr>
<td>91.67/100 Hertz carrier</td>
<td>90 Hz to 102 Hz</td>
<td></td>
</tr>
<tr>
<td>270 code rate</td>
<td>268 – 283 CPM</td>
<td>11 half cycles</td>
</tr>
</tbody>
</table>
The OBC shall be designed such that it is possible to adjust the F1 and F2 threshold values manually at the filter/amplifier board.

### 14.5.8 Power Supply

The ATC/PTC equipment shall be powered by 2 isolated power supplies. Each power supply shall provide complete isolation from each other along with isolations from all vehicle circuits. If either the ATC or PTC power supply enters a fault condition, the non-faulted system shall continue to operate.

The car battery system shall be designed to be floating from ground. The ATC/PTC system shall be totally independent of positive, negative, or combined battery ground faults.

### 14.5.9 Track Receivers

With new wheels installed on the car, the track receivers shall be mounted 7.0 inches nominally from the top of the rail. The system shall function properly throughout the range of 6 inches to 9 inches above the top of the rail. The track receivers shall have a minimum height adjustment of a 4 inch range in 0.5 inch increments. The track receivers shall have a horizontal adjustment of 4 inches with 0.5 inch increments.

### 14.5.10 Aspect Display Unit (ADU)

An aspect display unit (ADU) shall be fitted in each cab. The ADU shall incorporate a photosensitive device that senses ambient light intensity. Utilizing this sensor, the ADU display intensity shall be automatically adjusted to compensate for changes in the ambient light. In order to override this feature, the ADU shall contain a pushbutton switch that will manually control the auto dimming feature of the ADU. The manual mode of adjustment will remain in effect until the time the unit is no longer the controlling cab. The ADU shall default to automatic brightness control each time the cab is activated.

Pictured is the SEPTA ADU along with a brief description of the respective ADU functions:

<table>
<thead>
<tr>
<th>Signal</th>
<th>Operating Range</th>
<th>Signal Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>180 code rate</td>
<td>178 – 188 CPM</td>
<td>6 half cycles</td>
</tr>
<tr>
<td>120 code rate</td>
<td>118 – 125 CPM</td>
<td>4 half cycles</td>
</tr>
<tr>
<td>75 code rate</td>
<td>71 – 77 CPM</td>
<td></td>
</tr>
<tr>
<td>Cab signal aspect hold time</td>
<td>3.4 seconds (minimum)</td>
<td></td>
</tr>
<tr>
<td>Code rate duty cycle (worst case)</td>
<td>75/25</td>
<td></td>
</tr>
<tr>
<td>Onboard equipment minimum</td>
<td>1.65 ± 0.15 amps (91.66/100 Hz)</td>
<td></td>
</tr>
<tr>
<td>Rail current detection</td>
<td>0.80 ± 0.1 amps (250 Hz)</td>
<td></td>
</tr>
</tbody>
</table>
The table below describes the ADU front view functional items:

<table>
<thead>
<tr>
<th>Item</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOVEMENT AUTHORITY</td>
<td>This is a 2 row X 8 character alphanumeric display and 2 square LED signal indicators. The 2 square LED signal indicator shall be capable of a green, yellow, and red (or any combination thereof, including lunar white) display. These 2 square LEDs shall display the NORAC certified cab signal aspect. The 2 row X 8 character display is a green LED dot matrix device with an overall character height of at least 7 mm. The LED based display shall indicate the cab signal aspects and shall be worded identically to SEPTA’s current ADU movement authority display along with NORAC Rules. This includes a positive stop aspect indication from PTC.</td>
</tr>
<tr>
<td>2</td>
<td>MAXIMUM AUTHORIZED SPEED</td>
<td>This is a red LED display that indicates the maximum authorized vehicle speed (MAS). This will be the lower of the maximum authorized speed permitted by the ATC or PTC system, with the governing system being indicated by LEDs to the left side (ATC) or right side (PTC) of the MAS display. This speed indication shall track the brake warning curve enforced by the PTC system when the PTC system is the governing system.</td>
</tr>
<tr>
<td>3</td>
<td>ACTUAL SPEED</td>
<td>This is a red LED display that indicates the actual vehicle speed.</td>
</tr>
<tr>
<td>4</td>
<td>ATC</td>
<td>This is a yellow LED that when lit indicates that the ATC system is generating a MAS lower than the PTC system. If there is currently a penalty associated with the ATC system, this LED will flash.</td>
</tr>
<tr>
<td>5</td>
<td>PTC</td>
<td>This is a yellow LED that when lit indicates that the PTC system is generating a MAS lower than the ATC system. If there is a penalty currently associated with the PTC system, this LED will flash.</td>
</tr>
<tr>
<td>6</td>
<td>OVERSPEED</td>
<td>This is a yellow indicator that when lit indicates that the vehicle speed is in excess of either the ATC MAS or the PTC MAS.</td>
</tr>
<tr>
<td>7</td>
<td>NO VALID TSR DATA</td>
<td>This is a red LED that when illuminated indicates that there is no valid temporary speed restriction (TSR) data. This is typically caused by the PTC transponder or the data radio not picking up correct TSR messages. Under this condition, the MAS display will indicate “- -“.</td>
</tr>
<tr>
<td>8</td>
<td>ATC CUT-IN</td>
<td>This is a green LED, that when illuminated indicates that the ATC system is cut in and operational.</td>
</tr>
<tr>
<td>9</td>
<td>PTC CUT-IN</td>
<td>This is a green LED, that when illuminated indicates that the PTC system is cut in and operational.</td>
</tr>
<tr>
<td>Item</td>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>10</td>
<td>ATC CUT-OUT</td>
<td>This is a red LED that when illuminated indicates that the ATC system is cut out.</td>
</tr>
<tr>
<td>11</td>
<td>PTC CUT-OUT</td>
<td>This is a red LED that when illuminated indicates that the PTC system is cut out.</td>
</tr>
<tr>
<td>12</td>
<td>ATC FAILURE</td>
<td>This is a red LED that when illuminated indicates that there is a failure in the ATC system. This is an indication that the train Engineer should manually cut out the ATC system, and subsequently follow all relevant operational rules.</td>
</tr>
<tr>
<td>13</td>
<td>PTC FAILURE</td>
<td>This is a red LED that when illuminated indicates that there is a failure in the PTC system. This is an indication that the train Engineer should manually cut out the ATC system, and subsequently follow all relevant operational rules.</td>
</tr>
<tr>
<td>14</td>
<td>ERS FAILURE</td>
<td>This is a red LED that when illuminated indicates that there is a failure in the event recorder system (ERS).</td>
</tr>
<tr>
<td>15</td>
<td>VALID DATABASE</td>
<td>This is a green LED that when illuminated indicates that a valid database has been uploaded from the PTC transponder.</td>
</tr>
<tr>
<td>16</td>
<td>SUPPRESSION</td>
<td>This is a yellow LED that when illuminated indicates that the brake system is in suppression.</td>
</tr>
<tr>
<td>17</td>
<td>[SPARE]</td>
<td>This is a SPARE orange LED.</td>
</tr>
<tr>
<td>18</td>
<td>MESSAGES</td>
<td>This is a textual display that is used to pass messages to the train Engineer. These messages are related to the PTC and ATC departure test, TSR Messages, fault annunciation, NON-CAB SIGNAL TERRITORY operation and ADU indicator DIMMING mode control.</td>
</tr>
<tr>
<td>19</td>
<td>MESSAGE SELECT</td>
<td>This is a pushbutton switch that is used in conjunction with the message display. The train Engineer can also select indication illumination intensity using this switch</td>
</tr>
<tr>
<td>20</td>
<td>ALERTER</td>
<td>This is yellow LED that is caused to flash by the alerter (vigilance) system.</td>
</tr>
<tr>
<td>21</td>
<td>ATC/ALERTER SONALERT</td>
<td>This is a dual tone alarm. One tone shall sound when the alerter system reaches a time out. A different tone shall sound when the ATC system annunciates an overspeed condition or downward code change.</td>
</tr>
<tr>
<td>22</td>
<td>PTC SONALERT</td>
<td>This is a single tone alarm that sounds when the PTC system annunciates an overspeed.</td>
</tr>
<tr>
<td>23</td>
<td>‘C’ SIGNAL</td>
<td>This is a lunar white LED that when illuminated indicates that the ATC is cut out and that there is no wayside cab signal present, and PTC is providing authority via the data radio to proceed to the next home signal.</td>
</tr>
<tr>
<td>Item</td>
<td>Function</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>24</td>
<td>PTC DEPARTURE TEST</td>
<td>This is a key switch that when rotated 90 degrees clockwise initiates a PTC departure test.</td>
</tr>
<tr>
<td>25</td>
<td>ATC DEPARTURE TEST</td>
<td>This is a key switch that when rotated 90 degrees counter clockwise initiates an ATC departure test.</td>
</tr>
<tr>
<td>26</td>
<td>BRIGHTNESS</td>
<td>This is a pushbutton switch that overrides the auto dimming feature of the ADU. It is used to control the brightness of the display. Repeated pushing of the button shall cycle the brightness of the display through five (5) different brightness levels. All brightness levels shall be approved by SEPTA.</td>
</tr>
</tbody>
</table>

### 14.6 DEPARTURE TEST

A departure test is a sequence of cab test functions that are performed to verify the operational integrity of the equipment as well as external control devices and operator controls and indicators. The provided ATC/PTC system shall include provision for separate ATC and PTC departure tests that are sufficient in scope and design so as to meet all ATC, PTC, and alerter requirements as currently mandated by the FRA.

In order to initiate a departure test, the operator shall first move the ADU key switch in the PTC or ATC direction. If all prerequisite entry conditions are met, the departure test will proceed. If the prerequisite entry conditions are not satisfied, the ADU will display the fault condition to the Operator.

In order to perform a departure test, the following prerequisite conditions are required:

- a. Cab active
- b. The vehicle speed shall be 0
- c. The brake pipe is at least 90 psi
- d. An air brake application of suppression or greater is present

If a fault is detected during the operation of either departure tests, the ATC/PTC system shall display the fault condition to the operator on the ADU and record the fault within the diagnostic system.

### 14.7 EQUIPMENT HARDWARE AND LABELING

A momentary pushbutton acknowledge switch shall be provided within the equipment enclosure.

Visual indications, such as LED lamps, shall demonstrate that the system is functioning properly; similarly, failure and diagnostic indications shall be provided. Indications shall isolate a failure to a particular function or to the interface between two functions.

Inputs for the equipment shall be debounced and shall be electrically isolated from one another. A visual indication, such as an LED lamp, shall be provided on the input board to each input to indicate when the input is activated.
Vital outputs for the equipment shall be electrically and physically isolated from one another. A visual indication, such as an LED lamp, shall be provided on the input board to each input to indicate when the output is activated.

Labels shall be provided by each input and output indication which clearly denote the respective function of each for ease of maintenance and troubleshooting.

14.8 MODULAR DESIGN

Modular design of components shall be incorporated to the maximum practical extent. Components or subassemblies with discrete function shall be plug in modules and shall be labeled for ready identification. The circuit board rack shall be easily and quickly removed and replaced as a unit and shall be designed for handling. Plug connectors shall be of rugged design suitable for the safety related circuits involved. Positive retention of plug in modules shall be provided. Functionally interchangeable modules shall be physically interchangeable, and those that are not functionally interchangeable shall be provided with positive means to prohibit physical interchangeability. The design shall be such that failure to install a module shall cause a more restrictive than normal system operation.

14.9 ENVIRONMENTAL CHARACTERISTICS

At a minimum, all electronic apparatus shall be designed and tested in accordance with IEEE 16 and all of the referenced standards contained therein. This includes, but is not limited to, operating/storage temperature environment, EMC, and shock and vibration. Any variation from these requirements shall be submitted to the Engineer for review and approval.

14.10 ALERTER SYSTEM

The Contractor shall provide an FRA mandated alerter within the ATC/PTC system. The alerter shall be an OBC based system that is designed to enhance the safe operation of the car by monitoring the alertness of the Engineer. The system shall continuously monitor the action taken by the Engineer. In the absence of the detectable movement of the Engineer in the specified time period, the alerter system notifies the Engineer by means of an overspeed light located on the ADU. The visual overspeed light shall flash at a predetermined rate for ten (10) seconds. Five (5) seconds into the visual alarm cycle, a second audio alarm located within the ADU will activate. Failure to acknowledge the two alarms within the allotted time (ten (10) seconds) shall result in a penalty brake application.

14.10.1 Alarm Sequence Conditions

The alerter system shall activate the alarm sequence whenever any one of the following conditions occurs:

a. No monitored input has changed within thirty (30) seconds with a restrictive aspect present

b. No monitored input has changed within thirty (30) seconds in non-cab signal territory mode

c. No monitored input has changed within thirty (30) seconds in “Departure Test Required” mode
d. The alerter, while in cab signal territory, shall with an aspect greater than restricting activate the alarm sequence when no monitored input changes within \((2400 \div \text{train speed})\) seconds.

### 14.10.2 Operator Actions

The following operator actions shall reset the alerter function and deactivate an alarm sequence:

- a. Activating the horn
- b. Activating the ATC/PTC acknowledgement switch
- c. Moving the throttle handle
- d. Ringing the bell
- e. Movement of the brake valve handle.

### 14.10.3 Inactive Conditions

The alerter shall become inactive and the timing cycle shall reset when any one of the following conditions are present:

- a. The cab is deactivated
- b. Suppression is applied
- c. The brake pipe is at 0 psi
- d. The speed is at 0 mph

### 14.11 ODOMETER

A new cumulative mileage odometer with a visual display shall be installed in all cars. The odometer display shall utilize ATC/PTC system data for its display. The information shall be displayed and recorded to the nearest mile.

- a. For cab cars, the odometer display shall utilize ATC/PTC system data for its display.
- b. For non-cab cars, the Contractor shall propose an odometer system for the Engineer’s approval. [CDRL 14-005]
- c. The display shall be the same for cab cars and non-cab cars.

### 14.12 ROADWAY WORKER ALERT SYSTEM

A roadway worker alert system (RWAS), as manufactured by ProTran, Inc., shall be installed at the cab end of the car. The operation and configuration of the RWAS shall be identical to SEPTA’s current RWAS system.
14.13 EVENT RECORDER SYSTEM

The event recorder shall be an ASTS PTC Deuta Werke RedBOX Star Type 3AW event recorder, Deuta Werke part number 2RBS2A1. All FRA required ATC and PTC system inputs, outputs, and messages will be communicated and stored within the event recorder. Access to event recorder data shall be available by portable test equipment (PTE), the vehicle WI-FI network, and over the car’s cellular network.

The event recorder shall provide all functions necessary to comply with the requirements in the Code of Federal Regulations (CFR), Title 49, Parts 218 and 229, as published in the Federal Register. In addition to the data elements listed in Title 49 CFR Section 229.135, SEPTA shall have the option of adding data elements. The final ERS configuration, including additional SEPTA specified events and sampling rate, shall be subject to approval by the Engineer during periodic design reviews of these systems. The event recorder shall be designed to meet all self-monitoring event recorder requirements as described in Title 49 CFR 229.

14.13.1 Vehicle Configuration

The event recorder shall determine the type of vehicle in which it is installed based on the vehicle number sent by the SEPTA PTC system to the event recorder over the RS422 interface. The Contractor shall be responsible for creating a new vehicle configuration for this Contract and shall be responsible for the supply of revised software to SEPTA.

14.13.2 Time Management

The ERS time shall come from the mobile communications package (MCP). When the time is not available from the MCP, the event recorder shall utilize its internal clock until time is received. The real time clock shall be buffered by a super capacitor which shall keep the real time clock operating for a minimum of ten (10) days in the absence of power from the car’s low voltage network.

14.13.3 Digital Inputs

There shall be a total of 35 digital inputs. The digital inputs shall be checked every 20 ms and a change shall be validated after 40 ms.

14.13.4 Analog Inputs

There shall be a total of eight (8) analog inputs. Six (6) analog inputs shall be 4-20 mA, one (1) analog input shall be 0-10 V, and one (1) analog input shall be -5 V to 5 V.

14.13.5 Download Log

For all downloads, the status of the download process shall be indicated at the download location. All event recorder download ports shall be at SEPTA approved locations which are easily accessible from within the car.
14.13.5.1 Wireless

The log shall be able to be downloaded wirelessly via the vehicle’s MDS WiFi or cellular network.

14.13.5.2 Ethernet Connection

The log shall be able to be downloaded with a laptop directly connected to the Ethernet service interface on the recorder.

14.13.5.3 USB Flash Drive

A standard non-Deuta formatted USB flash drive shall download the last 48 hours of data.

14.13.5.4 Deuta-Werke Playback Software Configured USB Flash Drive

Depending on the user selected configuration, the following will be available for download:

a. All data
b. All new data (from last download)
c. Most recent 48 hours of operation

14.13.6 ERS 92 Day Activity Check

The event recorder shall have internal software designed to check for activity of each FRA required input. Each FRA required input shall change a minimum of one (1) time during a 92 day period. A failure of an input to change state during a 92 day period shall display an event recorder fault status on the ADU.

14.13.7 ERS FRA Inspection Report

The event recorder playback software shall be capable of producing an FRA INSPECTION REPORT generated by the push of a button. The inspection report shall provide the date, car number, and activity of each FRA required input for the last 48 Hours of operation. This inspection report shall be able to be saved electronically and/or printed for SEPTA’s records.

14.13.8 ERS Monitoring and Diagnostic Interface

The event recorder shall be accessed through the monitoring and diagnostic system. The monitoring and diagnostic system shall capture the event recorder fault and status (diagnostic) data as it occurs and provide full diagnostic data recording, security, and downloading capability.

14.14 TEST EQUIPMENT

The Contractor shall provide two (2) Siemens ATC portable test boxes and two (2) collapsible loops identical to those provided to SEPTA during the SEPTA PTC project. The Contractor shall provide all wiring required adapters and related items to make the test equipment functional.
The Contractor shall be responsible to update SEPTA’s bench test equipment to make it suitable for use with the material specified in this Section.

### 14.15 CONTRACT DELIVERABLE REQUIREMENTS LIST

<table>
<thead>
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<th>CDRL Number</th>
<th>Title</th>
<th>Car Type</th>
<th>Reference Paragraph</th>
</tr>
</thead>
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<tr>
<td>14-001</td>
<td>Operational Safety Systems Design</td>
<td>All</td>
<td>14.1.3.a</td>
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<tr>
<td>14-002</td>
<td>Operational Safety Systems Hardware Configuration</td>
<td>All</td>
<td>14.1.3.b</td>
</tr>
<tr>
<td>14-003</td>
<td>Operational Safety Systems Software Configuration</td>
<td>All</td>
<td>14.1.3.c</td>
</tr>
<tr>
<td>14-004</td>
<td>Operation Safety Systems Installation</td>
<td>All</td>
<td>14.1.3.d</td>
</tr>
<tr>
<td>14-005</td>
<td>Non-cab Cars Odometer System Proposal</td>
<td>Non-cab</td>
<td>14.11.b</td>
</tr>
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15 VEHICLE AND TRAINLINE NETWORKS

15.1 GENERAL

The multi-level cars described in this Specification shall use data networks as the primary means of data communication both within the vehicle and between vehicles within the same train. An Ethernet based digital trainline network designed to have consistent one (1) Gbps of bandwidth shall be provided to facilitate networked communication throughout a consist of DTN enabled vehicles. The design, configuration, and operation of the digital trainline network shall be submitted to the Engineer for review and approval. [CDRL 15-001] The network design shall be non-proprietary and based on open, extensible standards such as TCN Open / Train Real-time Data Protocol (TRDP).

The Ethernet network shall be based using IEEE 1473:2010 or later Type E network as a starting point. The network shall be utilized to support the transmission of diagnostic, control functions, audio, video, and passenger information. Alternate network architecture may be proposed if approved by SEPTA. Use of proprietary protocols is prohibited.

The Contractor shall provide a description of the digital network control and architecture to the Engineer review and approval. [CDRL 15-002] This description shall include detail on the data network protocols, fault tolerance, degraded operating modes, redundancy arbitration, error detection, and a description of network initialization and configuration.

The Contractor shall submit a list of all IP devices on the digital network to the Engineer for review and approval. The IP address scheme shall be based on EN IEC 61375. The IP addressing scheme shall be submitted to the Engineer for review and approval. [CDRL 15-003]

The Contractor shall ensure that all trainline components and networks are designed to provide proper operation of trainlined functions for train lengths of up to 14 cars.

The Contractor shall designate a single supplier as having system integration responsibility for the trainline networks. The selected supplier shall have successful prior rail industry experience in performing such integration. The Contractor shall submit the selected integrator to the Engineer for review and approval. [CDRL 15-004]

The network architecture shall be hierarchical comprising the following levels:

15.1.1 Train Level

A Gigabit Ethernet based digital trainline network (DTN) shall be provided on all cars for data communication between vehicles.
15.1.2 Vehicle Level

A Gigabit Ethernet based data car network (DCN) shall be provided on all cars for data communication within each vehicle.

DTN cabling and receptacles shall interface and be compatible with the cabling and receptacles selected for use on other SEPTA fleets outfitted with DTN. In addition, the multi-level cars shall be backward compatible with SEPTA’s existing fleet of commuter cars and locomotives that are fitted only with the 27 pin discrete locomotive MU control and door and communication trainline systems.

15.2 DTN TRAINLINE AND NETWORK ARCHITECTURE

The network architecture shall include a digital trainline network (DTN) between cars and locomotives and a ring-based data car network (DCN) for data communication within each car.

15.3 DIGITAL TRAINLINE NETWORK (DTN)

A Gigabit Ethernet digital trainline network (DTN) shall be provided on each car using IEEE 1473:2010 or later Type E network as a starting point. Two (2) DTN receptacles shall be provided on each end of the vehicle, to be used by separate DTN jumper assemblies. Each receptacle shall be pre-wired with two (2) Category 7 cables (one as a spare) that shall be terminated with an A-coded bulkhead M12 connector. The physically separated receptacles and jumpers shall both be connected to the Train Ethernet Switch (TS 15.4.1) located at that end of the vehicle. The jumper cables shall meet the requirements of PRIAA Specification 305-919 section 3.3 “Jumper Cables”. The DTN shall ensure network function when a minimum of one (1) of the Ethernet jumpers on each end is connected.

![Figure 15-1 Ethernet Switch Diagram](image)

The DTN shall be capable of operating in a consist of between two (2) and 14 vehicles.

15.3.1 Extent of Minimum DTN Functions

The extent of the minimum DTN communication functions shall be as follows:
a. Exchange of diagnostics and status data on functional units between cars via DTN

b. Information for train consist overview including status of doors, HVAC, PEI, PA/IC, and other vehicle components

c. GPS position and time supplied from DTN from cab car

d. Automatic train inauguration when train composition changes. Automatic inauguration shall take no longer than 30 seconds to complete.

e. Collect and store car diagnostics information. The DTN shall be configured for remote access to retrieve the diagnostic information from each car.

   1) Diagnostic information includes logged event data associated with one (1) group of environmental data (condition data items, the same for event data types).

   2) Diagnostic information shall be retrievable via DTN by Operator’s display, MDS, or remotely via the TWC system in the cab car.

f. Implementing the DTN functionality for passenger information sign

g. Implementing passenger information sign database update via DTN

15.3.2 Incorporated DTN Functions

The following functions, at a minimum, shall be incorporated into the DTN:

a. Recognition of train consist including vehicle order, orientation, and vehicle number within the consist

b. Automatic reconfiguration of the network when cars are coupled or uncoupled or rearranged

c. Train consist monitoring and diagnostics

d. Train to wayside (TWC) data transfer including transmission from non-cellular/WLAN equipped cars to vehicles with cellular and WLAN connections (locomotives and cab cars)

e. Transfer of data needed from/by trailer cars to/from cab cars and locomotives

The DTN shall also support all of the diagnostic and monitoring functions of the CLDS as described in TS 16.
15.4 DATA CAR NETWORK (DCN)

A Gigabit Ethernet data car network (DCN) shall be provided on all cars utilizing IEEE 1473:2010 or later Type E as a starting point. The DCN shall be configured as a loop so that car operation shall be unaffected by a single open circuit in the network. In addition, loop integrity shall be checked automatically, and open circuits in the loop shall be annunciated to the CLDS.

All networks shall be based on the seven (7) layer open systems interconnection (OSI) model. Full documentation of each layer for each network shall be provided in a network interface control document to be submitted prior to the preliminary design review. [CDRL 15-005] The document shall be updated with all changes through testing and the end of the warranty period. [CDRL 15-006]

Subsystem monitoring and control within the car shall be primarily by means of the DCN with minimal use of discrete control wires. Systems controlled and/or monitored by the DCN shall, at a minimum, include the following:

Systems Monitored by DCN

<table>
<thead>
<tr>
<th>System</th>
<th>TS Section</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door System</td>
<td>TS 6</td>
<td>Includes end door unlatch function</td>
</tr>
<tr>
<td>Communication System</td>
<td>TS 13</td>
<td></td>
</tr>
<tr>
<td>Wheel Slide System</td>
<td>TS 12</td>
<td></td>
</tr>
<tr>
<td>Brake System</td>
<td>TS 12</td>
<td></td>
</tr>
<tr>
<td>Passenger Destination Signs</td>
<td>TS 13</td>
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<tr>
<td>Automatic Passenger Counting System</td>
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<td></td>
</tr>
<tr>
<td>Onboard Dynamic Advertising System</td>
<td>TS 13</td>
<td></td>
</tr>
<tr>
<td>Video Surveillance System</td>
<td>TS 13</td>
<td></td>
</tr>
<tr>
<td>Battery/LVPS</td>
<td>TS 10</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>TS 8</td>
<td></td>
</tr>
<tr>
<td>ATC/PTC</td>
<td>TS 14</td>
<td>Cab car only</td>
</tr>
<tr>
<td>Event Recorder</td>
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<td></td>
</tr>
<tr>
<td>Trainline</td>
<td>TS 5</td>
<td></td>
</tr>
<tr>
<td>CLDS and MDU (Maintenance Display Unit)</td>
<td>TS 15</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Equipment Monitoring</td>
<td></td>
<td>As appropriate</td>
</tr>
</tbody>
</table>

Details of the vehicle systems to be controlled and/or monitored by the DTN system shall be submitted to the Engineer for review and approval. [CDRL 15-007]
15.4.1 Train Ethernet Switches

Train managed Gigabit Ethernet switches shall be installed at each end of the vehicle. The train Ethernet switches shall be equipped with failover contacts such that if a switch fails or power is lost, the trainlined Ethernet ports automatically bridge through to the next vehicle. The train Ethernet switches shall be configured to allow VLAN assignments to manage network traffic flow and shall conform to IEEE 802.1Q. The train Ethernet switches shall be configured to utilize both receptacles when a jumper is available on each to provide redundancy by utilizing IEEE 802.3ad. The network shall remain fully functional providing consistent one (1) Gbps of bandwidth when only one (1) jumper is installed.

15.5 GENERAL NETWORK FUNCTIONAL REQUIREMENTS

15.5.1 Installation

All network cables shall be installed, shielded, and grounded to minimize EMI emissions and susceptibility.

Cables for redundant networks shall not be installed in the same wire bundle, conduit, or wireway.

Gigabit Ethernet connectors used throughout the vehicle shall be eight (8) pin A-coded M-12 connectors. Fast Ethernet (100 mbps) connections shall be connected utilizing four (4) pin D-coded M-12 connectors.

15.5.2 Fault Tolerance

Failures in either physical DTN trainlines shall not result in more than a transient loss of DTN function. Recovery from such failures shall take no longer than 1.4 seconds.

A single failure in the DTN gateway shall result at most in the loss of DTN communication to and from the affected vehicle; trainline operation and internal vehicle operation shall not be otherwise affected. The DTN is to be designed such that the failure of any active component or power failure within one (1) vehicle shall not interrupt the DTN functionality for the remainder of the consist. Any failure of the DTN shall not impact the primary operation of the vehicle that is enabled by the 27 pin jumper.

15.5.3 Time Response

For trainlined network control functions, the maximum delay from the control actuation to the beginning of the control response shall be 500 ms. The Contractor shall submit a detailed analysis identifying and quantifying all network delays to the Engineer for review. [CDRL 15-008]

15.5.4 Network Integration and Fault Tolerance Testing

The Contractor shall perform a network interface card (NIC) test of each networked device to verify compliance with IEEE standards.
The Contractor shall perform a complete network integration test of all train subsystems including transmission through the jumper and receptacles to determine the network noise limits and to prequalify the proposed architecture of networks before vehicle implementation. This test shall consist of a simulated 14 car train with all train switches, actual cable and cable length, and connectors that will be used on the vehicles. All intelligent system controls connected to the digital train network shall be the actual units in one (1) cab car and one (1) trailer car with the other cars simulated by traffic generators. These tests shall also verify that the protocols, datasets, and messages used on all networks correspond to the network interface control document and the specific signal, message, and dataset documentation provided for each network. At the time of the integration test, the Contractor shall also demonstrate the fault tolerance of all networks by simulating possible faults. SEPTA shall have the option of witnessing the tests. The test procedures [CDRL 15-009] and results [CDRL 15-010] shall be submitted to the Engineer for review and approval.

15.5.5 Network Diagnostic Capabilities

For the purposes of network maintainability and diagnostics, full per interface statistics of each network connected device shall be available. The interface statistics shall include, at a minimum, packets transmitted, received, transmitted errors (broken down by type), received errors (broken down by type), packet types (unicast, multicast, broadcast, etc.), as well as interface connection duration, speed, and resets.

The network statistics shall be stored on each end device and reported when requested via the PTU, onboard diagnostic system, or wayside diagnostics system. The display of the network statistics shall provide a network device overview and indicate issues such as interfaces which have a high number of errors and resets. In addition to the interface statistics reported by each interface, a resettable local counter on each display type shall be provided to facilitate troubleshooting and identification of fixes.

Each network interface shall support a guided network traffic self-test as a method of diagnosing the ability of the systems to support network traffic as designed. The network self-test shall respond to requests by the PTU, onboard diagnostic system, and wayside diagnostics system. The onboard network hardware shall generate worst case round-trip traffic and characterize the performance of the network (using and providing reports on latency, throughput, and interface errors) in an attempt to identify latent defects in network cables, connectors, or devices. The network self-test shall be such that each physical link can be traversed, and the network self-test (including screen to be implemented by the monitoring and diagnostics system) shall allow maintainer selection of either a complete network characterization (testing all interfaces), or a per interface characterization. The completion of the self-test shall indicate test results, expected values, and highlight potential issues.

The network diagnostic capabilities shall be submitted to the Engineer for review and approval [CDRL 15-011].

15.5.6 Maintainability

When nodes on the network are replaced using parts supplied by the Contractor or equipment supplier, the network system shall automatically identify the replacement equipment and its communication links.
Replacement of networked subsystem controllers shall not require any configuration of the controller or vehicle/train switches.

All software configuration items installed on any network connected device shall be maintained by an onboard controller to facilitate component replacements. A report of expected and current onboard software versions shall be accessible through the PTU, onboard diagnostic system, and wayside diagnostic systems. A software update command using a copy available on the update controller shall be available to maintainers when the report indicates that an expected version of a software configuration item is in conflict with the installed version on the network device.

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16 MONITORING AND DIAGNOSTIC SYSTEM

16.1 GENERAL

16.1.1 Introduction
The monitoring and diagnostic system (MDS) shall provide information for the crew of the cars to inform them of the cars’ operating condition and to facilitate repair. Crew shall be informed of the readiness of the cars in the train and of any problems requiring their attention. Maintainers shall be provided information at both the train or car level to allow them to determine problem causes, to replace the lowest replaceable units without the need for other diagnostic tools such as portable test units, and to confirm proper operation upon replacement. The system shall provide the central wayside locations with information to monitor the status of the fleet and to help prepare for the maintenance functions before the vehicles are directly accessible. The system shall also provide the central wayside locations with all faults, status, FRA event recorder down load information, and other subsystem data. During the warranty period, the effectiveness of the fault reporting system shall be monitored by the Contractor to ensure that it provides accurate information. The Contractor shall develop performance criteria which shall include such items as maximum allowable percentage of false failures reports and maximum allowable percentage of missed failures. The performance criteria shall be submitted to the Engineer for approval. The details of the design, installation, arrangement, and testing of the MDS shall be submitted to the Engineer for review and approval. [CDRL 16-001]

16.1.2 General Architecture
The MDS functions shall be performed at several levels within the constituent systems of the cars:

a. At the car level
b. At the train level
c. At a central wayside location

Networking between these components is described in TS 15.

The systems within each car shall monitor their operation and report various status and fault information to the car level. The car level shall be able to display information to assist in maintenance and report information at the train level to inform the crew of conditions that limit the car’s performance or otherwise need their attention.

16.1.3 Diagnostic System Levels
The monitoring and diagnostic system shall consist of the following levels:
a. Car System Level Diagnostic System (CSLDS) – the CSLDS individual constituent level systems on the car such as the HVAC, braking, doors, and others.

b. Car Level Diagnostic System (CLDS) – The car level systems collect data from the car level systems and are the interface to the higher train level system.

c. Train Level Diagnostic System (TLDS) – The train level system collects information from the cars and interfaces with both the crew and the radio links to the wayside systems.

d. Wayside Diagnostic System (WDS) – The wayside systems collect and save data from all trains and make it available through SEPTA’s corporate data networks.

16.1.4 MDS Functions

The monitoring and diagnostic system (MDS) shall monitor conditions and detect problems (failures). The status of the cars and detected faults shall be retained and displayed for crew, maintainers and others. Sufficient information shall be provided by the car level systems so that there shall be no need to use a carry on PC to diagnose problems to the replacement unit level. This shall generally be the printed circuit board level rather than the discrete component or box level. At the level of the systems within the cars, the car systems level diagnostic systems’ (CSLDS) faults shall be detected according to algorithms defined in the corresponding system documentation. Fault information shall be retained within the car systems and shall be transferred to the higher level car level diagnostic system (CLDS).

The car level diagnostic system (CLDS) shall retain information, present it to maintenance personnel, and provide other assistance in problem resolution and replacement unit determination. The car level diagnostic system shall also report information to the train level diagnostic system (TLDS).

The train level diagnostic system (TLDS) shall provide communication to the train crew and shall transfer certain status and fault data via the train to wayside communications system (TS 13.10) to the wayside.

A user shall be able to select certain variables within the car systems to be sampled and recorded. It shall be possible for the user to request that the file of these observations be transferred to the wayside diagnostic system database.

16.2 FAULTS, FAULT DATA, AND STATUS INFORMATION

16.2.1 Faults

Faults shall include detection of incorrect operation of onboard systems and the occurrence of external conditions that are outside of the required ranges.

The set of faults shall be such that all failures are detected and the specific LLRU can be easily and uniquely determined. An analysis shall be presented showing how each failure mode will result in one (1) or more faults and how these faults can then be traced back to a unique LLRU. Exceptions shall be permitted only with the specific approval of the Engineer.
Each fault shall have an associated fault code. Whenever the conditions that trigger a fault occur, the fault shall be “set”. A “set” fault may then be “cleared” when a separate clearing criteria is met. Both the “set” and “clear” criteria shall be defined in the corresponding car system documentation.

### 16.2.2 Fault Attributes

There shall be a standard set of attributes which will be associated with each fault code. The default value for each of these attributes for each fault shall be set as part of the system and software development process. These values shall be changeable through the CLDS user interface and through loading an attribute file from a USB drive, cellular, the vehicle’s WLAN, PTU, and via the train to wayside communications system (TS 13.10) through the TLDS. The attributes shall determine the actions to be taken on a fault report by the car system level diagnostic system, the car level diagnostic system, and the train level diagnostic system. The version and CRC for the attribute file shall be subject to the same display requirements as the version and the CRC for the car system software.

The systems shall allow for 16 attributes for each fault code. These attributes shall determine the actions to be taken by various systems in processing fault reports.

The attributes shall be:

- a. Archive in car system – If true, specifies that the fault reports shall be logged at the system that generated the fault
- b. Critical – if true, indicates fault must be addressed before the next periodic maintenance
- c. Crew access – if true, fault shall be displayable for the train crew
- d. Maintenance access – if true, allows train maintenance access to the fault
- e. Failure forecasting – if true, indicates fault is associated with incipient failure detection
- f. Transfer to wayside diagnostic system – if true, indicates the fault reports are to be sent to the wayside diagnostic system from the TLDS
- g. Operator alarm – if true, indicates that when the fault is set the Operator should receive an indication of the condition

The remaining attributes shall be reserved for later definition. These may be defined by SEPTA at the PDR or FDR stages.

### 16.2.3 Fault Reports

A fault report shall include the following:

- a. Short name for the generating system such as HVAC, ATC, Brks, etc.
- b. Fault code
- c. Attribute values
d. Set/reset code and snapshot available code

The set/reset code shall indicate whether the fault report is showing that the fault is being set or if it is being reset.

The snapshot available code shall indicate if, when a fault was set, a snapshot was recorded.

### 16.2.4 Fault Snapshots

Snapshot data shall be appropriate for the fault and the system. The data shall be taken at sufficient time intervals and with appropriate variables recorded to capture the significant events leading up to the fault and the responses for a short time after the fault.

Snapshots shall be retrievable from the generating system in a snapshot report. These reports shall be in a generic and self-defining format that can be transferred through the system and viewed at either the CLDS-MDU or at the wayside diagnostic system.

The snapshot data shall be approved by SEPTA [CDRL 16-002] and selected based on the fault it is associated with. Examples of snapshot data likely to be required to be provided along with the occurrence of a fault include battery voltage, battery current, brake cylinder pressure, brake pipe pressure, equalizing reservoir pressure, brake handle position, cab active status, contactor status, temperature status, blower status, heater status, door system status, axle speeds, parking brake application status, zero speed status, and others as defined during design review.

### 16.2.5 Fault Snapshot Reports

The snapshot report shall include the following:

a. The short name of the generating system

b. The fault code or codes with the times they were set (in the case of more than one (1) fault at the same time or within a time adjustable by SEPTA)

c. The number of observations (rows in the data table)

d. The time of first observation and the time increment between observations

e. The names of each variable in the snapshot table with the number of bits used

f. The table of data with one (1) row for each observation and the values of each variable in the columns

Readers for these snapshots shall be provided for the CLDS, WDS, and laptop PCs. [CDRL 16-003]
16.2.6 Status Information

Status information shall be sent periodically indicating the operational status of the individual car systems.

16.3 CAR SYSTEMS LEVEL DIAGNOSTIC SYSTEM (CSLDS)

16.3.1 Car Systems

All processor controlled car systems shall include a CSLDS and shall interface to the CLDS through the digital car network (DCN).

At least the following systems within the cars shall have a diagnostic system:

a. Auxiliary power system (APS) including LVPS and battery (TS 10)
b. Operational safety system (TS 14)
c. Friction brake control system and wheel slide system (TS 12)
d. Car level diagnostic system (CLDS) (TS 16.4)
e. Communications system (CS) (TS 13)
f. Door control system (DCS) (TS 6)
g. Event recorder system (TS 14)
h. HVAC system (TS 8.2)
i. Destination signs (TS 13.8)
j. Ground fault detection system (TS 10.6.1.4)
k. Operator’s display (TS 7.12)
l. Train to wayside communications system including wireless LAN and cellular communication (TS 13.10)
m. Automatic passenger counters
n. Video surveillance system
o. Audio frequency induction loop
16.3.2 Status Reports
The result of “power on” self-tests, if used, shall be included in status information reported to the CLDS. Status reports shall be provided periodically to the CLDS. The CLDS shall detect a fault if status reports are not provided within a set time.

16.3.3 Faults
The fault detection logic shall be sufficiently robust to distinguish between actual internal failures and the failure of external systems or inputs.

Any redundant system’s failure shall be detected and reported so as to assure attention to and repair of the redundant system.

Because some systems will not have microprocessor controllers but may still have failure conditions that need to be detected, the Contractor may detect some faults at the CLDS or may elect to include them in the requirements for other systems with the detection of additional faults to cover these failure conditions. The Contractor may also elect to specify additional faults for the CLDS, if needed, to meet the requirements for LLRU determination such as when the individual car systems lack sufficient information to detect a fault condition.

The level of battery diagnostics required is overvoltage, overtemperature, undervoltage, current limit, circuit breaker trip, or no charge for any other reason.

16.3.4 Snap Shots
Detailed snap shots shall be taken when selectable triggers or events occur. Sample rates, signals to record, pre-trigger recording time, and recording time shall be adjustable and shall have the ability to be set separately for each different trigger or event as required by SEPTA.

16.3.5 Custom Monitoring of Real Time Data
The user shall be able to select specific variables for reporting to the car level diagnostic system. These shall be selected by command from the CLDS, cellular, WLAN, PTU, and the train to wayside communications system (TS 13.10). They shall be sampled at a selectable interval.

16.4 CAR LEVEL DIAGNOSTIC SYSTEM (CLDS)

16.4.1 Functions
The car level diagnostic system shall perform the following basic functions:

a. Collect and store fault report and status information from the car systems and the CSLDSs

b. Process fault reports according to their attribute values
c. Provide the user high level status information regarding the car

d. Reply to user requests for information

e. Perform the functions usually carried out by a portable test unit attached to the car system

f. Reply to requests from the train level diagnostic system (TLDS)

g. Display the status of individual trainlines in the door and communications, HEP, and locomotive control trainline systems

h. Provide through the digital train network (DTN) access to the car status information for other cars in the train

i. Display all current cab control and ATC/PTC status information

j. Write selected data to a USB drive

k. Reload software into car systems and the CLDS itself

l. Send clock set commands to the car systems

The CLDS shall be arranged to permit the following levels of access:

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<td>2</td>
<td>Level 1 plus</td>
<td>Login Required</td>
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<td></td>
<td>Individual Systems Diagnostics</td>
<td>CLDS logs employee ID</td>
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<td></td>
<td>All Reset Operations</td>
<td>Number</td>
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<td></td>
<td>Download Operations</td>
<td>Date and time stamps access</td>
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<td></td>
<td>Set Temporary Parameters</td>
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<td>3</td>
<td>Same as Level 2 plus</td>
<td>Login Required</td>
</tr>
<tr>
<td></td>
<td>Software Upload Capability</td>
<td>CLDS logs employee ID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Date and time stamps access</td>
</tr>
</tbody>
</table>

The access shall be granted by a combination of user ID and password entered via the CLDS. The software necessary for management of user IDs, passwords, and access levels shall be provided to SEPTA and implemented in a secure fashion. Updates to the login database shall be possible via USB flash drive, train network, cellular, WLAN, PTU, and the train to wayside communications system (TS 13.10). Details of the system configuration for the functions and access of the CLDS shall be submitted to the Engineer for review and approval. [CDRL 16-004]
16.4.2 Components of the CLDS
The CLDS shall consist of a CLDS unit and a maintenance display unit (MDU) with an LED touchscreen. The CLDS unit and the MDU shall be located in a vestibule locker of each car. The MDU LED touchscreen shall be located so as to be convenient for maintenance operations from a standing position. The screen shall provide a normal rectangular viewing area with at least a 12 inch diagonal dimension and shall support a minimum of SVGA resolution of at least 1024 by 768. The screen shall be readable under all lighting conditions. The display shall be subject to approval by the Engineer at the pilot car FAI and at the maintainability demonstration. [CDRL 16-005]

The touchscreen shall be capable of performing all of the operations of the software. A USB interface connector shall also be provided for a regular PC type keyboard.

The CLDS unit shall communicate on the car network and on the train network as described in TS 15.

16.4.3 Processing Individual Faults
The car systems shall send fault reports to the CLDS. A fault report shall be generated whenever a car system detects a fault and the associated attribute specifies that the fault report shall be sent to the CLDS.

The CLDS shall provide a clock that shall maintain the date in Eastern Standard Time and, when appropriate, Daylight Savings Time both in 24 hour format. This time shall be periodically updated from an onboard system or device (such as GPS or PTC) which will be defined by SEPTA during the design review. The CLDS shall send date and clock set commands to the CSLDS to set their clocks at regular intervals. All data reported to the CLDS shall be time stamped using the internal clock.

The CLDS shall append the following information to each fault report received from a car system including faults from the car level diagnostic system (see also TS 16.2.3):

   a. Car number
   b. Train number
   c. GPS location

16.4.4 Custom Monitoring of Real Time Data
A user shall be able to select variables to be monitored with the values saved in a file that can be transferred to a PC or to the wayside system. This custom configuration shall be able to be saved to a file and SEPTA shall have the capability to load this configuration with a USB flash drive, cellular, WLAN, PTU, and the train to wayside communications system (TS 13.10).
16.4.4.1 Selection of Data to Be Collected

The user shall be able to select up to 100 variables to be recorded. These may be selected from menu screens for each car system. A group of these selections may be saved with an associated name for later recall and use. Sample rates shall be configurable by SEPTA. The default sample rates shall be 50 samples per second for rapidly changing data and may be lower for other data subject to approval of the Engineer.

16.4.4.2 Storage of Real Time Data

Sufficient storage shall be provided to store a minimum of 30 hours of monitored variables not including snap shots. SEPTA shall have the ability to add external USB storage when required to store more data.

16.4.4.3 Retrieval of Real Time Data

When requested through the MDU, the real time data shall be transferred to a USB Drive, cellular, vehicle WLAN, PTU, and the train to wayside communications system (TS 13.10).

A user at the wayside diagnostic system shall also be able to request the data files in which case the file shall be transferred through the TLDS to the WDS.

The real time data shall be provided in a real time data report. This report shall consist of the following:

a. A header giving the car number, train number, date, time, and GPS coordinates
b. A header record listing the names of variable
c. The table of data with one (1) record for each observation and the variables in the columns

A sample report shall be submitted to SEPTA during the detailed design phase and shall be approved by the Engineer. [CDRL 16-006]

16.4.4.4 Viewing of Real Time Data

When requested through the wayside system, it shall be possible to view real time data via the train to wayside communications system (TS 13.10). The system shall allow the selection of up to 100 signals and provide the capability for requesting the real time data once or on a periodic polling basis.

16.4.5 CLDS Fault Detection

In addition to collecting and storing fault information from the car systems, the CLDS shall also detect faults itself. These faults shall include:

a. Failure of communications with any car system diagnostic system or with the train level diagnostic system

b. Detection of additional faults necessary to determine failed replacement units. (This could occur for systems that do not have their own processor or for faults that depend on status information from more than one (1) car system.)
16.4.6 USB / PTU Interface

The following specific requirements pertain to the USB drive and PTU interface:

a. The crew shall be able to select certain information to be copied to the USB drive or PTU.

b. The files shall be in a format approved by the Engineer.

c. The files shall include the train ID, car ID, time and date, GPS coordinates, variable names, and units for all data in the file.

d. All software needed to review and analyze the data shall be provided. [CDRL 16-007] This includes the ability to chart, sort, export the data, etc., as approved by the Engineer.

16.4.7 User Interface and User Commands

The MDU shall display specific screens of information and allow the user to navigate through the screens by selection of screen names. The normal default display shall be the train overview screen.

In addition to the normal access level, there shall be two (2) higher levels of system access: maintenance access level and engineering access level. Both of these shall require an employee ID and password.

16.4.7.1 Normal Access Level

The normal access level shall provide the following:

a. The train overview screen which shall show the numbers and status of all cars in the train

b. The car system status screen which shall show the status and fault list for a particular car. Any car in the train may be selected.

16.4.7.2 Maintenance Level

The maintenance level shall allow access to the following additional screens:

a. A fault log screen showing a scrollable list of faults detected for a particular car

b. A download screen allowing download of fault information to all of the following: USB flash memory drive, cellular, vehicle WLAN, PTU, and the train to wayside communications system (TS 13.10)

c. A self-test and parameter screen for car systems that provide externally initiated self-tests or allow changes in maintenance related parameters
### 16.4.7.3 Engineering Level

The engineering level shall allow in addition to the maintenance level screens the following:

**a.** A software update screen that shall allow loading of software from a USB flash memory drive, cellular, vehicle WLAN, PTU, and wayside diagnostic system (TS 13.10) to the CLDS or one of the car systems

**b.** An attribute display and update screen that shall allow the display of all fault attributes by fault code for any one (1) selected car system and shall allow changing the attributes individually or by loading an attribute file from a USB flash memory drive, cellular, vehicle WLAN, PTU, and wayside diagnostic system (TS 13.10) to one (1) of the car systems

**c.** A snapshot display screen that shall allow the selection of a particular fault report and the display, if recorded, of the snapshot report associated with it

**d.** Allow changes for non-maintenance related parameters on the parameter screen

### 16.4.8 Software Loading into Individual Car Systems

When selected by the user, software for a specific car system shall be transferred from all of the following: USB flash memory drive, cellular, vehicle WLAN, PTU, and wayside diagnostic system (TS 13.10) to the target system. The user shall be able to request the calculation and display of the software CRC check sum of the target system before or after the software load to confirm the validity of the loaded software. They also shall be able to display the calculated check sum of a software load file on the USB flash memory drive, cellular, vehicle WLAN, PTU, or wayside diagnostic system (TS 13.10) respectively. The check sums shall be CRC16 or equivalent as approved by the Engineer.

The wayside system shall be able to request a software version and CRC report for a car. This report shall be a table providing the name of each software configuration item (SCI) for each car system and subsystem, the version of the SCI, and the CRC as reported by the software from a calculation. Data files (e.g. configuration or other setup files) shall also be included with the same information.

The wayside system shall be able to request a hardware revision and serial number report for a car. The report shall be a table providing the name of each hardware item, the hardware revision level, and the serial number of the equipment installed on the vehicle. The Contractor shall provide a means of updating the hardware revision level on each item that stores the hardware revision information, such that hardware modifications can be tracked by the report through the life of the equipment. The hardware revision and serial number report shall list each intelligent lowest line replaceable unit that is serialized and directly or indirectly connected to the car network.

It shall also be possible to load software from the WDS through the TLDS and the CLDS to a target car system. Such transfers shall be initiated from the TLDS.

The system shall also have the capability to load data files for announcements, signs, or other similar applications from the CLDS. Such data file transfers may originate from a wayside application and be transferred through the train to wayside communications system (TS 13.10), cellular, WLAN, and the TLDS to the CLDS and then to the specific car system.
16.5 TRAIN LEVEL DIAGNOSTIC SYSTEM (TLDS)

The information, capabilities, and functions of the vehicle monitoring and diagnostic system shall be made available via the Gigabit Ethernet based digital train network to other vehicles in the train including future fleets. The Contractor shall submit the functional description, detailed design, interface control documents, and all required development documentation describing the fleet interface for SEPTA’s review and approval. [CDRL 16-008]

The vehicle specific definition of faults, alarms, screen and screen layouts, display panels, vehicle status, and vehicle network capabilities shall be transmitted by each vehicle via the digital train network during the consist inauguration process. The transmission of these data items shall enable future fleets to be integrated without modification to the vehicle’s software. It is anticipated that this will be accomplished utilizing a stack of technologies including service discovery protocols such as zeroconf, application protocols such as HTTP, markup languages such as XML or HTML, and scripting languages such as JavaScript. The technologies utilized shall be non-proprietary and fully defined by the Contractor to enable future fleets to add displays to the vehicle monitoring and diagnostic display, as well as allow access to the monitoring, diagnostic, and status information of the vehicle to the displays integrated on future fleets.

The digital train network design shall enable the identification and report of a consist layout including the road number, orientation, ordering, and travel direction of vehicles within a consist. The design, interface, and operation of the digital train network shall be submitted for approval by SEPTA. [CDRL 16-009]

16.5.1 Functions

The train level diagnostic system shall perform the following basic functions:

a. Collect and store fault and status information from the cars’ CLDSs

b. Provide the user high level status information regarding the car

c. Reply to user requests for information

d. Buffer and pass fault reports to the wayside diagnostic system using the cellular and train to wayside communications system (TS 13.10)

e. Reply to requests from the wayside diagnostic system through the cellular and train to wayside communications system (TS 13.10)

f. Display all the current cab control status information

g. Write selected data to a USB flash memory drive, cellular vehicle WLAN, PTU and wayside diagnostic system (TS 13.10)
16.5.2 Components of TLDS

The train level diagnostic system shall consist of a driver display unit (DDU), MDS control unit (MCU), and all appropriate cables, connectors, hardware, and antennas.

Time and location data will be available from the GPS in the cab car.

The driver display unit shall provide the user interface. In normal operation, it shall display the operating screen showing the locomotive or cab car commands and status of the cars. It shall also be capable of displaying the car status display screen that shall show the status of the individual systems within a selected car. All DDU screens shall be approved by the Engineer.

The DDU shall also be capable of displaying the car status and car subsystem information for a particular car in the consist.

16.5.3 Actions for Processing Individual Faults

The TLDS shall maintain a most recent location and time triplet consisting of values of the latitude and longitude and the time the reading was obtained from the GPS unit. This triplet of values shall be updated with new readings from the GPS every 0.2 seconds provided that the readings are available and valid. The TLDS shall append this triplet to each fault report as it is received. This information shall identify the train location at the time the fault is identified. Since the fault report also includes the time the fault occurred, the time difference can be determined between the fault occurrence and the location reading. In this manner, conditions such as the failure or lapse of the GPS can be detected.

Fault reports shall be processed according to their attributes. These attributes shall determine certain actions to be taken by the train level system.

16.6 WAYSIDE DIAGNOSTIC SYSTEM (WDS)

The wayside diagnostic system shall communicate with the trains through the train to wayside communications system (TS 13.10).

The WDS shall collect data from the trains and stores it in one (1) or more industry standard databases. This data will then be accessed through a database manager through the existing SEPTA network as well as from the wayside access point described in TS 13.19. The WDS shall also transfer software, data files, and requests for additional information to the trains.

16.6.1 WDS Requirements

All fleet status information shall be integrated into a real time information software system with monitoring capabilities at each yard, the SEPTA Control Center, and one (1) key management location through a common extranet provided by the Contractor.
The WDS shall be configurable to different types of data that may be recorded or transferred and allow changes to the frequency of scheduled queries/transmissions to assure flexibility of the system. It shall also provide options for searching, sorting, and/or filtering the information and include export capabilities that allow standard delimited formats for use with external software applications. The software shall allow customizable reports based on fleet, area, and local information along with visual screen and/or audible alerts (blinking data/chime, etc.) for subject matter or values chosen by the user. The final software configuration is subject to the Engineer’s review and approval. [CDRL 16-010]

The WDS shall, as a minimum, meet the following requirements:

a. Enable the onboard functions for remote services such as onboard remote access to retrieve diagnostic information and process data from cars

b. Access to key process and diagnostics data of the cab car using the Operator’s display of a cab car

c. Access to key process and diagnostics data of coupled cars via DTN using the Operator’s display of a cab car

d. Access to key process and diagnostics data from the locomotive via DTN using the Operator’s display in the cab car

e. Implementing the remote access to update passenger information signs

f. Remote access and diagnostic services which allow SEPTA to access the ground station and the car using standard web browser software. The services shall include, but are not limited to:

   1) Administration
   2) Communication management
   3) Maintenance and diagnostics
   4) Fleet management
   5) Passenger services.

g. Simultaneous interactive sessions to ground station and to the cars:

   1) Minimum of two (2) simultaneous interactive sessions to one (1) cab or coupled trailer cars

   2) Minimum of ten (10) simultaneous interactive sessions to the ground station and to the cars

h. Support of wireless media as defined in TS 13.10 (train to wayside communications system) for communication between RDS ground station and cab cars

i. Information from trailer cars shall be accessed via DTN before it can be transmitted through the RDS system
j. It shall be possible to view the following information during an interactive session: all disturbance information stored in the diagnostic computer on every car that can be reached through the RDS and DTN.

k. Process data as a list of signals and values with the possibility to select the variables from a predefined list or on predefined screens. Similar to the IDU, process data from other cars without RDS mobile stations (trailer cars) shall be transmitted via DTN to a car with a mobile station (cab car).

l. Access the video surveillance system.

m. Access the automatic passenger counting system.

16.6.2 WDS General Functions

The general functions of the WDS shall be to:

a. Receive diagnostic data including fault reports and snapshot reports and update the WDS databases

b. Upload sign database updates from the WDS

c. Upload announcement files

d. Upload software and other data files for the car systems

e. Pass train wide pager message to the communication system

f. Pass requests for specific information to be transferred from the train

g. Pass the trigger for the train wide public and special messages to the communication system

16.7 BENCH TEST SYSTEM

To allow the proper testing, troubleshooting, and calibration of car components on a test bench in a specialized workshop environment, the Contractor shall supply two (2) complete sets of each type of bench type shop test equipment to be delivered by the 20th production car. [CDRL 16-011] Each tester shall be delivered as a completely wired and assembled unit and use shop electrical power and/or compressed air. Each tester shall have a receptacle for connecting to the device under test. Ease of operation to provide various inputs and for measurements of all signals shall be provided. The connections to the device under test, if not contained in the receptacle, shall be from the front of the tester and shall have provisions to neatly store out of the way when not needed. Extensive rear mounted connectors shall be provided to allow interconnections with supplied generic test equipment without a mass of jumper wires being necessary. The test units shall be for use in several SEPTA shop facilities. The Contractor shall coordinate with SEPTA to ensure compatibility with SEPTA's maintenance facilities.
The bench test equipment shall make use of known good system components, frequently called Golden Units, which shall be mechanically modified such that they cannot intentionally or unintentionally be removed from the bench test equipment and used in an operating system of the type under test. All Golden Units shall be marked or painted in a distinctive manner such that they can easily be identified as Golden Units.

Testers shall be used for the purposes of testing, troubleshooting, and calibrating electric, electronic, mechanical, pneumatic, and electromechanical components of each car subsystem. They shall contain provisions for the rapid testing, troubleshooting, and calibration of each and every type of electronic circuit board including motherboards and backplane wiring, plug in relay, current sensor, speed sensor, transducer, friction brake element, module, pressure switch, etc., used in any car system. Design of the testers shall be such that all inputs can be varied over the full working range of the device.

The bench test equipment shall be designed to enable a technician to perform rapid testing, troubleshooting to the discrete component level, repair, and calibration of all equipment. The bench test equipment shall be automated to the extent possible so that a technician need only plug in or hook up a component for testing, identify the board or component, and the automatic test shall begin. This automatic test shall indicate the health of the unit under test. If the unit is acceptable for service or not, this shall include an evaluation of the unit’s calibration status. If the unit under test is declared defective or out of calibration, the bench test unit shall allow the technician to troubleshoot the defective unit to determine which component is defective. For example, if a printed circuit board is under test and it is identified as being defective, the bench test unit shall allow the technician to single step through the automatic test to maintain the required inputs to the board for troubleshooting by the technician, which may include probing the circuit board to make various measurements, to determine which component such as a resistor, capacitor, transistor or IC chip is defective. It shall also include a manual mode to allow the application of inputs to the unit under test as selected by the technician for troubleshooting. The Contractor shall supply all hardware and software required to perform these functions for approval by the Engineer. [CDRL 16-012]

Each supplier of circuit boards under this Contract shall supply SEPTA all necessary electrical and physical information needed for fault finding and repair testing of these boards on this shop equipment. The shop testers shall be preprogrammed by the Contractor with algorithms needed to test and diagnose all of the car’s circuit boards as determined by the Engineer. Suppliers of circuit boards shall provide the information required to program the shop testers in a format designed for ease of entry and implementation by the Contractor.

For each item of shop bench test equipment, one (1) set of all peripheral test equipment required to make the necessary tests and adjustments such as frequency generators, digital voltmeters, oscilloscopes, etc., shall also be provided. They shall be rack mounted adjacent to and rear connected to the specialized equipment such that the end result is neat and tidy. These items shall be premium quality heavy duty devices supplied by Hewlett-Packard, Tektronix, Fluke, or other similar-quality approved supplier. The bench test equipment shall include all support devices required to enable testing of the line replaceable unit without the need to remove additional equipment from the car to support the use of the bench test equipment.

Shop test equipment shall be provided for, but not limited to, the following:

a. Wheel slide control unit
b. Auxiliary power control units

c. Low voltage power supplies

d. Friction brake control unit

e. All printed circuit boards

f. Plug-in relays

g. Operational safety systems

h. Communications system including radio and communications control units

i. Heating and air conditioning control

j. Passenger communication, signs, and information systems

k. Door system and door system control units

l. Microprocessor, EPROM, EEPROMs, and other electronic device reprogramming for all car systems except as approved by the Engineer

m. Train network equipment

n. Audio frequency induction loop

o. All electronics units not identified above

The Contractor shall provide drawings of the test equipment. Each piece of test equipment except for laptop PCs shall be accompanied with the complete diagrams, schematics, maintenance parts’ information, and calibration instructions for the device and its intended use and repair. These shall be supplied as part of the maintenance manuals.

The Contractor shall make all modifications to the test equipment specified herein which are required because of changes and modifications made to the vehicle or any of its systems or subsystems to meet the requirements of this Contract.

As part of the acceptance testing of the test equipment, the Contractor shall fully demonstrate the function of each type of test equipment being supplied once delivered and setup in the SEPTA shop facility. Bench test equipment shall test every printed circuit board used on the car.
16.8 PORTABLE TEST UNIT (PTU)

16.8.1 General

The Contractor shall provide portable test units in the quantities identified in TS 16.8.2 for connection to vehicle systems and subsystems for diagnostic testing and software updating. Each portable test device shall include all required cables, connectors, and associated equipment required to interface with the car.

For all systems making use of a microprocessor, the portable test unit shall be a laptop PC computer as described in TS 16.8.2. The laptop PCs shall be standardized to perform testing for all vehicle systems using the one (1) standardized serial or USB or Ethernet cable and connection port throughout all car subsystems. All non-PC portable testers shall be delivered by the 20th production car.

All non-PC portable testers shall be rugged and suitable for the shop environment. They shall be supplied with a rugged shock absorbing carrying case. The quality of materials, wiring techniques, durability of face plate identifications, etc., shall be equal in quality and shall, as a minimum, make use of the same methods and materials as required for similar equipment on the cars. Weight shall not exceed 35 pounds. The design shall make use of quick disconnect multi-pin connectors meeting the requirements of TS 17.18.5 to establish all the connections required for utilization of the portable test devices. Power required for operation of the portable test devices shall be supplied by the car's low voltage power supply. The portable test devices shall meet the requirements of TS 17.

There shall be no high voltage connections (greater than 150 volts) required between the car and any portable test device. It shall not be necessary to remove, dislodge, dismount, or disconnect any component, card, wire, chassis, terminal, or cable in order to perform periodic calibration or trouble diagnosis while using the portable test devices.

The function of the portable test devices shall be to produce all of the operating commands and other input signals necessary to fully exercise all functions and components of the particular system under test and to measure or indicate all of the signals, responses, and outputs produced by a system by means of indicators such as lamps, meters, oscilloscopes, gauges, etc. It will be acceptable to require a visual check for a system response such as closure of a contactor or a relay or lighting an indicator provided that the responding item of equipment does not require the test device operator to move more than 15 feet to make the required observation.

The portable testers will supplement the built in diagnostic features specified herein for particular subsystems and in those cases shall not duplicate the specified features but shall complement them by providing deeper and more comprehensive diagnostic capability. When used according to the instructions supplied by the Contractor, each portable test device shall enable the maintenance technician to fully check out and calibrate the system under test and to locate and replace any removable component which has failed. The portable test device shall not be used to calibrate high current and high voltage devices. Response indicators and input signal generators shall be built into the portable test devices to the maximum extent possible and shall have accuracy commensurate with alignment tolerances specified. Meters shall be digital except where specifically approved to be otherwise.
It shall not be permissible to require connection of external apparatus to the portable test devices without the prior written approval of the Engineer. In such cases, terminals shall be provided to allow connection of the required apparatus to the portable test device. However, such apparatus shall be considered part of the portable test device and shall be supplied with it on a one to one basis. Portable test equipment shall be supplied for, but not limited to, the following:

a. Wheel slide
b. Auxiliary power systems
c. Door control and apparatus directly related (per door basis)
d. Trainline circuits
e. Operational safety systems
f. Public address system/intercommunication system/radio
g. Cab make up circuits
h. Friction brake system
i. Passenger communication, signs, and information systems
j. Automatic vehicle location system/GPS
k. HVAC

16.8.2 Quantities

The Contractor shall furnish to SEPTA four (4) complete sets (including cables, instructions, software, chargers, etc.) of all portable test units required to perform in service testing necessary to verify the proper operation of all car subsystems prior to the delivery of the first production car. Additional sets of all portable test units shall be delivered during production car delivery for a grand total of ten (10) sets.

[CDRL 16-013] The diagnostic test equipment shall be designed to isolate problems or defects to a hand tool replaceable component level. All parts used in the construction of diagnostic test equipment shall be of first class quality and shall be designed and sufficiently rugged for the transit car shop environment. The laptop PCs shall be approved by the Engineer, be of the premium quality environmentally sealed type with ruggedized screens and cases and water resistant seals and switches, have the largest screen size available, have prior successful experience in similar railroad or transit car workshops such as SEPTA, and shall use the Microsoft Windows operating system or approved equal. Each laptop PC shall be supplied with a carrying case which includes a communications cable and two (2) extra sets of extended life rechargeable batteries. The laptop PCs generally shall be of the highest performance level systems (processor speed, maximum available RAM, hard drive configuration, video display, WiFi functionality, CD/DVD/RW drive, etc.) available in the commercial marketplace at the time of the pilot car delivery. All equipment shall be registered by the purchaser in the name of SEPTA as directed by the Engineer.

All diagnostic connection ports for the laptop PCs throughout the car regardless of subsystem shall make use of the standard IEEE RS-232, USB, or Ethernet connection. The PTU shall also have the ability to perform its functions through the vehicle’s cellular and WiFi. No special cables, connectors, accessories, or wiring shall be required to run or copy diagnostic programs or to copy or upload new software to any piece of equipment on the vehicle including at the CLDS.

Portable test units shall be tested on the pilot cars following delivery.
16.8.3 Software Updating of PTU Software

It is expected that multiple versions of the same on-board software package will be in service, such as during testing or implementation phases of software releases. PTU software packages shall be designed with forward and backward compatibility with on-board software versions to facilitate maintenance of disparate on-board software versions from a single PTU device. The PTU software shall be included in the on-board software package, such that if a PTU which contains an incompatible or out of date version is connected to a vehicle system, the vehicle system will provide the necessary installation or upgrade files to provide the latest update of the PTU software package. Alternatively, systems may provide standards compliant web-based PTU software to be hosted on-board a particular system such that no client application on the PTU device is required.

16.9 RADIO PROGRAMMING EQUIPMENT

Five (5) complete sets of radio programming equipment shall be supplied for setup and maintenance of the car radio transceivers by SEPTA. [CDRL 16-014] Each set of programming equipment shall include a standard laptop PC computer with maximum available RAM memory and a CD-RW drive, 19 inch display, keyboard, printer, radio programming interface and software. Interface adapters shall include two serial communications ports, one printer port, and a keyboard interface. The radio interface unit shall be provided with connectors and cables which are compatible with the radio and the computer. The interface shall be through the standard RS232 interface port. The software shall include the latest version of Microsoft Windows and radio programming application software, and shall be licensed to SEPTA. The radio programming software shall permit adjustment of all programmable radio operational parameters. SEPTA shall be entitled to free supplier upgrades of the radio programming software.

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17 MATERIALS AND WORKMANSHIP

17.1 GENERAL

Materials and workmanship shall be in accordance with the requirements of this Section unless otherwise approved by the Engineer.

Inclusion of a material or method in this Section shall not necessarily indicate approval for the application or use in a specific situation. When a material or method is specified in this Section, it shall be applicable; however, specific requirements detailed in the applicable Technical Specification Sections shall take precedence.

Material Safety Data Sheets (MSDS) shall be submitted for all materials, including lubricants, used in the fabrication of the cars and brought onto SEPTA property except for non-hazardous metallic materials. Information shall be in a form compliant with ANSI Z400.1-1993. [CDRL 17-001]

17.1.1 Quality

In accordance with TS 1.13, the Contractor's Quality Assurance (QA) Program shall assure that all aspects of the Contract are in conformance with the design, materials, and workmanship requirements provided in this Specification.

17.1.2 Standards

The following domestic standards and specifications shall define the materials for this Contract: Federal or Military Specifications or Standards, the Specifications of the Aluminum Association of America, AAR, AISI, APTA, ANSI, ASME, ASTM, FRA, IEEE, and others as specified herein.

Where other or foreign standards are proposed by the Contractor, the Contractor shall submit documentation with a section by section comparison to demonstrate that the proposed standards are the equivalent of the foregoing standards and specifications for review and approval by the Engineer. Proposed substitute specifications shall be submitted in both English and the language of the country of origin. The most recent standards and specifications applicable at the time of issuance of the Notice to Proceed shall apply unless otherwise approved by the Engineer.

17.1.3 Marking

All materials intended for use on these vehicles shall be marked or stored so as to be readily identifiable and shall be adequately protected during handling and storage. Rejected material shall be clearly marked and stored in an area specifically designated for that purpose which is not accessible to manufacturing staff.
17.1.4 Cleaning Agents

A list of recommended cleaning agents shall be provided to the Engineer for all materials exposed to normal cleaning operations. [CDRL 17-002] This information shall also be included in the maintenance documentation for the vehicle. The Contractor shall make every effort to minimize the number of different cleaning agents proposed. Where possible, the recommended cleaning agents shall be among those currently used and approved by SEPTA for similar applications.

The following materials are currently used by SEPTA in the cleaning of its existing commuter rail cars with the SEPTA Class and Lot number identified where issued. All car surfaces and equipment, which can be exposed to such products, shall be unaffected by them.

a. Exterior Vehicle

1) Fine Organics # FO477 car wash acid (67-00404A)

b. Interior Vehicle

1) ZEP Venture Cleaner
2) Fine Organics #1168 Seat Cleaner
3) Instant Gum Remover (67-02650)
4) ZEP #143 stainless steel polish (67-02491)

c. Graffiti Remover

1) ZEP #311 Graffiti Remover (67-02652)
2) Write Away
3) Neleco Graffiti Remover
4) Chase Products Co. Vandal Mark Remover (67-R0483)
5) Graffiti Remover (67-026751-A)

d. General Purpose Cleaner

1) ZEP Venture Cleaner
2) Fine Organics #1168 Seat Cleaner
3) 20 Degree Cloudy Ammonia (61-00150)
4) Penetone #169
5) Power-Whistle 12 Wall Cleaner (67-R0466)
6) National Auto Cleaner #26824 - Spray Nine (67-00465)

e. Glass Cleaner

1) 20 Degree Cloudy Ammonia (61-00150)
2) Glass Cleaner (67-00470)
3) Windshield Washer Solution per SEPTA Spec. MS-0013 (67-00570)
f. Odor Counteractant

1) ZEP #177702 Odorstroyer (61-00298-B02)

17.1.5 Prohibited Materials

The following materials shall be prohibited from use on the cars:

a. PVC
b. Asbestos
c. Cadmium (except for battery)
d. Lead
e. PCB’s
f. Carcinogenic materials as listed by current Publication of ACGIH
g. Materials listed in 29 CFR Sec. 1910.19
h. All CFC and HCFC compounds except R-407C & R134a
i. Urethane Foam

17.1.6 Material Handling

The Contractor shall use care in handling all materials used in the manufacture of these cars. SEPTA reserves the right to require the Contractor to change material handling methods and procedures that are not deemed adequate and appropriate for the work.

17.2 JOINING AND FASTENING

17.2.1 Joining

17.2.1.1 General

Certain combinations of materials require particular care in joining to avoid the possibility of corrosion. Isolating and moisture proofing materials, appropriate to the materials being joined, shall be employed at all times where these combinations exist.

Isolating and moisture proofing materials, appropriate to the materials being joined, shall be used at all times. The Contractor shall submit a detailed plan for the installation of dissimilar materials. This plan shall be approved by the Engineer prior to beginning the assembly of the first pilot car.
17.2.1.2 Joint Fitting

Joints shall be properly fitted whether exposed or concealed. When not otherwise specified in Contractor drawings or specifications, gaps between joints shall be held to a dimension less than ten (10) percent of the thinner material being joined or 0.002 inch, whichever is greater. Gaps shall be uniform in width. The edges of panels shall have a smooth finished appearance.

Where excessive gaps (greater than those permitted by approved drawings or standards) are found to exist at the faying surfaces of structural bolted or riveted connections, metal shims of the same material as that of the deficient part may be used but only with the written permission of the Engineer on an individual exception basis only and shall not be a part of any application design. Shims, if used, shall be permanently fastened to one of the base parts being joined. The use of epoxy or other plastic filler at such locations is expressly prohibited.

Joints shall be arranged to eliminate crevices, pockets and hidden areas where water, cleaning agents, dirt, and debris can accumulate. Exposed corners shall be rounded and all edges shall be deburred.

17.2.1.3 Metal to Metal Connections

Where metals contact each other, the contact surfaces shall be free of dirt, grease, rust, and scale. Unless specified otherwise, the contact surfaces shall be coated with a metal based primer which conforms to the Society of Protective Coatings, Specification SSPC-Paint-25. Metal primer may be omitted for austenitic stainless steel to austenitic stainless steel joints.

For proper treatment of a connection involving aluminum, refer to TS 17.6.

17.2.1.4 Wood to Metal Connections

Wood to metal connections shall be limited to plymetal applications (see TS 17.9.2). Other uses of wood to metal connections shall be by written permission of the Engineer on an individual exception basis only and shall not be a part of any application design.

Where wood and ferrous metal surfaces are placed together, the wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38, and the metal shall be coated with a primer which conforms to the Society of Protective Coatings Specification SSPC-Paint-25.

All bolts or rods passing through wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38.

17.2.1.5 Wood to Wood Connections

Where wood and wood are placed together, both abutting surfaces shall be coated with aluminum paint conforming to Federal Specification TT-P-38.
17.2.1.6 Slotted Joints

All secondary structures shall be permanently attached by welds or Huck bolts and not slotted. Any slots shall only be used with written permission of the Engineer on an individual exception basis only and shall not be a part of any application design.

17.2.2 Fasteners

17.2.2.1 General

The Contractor and suppliers shall be responsible for selecting fastener types, sizes, styles, lengths, materials, grades, and finishes that will meet the requirements of this Specification. The Contractor shall minimize the number of different sizes and styles of fasteners used. The Contractor shall submit to the Engineer for review and approval a fastener plan that identifies all interior and exterior fastener types and details which fasteners are to be tamperproof. [CDRL 17-003] Tamperproof fasteners shall be used for safety sensitive equipment access panels and covers accessible to passengers.

Use of self-taping fasteners is prohibited unless expressly approved by the Engineer.

Fasteners used throughout the car shall be inch standard fasteners except that ISO Metric fasteners may be used in conformance with TS 17.2.2.2.3.

All fasteners used on this car shall be specified under one (1) of three (3) categories:

- Category 1: electrical and electronic
- Category 2: structural and safety-related
- Category 3: decorative

Design submittal packages shall indicate the type of fastener by category that is appropriate for the relevant application.

Fasteners, internal to electrical or electronic components, are specified in appropriate materials and workmanship subsections for electrical devices and wiring. All structural and safety related fasteners are specified under Structural Fasteners TS 17.2.2.3. Fasteners used to attach interior lining or trim and exposed to passenger view are specified under Decorative and Appearance Fasteners, TS 17.2.2.4. All fasteners in any category, which attach to car structure, shall be in accordance with the requirements of this Specification.

Safety related fasteners include, but are not limited to, those applied to trucks, bolsters, brake equipment, couplers, and power collection devices. A fastener is safety related if failures cannot be tolerated, that is, if even a single fastener fails there is a possibility of brake failure, derailment, or an accident. In the event of a dispute, the Engineer will be the final arbitrator on which fasteners are safety related.
All fasteners used to secure access covers, doors, or panels to equipment boxes or interior panels shall be made captive to the panel in which they are used. Where access for service is expected more often than every five (5) years, access panels shall be equipped with quarter turn fasteners. Quarter turn fasteners shall have a minimum shank diameter of 1/4 inch, be of adequate strength, and as manufactured by Southco or approved equal.

All fasteners used on the interior of the car shall be flush mounted with captive hardware. All fasteners visible to the passengers on the inside of the car shall be stainless steel. All fasteners not visible to the passengers on the inside of the car shall be either stainless steel, zinc plated steel, or cadmium plated steel, as appropriate to the materials being joined.

Fasteners used on the exterior of the car, exposed to passengers, crew, and maintenance personnel, shall be flush mounted unless specifically approved by the Engineer. All exterior and roof fasteners shall be stainless steel hardware or martensitic stainless steel. Fasteners not visible to the passengers on the exterior of the car may be stainless steel, zinc plated steel, or cadmium-plated steel, as appropriate to the materials being joined.

When making connections to heat producing apparatus, thermal expansion of the components shall be taken into consideration for selection of fastener materials. If the joined components are high expansion alloys such as copper or austenitic stainless steel, austenitic stainless steel fasteners shall be used. If the joined components are low expansion materials such as carbon steel or ferritic stainless steel, zinc plated carbon steel fasteners of minimum Grade 5 shall be used.

Cadmium plated fasteners are not permitted.

Nyloc nuts and split locks shall not be used for critical fasteners. Other specialty lock washers shall be selected and only used with written permission of the Engineer.

Tapping plates shall be used attached to the car structure with mechanical fasteners. The tapping plate must be equal to or greater in thickness than the diameter of the bolt for which the tapping plate is intended, and a clearance hole shall be drilled in the structure for the bolt. Tapping plates shall be designed to the same strength standards as the equivalent nut.

### 17.2.2.2 Threaded Fasteners

#### 17.2.2.2.1 General

When bolts are used to secure apparatus where the bolt head is not accessible, a reusable mechanical locking device shall be used to prevent the bolt head from turning when the nut is being turned.

At least 1 1/2 full screw threads shall be visible beyond all nuts. When used without elastic stop nuts, bolts shall not project more than 1 1/2 full threads plus 1/4 inch for bolts, 1/4 inch diameter or less, and shall not project more than eight (8) threads for larger diameter bolts unless otherwise approved by the Engineer. With elastic stop nuts, bolt threads shall not project more than 1/4 inch regardless of bolt size.
UNC thread shall be at least 60 percent of the bolt minor diameter or have at least five (5) threads visible beyond all nuts, whichever is most stringent. Fine thread fastener thread shall be at least 75 percent of the bolt minor diameter or have at least five (5) threads visible beyond all nuts, whichever is most stringent.

Prevailing torque type locknuts shall be nylon insert type, ESNA, or approved equal, conforming to IFI Fastener Standards or Military Standard MS-21044.

All metal prevailing torque type locknuts shall only be used where there is insufficient clearance to install ESNA type locknuts or where the locknut is exposed to temperatures above 200 degrees F.

For truck connections when the bolt length used is the closest size available, the bolt may project more than the maximum threads allowed above but shall not project more than 1 1/2 full threads plus 1/2 inch. Where the additional bolt length could adversely affect maintenance access, the bolt projection shall be limited to 1 1/2 full threads plus 1/4 inch.

Undercar equipment shall not be supported by bolts in tension.

### 17.2.2.2 Inch Standard Fasteners

All inch standard threaded fasteners shall conform to ANSI B1.1 Standard, Unified Inch Screw Threads (UN and UNR Thread Form), or Industrial Fasteners Institute Fastener Standards.

### 17.2.2.3 Metric Fasteners

Upon approval by the Engineer, specific line replacement units (LRUs) that are supplied by a supplier or subsupplier to the Contractor may be supplied with metric fasteners to ANSI B1.13M (ISO-metric) Standards. All internal fasteners and threaded components of the approved unit shall have ISO-metric threads. Internal to components, there shall be no mixing of metric and inch threaded fasteners. External mounting fasteners and threaded connecting components shall have ISO-inch threads to ANSI B1.1 Standards. Each unit, component, or group containing ISO-metric threads shall be indelibly identified in an approved manner and in a conspicuous approved location, to signify that the unit contains metric threaded fasteners. All repair and maintenance manuals shall be conspicuously marked on each page where metric threaded fasteners were used within the unit. Replacement, repair, or maintenance parts supplied under this Specification shall contain all necessary replacement fasteners of the correct size and grade.

Metric fasteners shall be marked as required in "Metric Fastener Standards", Industrial Fasteners Institute’s latest edition.
17.2.2.3 Structural Fasteners

All structural fasteners shall have documentation identifying manufacturer and purchase specifications available for examination by the Engineer at the Contractor’s QA department. This documentation shall include the fastener material or grade and finish including plating material and specifications when applicable. Whether the buyer is a subcontractor, supplier, or the Contractor, the Contractor shall obtain and hold this documentation for a period ending no sooner than the termination date of the warranty period for the last car.

All safety related fasteners shall conform to the requirements of SAE J429, and a representative sample of each production lot of fasteners shall be tested for conformance to purchase specifications by an independent laboratory accredited by the American Association of Laboratory Accreditation (AALA) or approved equal. A production lot is defined as one size of fastener, from one manufacturer, produced during one continuous production run. Fasteners not meeting this definition of production lot shall be treated as separate lots. Testing shall be performed using sample quantities as proposed by the Contractor and approved by the Engineer. Tests conducted shall confirm that fastener material meets specified chemistry and strength requirements. The Contractor shall obtain certified test results from the testing laboratory and hold the documents for a period ending no sooner than the termination date of the warranty period for the last car.

All safety related fasteners that are plated or chemically cleaned shall have certifications showing freedom from hydrogen embrittlement, based on a representative sample of the actual production fasteners, tested for hydrogen embrittlement by the OEM Contractor or a supplier following ASTM F519 procedures. An ASTM F606 wedge test sample may be used in place of the F519 standard samples. Test loads shall be a minimum of 80 percent of yield strength or proof load and held for a minimum of 168 hours. Any failures shall reject the entire lot.

All structural bolts for undercar and overhead mounted equipment shall be a minimum Grade 5, and the bolt diameter shall be no less than 3/8 inch regardless of design load. Stronger fasteners shall be used if required by the application. The mounting and attachment bolts for undercar and overhead mounted equipment and equipment support structures or brackets shall be sized to the design strengths for Grade 2 bolts and Class A nuts.

Where applicable, safety related fasteners shall comply with all requirements of 49 CFR 231.

17.2.2.4 Decorative and Appearance Fasteners

All interior fasteners exposed to passengers shall be either bright or finished to match the surfaces being joined and installed such that the fastener head is flush with the mating surface.

Bright finished interior fasteners may be either austenitic or martensitic stainless steel.

All exterior fasteners, including the roof and those visible to passengers, shall be austenitic stainless steel. Fasteners used on the side sill to attach heavy equipment brackets are structural fasteners specified under the structural fasteners section.
Fasteners on access panels, plates, covers, or other components accessible by passengers shall be of a single style tamperproof type approved by the Engineer. Fasteners shall be quarter turn type if required by TS 17.2.2.1.

All decorative and appearance fasteners shall have documentation that identifies the manufacturer, base material, plating, or finish, if applied, and the fastener type. The Contractor or supplier shall maintain this documentation on file for the Engineer to review for a period ending no sooner than the termination date of the warranty period for the last car.

17.2.2.5 Torquing

All safety related fasteners, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, shall be torqued to a minimum preload equal to 75 percent of their proof load and "torqued striped" after torquing by paint or other approved means. All other fasteners shall be torqued to a value appropriate to the application so that they do not loosen in service.

Fastener installation torque for standard oiled or waxed bolts with standard or heavy hex nuts shall be calculated from Industrial Fasteners Institute Fastener Standards’ equations using values for "K" of 0.18 for unplated and 0.15 for plated threads. Locknuts shall be torqued in accordance with their manufacturer's recommendations, or the Contractor may conduct tests to determine the proper installation torque. For those nuts or bolts requiring "torque striping", the Engineer may require bolt torque tension tests to verify that the installed preload is equivalent to 75 percent of proof loads.

17.2.2.6 Washers and Lock Washers

Washers shall be used under the heads of all bolts and under all nuts. Washers shall be ANSI B18.22.2 or ANSI B18.22M as appropriate for the application. Where high strength fasteners are applied, washers shall be hardened and comply with IFI Fastener Standards.

Lock washers when applied shall conform to IFI Fastener Standards. Lock washers shall not be used for fatigue applications where the fastener must be torqued and marked. If applicable, prevailing torque nuts shall be used for these applications.

Other types of washers including Belleville washers may be used for special applications with approval by the Engineer.

17.2.2.7 Rivets and Lock Pins

Rivets and lock pins exposed to passengers shall be austenitic stainless steel or aluminum as appropriate to the materials being joined. Structural steel rivets shall conform to ASTM A 502 or American National Standard B 18.1.2 Standards. Rivets may be hand driven when hot and shall completely fill the rivet holes. Rivets driven cold shall be mechanically driven. Exposed heads shall be concentric with the shank and free from rings, fins, pits, and burrs.
Swage locking (Huck bolt type) fasteners shall conform to Military Specification MIL-P-23469. All rough surfaces of the collar end of these fasteners shall be machined or ground smooth where accessible to passengers, crew, or maintenance personnel performing routine maintenance functions. The Engineer shall be the final arbiter in determining whether an application is hazardous to maintenance personnel.

17.2.2.8 Plating of Fasteners

All carbon fasteners shall be plated with zinc unless specifically waived by the Engineer.

Zinc plating shall conform to ASTM-B-633 Type II and SC2, SC3, or SC4 or ASTM B695 Class 8 Type II.

Grade 8, Metric 10.9 or stronger fasteners shall not be plated if the OEM finish is other than plating.

Request for alternative coatings must be submitted to the Engineer for review and approval. The Contractor shall submit qualification results for each process used by each subcontractor applying the proposed coating as noted below.

Any request for alternative coating shall, as a minimum, include:

a. Coating manufacturer’s product data including required thickness

b. ASTM B117 test results from an accredited third party laboratory

c. Documentation of torque/tension characteristics

d. Supporting documentation from the coating manufacturer regarding the propensity for the coating process to cause hydrogen embrittlement of the fastener during coating

Regardless of the coating’s propensity for hydrogen embrittlement, each lot of high strength fasteners including OEM plated zinc or yellow bolts (Grade 5 or Metric Grade 8.8 or higher) shall be tested for hydrogen embrittlement. Each lot of lower strength fasteners shall be tested for hydrogen embrittlement if the coating has the possibility of causing hydrogen embrittlement.

If the proposed coating results in a change in the K-value for the plated fastener to outside the range of 0.13-0.15 as defined by Industrial Fasteners Institute Standard IFI-543, the vendor shall use the alternate coating on all fasteners within the particular LRU. The LRU shall contain an indelible label identifying the coating type used within the LRU and the required torque values for each size fastener used therein. Fasteners internal to a subcomponent within an LRU may use the standard coating system if they are not subject to removal during SEPTA’s maintenance activities. Alternative coatings shall not be used unless specifically approved by the Engineer.

Cadmium plated fasteners are not permitted.
17.2.2.9 Rivet and Bolt Holes

Rivet and bolt holes shall be accurately located and aligned, and when necessary during assembly, holes shall be reamed round to specified size in position. This allowance does not relieve the Contractor of the interchangeability requirements of the Specification. Bolt hole clearances shall not exceed the Industrial Fasteners Institute’s requirements. All removed and replaced rivets shall have the holes reamed to the size required such that the next larger rivet may be driven securely.

All holes for mechanical fasteners shall be clean and free of burrs. The Contractor shall submit a procedure for removing burrs on the far/blind side of the fastener hole and a method for inspection. [CDRL 17-004]

17.3 STAINLESS STEEL

17.3.1 General

Permitted uses of structural stainless steels uses are specified throughout this Specification. Ferritic stainless steels shall be painted where exposed to passengers or the weather. Austenitic stainless steels may be unpainted. Unpainted stainless steels exposed to passengers shall be a single grade of austenitic stainless steel in which both the color and surface finish of abutting pieces shall match except where the design specifically calls for contrasting appearance.

17.3.2 Austenitic Stainless Steel

Structural austenitic stainless steel components assembled by fusion or resistance welding shall be of AISI type 201L (UNS S20103), 301L (UNS S30103), 301LN (UNS S301153), or JIS SUS301L (with nitrogen) and shall conform to the requirements of ASTM A 666 except that the carbon content shall not exceed 0.03 percent and type 301LN and SUS301L (with nitrogen) shall not exceed 0.25 percent nitrogen. Other stainless steels conforming to ASTM A 666 are acceptable for non-welded applications.

Stainless steel used in structural applications covered by this Specification shall also conform to paragraph (f) from Section 2 of AAR “Specifications for the Construction of New Passenger Equipment Cars” and APTA-PR-CS-S-004-98.

General requirements for delivery of stainless steel shall be as required by the Certification Provisions of ASTM A 666, and stainless steel to be used in structural applications shall be tested for susceptibility to intergranular corrosion in accordance with ASTM A 262 latest revision. Practice A of ASTM A 262 can be used to accept material only; Practice E is required for final determination of acceptance or rejection of material that is not acceptable by Practice A.

The finish of any stainless steel components visible to passengers in the interior of the car shall be a grit finish professionally blended in regards to the shape of the object as applicable. Polished stainless steel is not acceptable.
17.3.3 Ferritic Stainless Steel

When specified, ferritic stainless steel conforming to ASTM A 176 may be used for sheeting up to 0.2 inch thickness. A ferritic stainless steel sheet shall have a ductile to brittle transition temperature (DBTT) or nil ductility temperature (NDT) below 0 degrees F. Weld heat affected zones shall also have a DBTT or NDT below 0 degrees F. A ferritic stainless steel sheet shall have a balanced composition (low carbon and/or suitable titanium content) that will for all conditions of fabrication and assembly into the carbody inhibit formation of martensetic and limit chromium depletion in weld heat affected zones so that the material shall meet ASTM A 763 requirements for resistance to intergranular corrosion.

General requirements for delivery of stainless steel shall be per ASTM A 480.

Where ferritic stainless steels are welded to other structural steels, the less noble steel shall be painted with weld through primer. Ferritic stainless steel shall be used only with specific written approval by the Engineer.

17.3.4 Testing

The Contractor shall prepare (or have prepared), submit, and receive approval from the Engineer of a test and inspection plan for acceptance of all stainless steel to be used in welded applications prior to purchasing any such material. The tests and inspections shall verify that the stainless steel conforms to specified requirements. For austenitic stainless steels, the test and inspection plan shall include frequency of submittal of certifications in accordance with the Certification Provision of ASTM A 666 and frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A 262. For ferritic stainless steel, the test and inspection plan shall include frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A 763. [CDRL 17-005]

17.4 LOW ALLOY HIGH TENSILE STEEL

17.4.1 General

Low alloy high tensile (LAHT) steel structural shapes, plates, and bars shall, as a minimum, conform to the requirements of ASTM A 588 where available. Plate steel may alternatively conform to ASTM A 710, Grade A, Class 1, 2, or 3. For trucks only, steel plate conforming to the minimum requirements of ASTM A 572 may be used with the approval of the Engineer. Where not available in A 588, hot rolled or formed structural shapes conforming to ASTM A 36 may be used for limited applications including equipment supports and jack pads.

General requirements for delivery of LAHT shapes, plates, and bars shall be as required by ASTM A6.

Cold and hot rolled LAHT sheet and strip shall, as a minimum, conform to the requirements of ASTM A 606, Type 4. General requirements for delivery of these products shall be as required by ASTM A 568.

Other low alloy high tensile steels, which meet or exceed the above minimum requirements, may be used provided their detailed specifications are submitted and approved as equivalent or better material for the proposed applications. All LAHT steel shall be applied according to their specification properties.
Welded LAHT steel shall develop 15 ft/lbs Charpy V Notch impact strength in the CGHAZ (coarse grain heat affected zone) 0.039 inches from the fusion area at -20 degrees F.

17.4.2 Testing
The Contractor shall prepare (or have prepared), submit, and receive approval from the Engineer of a test and inspection plan for acceptance of all structural steels in accordance with the requirements of this Section before purchasing any such material. The test and inspection plan shall include provisions for submission of reports and certification to the Engineer for each shipment in accordance with the applicable requirements of the purchase specification and the specified CGHAZ impact tests. [CDRL 17-006]

17.5 STEEL CASTINGS

17.5.1 General
The Contractor shall be responsible for selecting casting grade composition strength and finishing. However, steel castings used in the carbody structure and truck assemblies shall meet AAR Specification M-201, latest revision, Grade "B" plus two (2) percent nickel minimum. These castings shall be heat treated to develop a minimum tensile strength of 75,000 psi, a minimum yield strength of 48,000 psi, elongation of not less than 25 percent in two (2) inches, and reduction of area of not less than 50 percent. Also, steel castings used for coupler, drawbars, and anchors shall meet AAR Specification M-201, latest revision, grade "C" or “E” quenched and tempered.

Where cast steel of superior properties is required for a specific application, the Contractor may propose such castings for review and approval by the Engineer.

Stainless steel composition and processing must be selected such that the castings shall be able to meet or exceed the strength required by the specified application as determined by the Engineer. Stainless steel castings shall be made in accordance with the appropriate ASTM standard(s) depending on the type of stainless steel used. Other standards may be used upon approval of the Engineer.

17.5.2 Design Qualification of Structural Castings
One casting selected by the Engineer from the first lot of production castings shall be subjected to a qualification test of the casting design by the Contractor. Qualification tests shall include radiographic examination for material soundness using reference radiographs to ASTM E 446 and any mechanical testing.

A statistical sample of stainless steel castings, as agreed upon by the Engineer and the Contractor from the first lot of production stainless steel castings, shall be subjected to a qualification test of the casting design by the Contractor. Qualification tests shall include radiographic examination for material soundness using reference radiographs to ASTM E 446 and any mechanical testing.
Acceptance levels for the design qualification radiographic examinations shall be selected by the Contractor, as appropriate, for the service intended subject to the approval by the Engineer before any castings are produced. Radiographs shall meet the requirements of ANSI/ASTM E 94 and E 142 for steel castings and ASTM E 1742 for stainless steel castings, and the quality level in the area of inspection shall be at least two (2) percent (2-2T).

A qualification test report shall be prepared and submitted to the Engineer for approval. The production of any castings before receipt of the Engineer’s approval of this report shall be at the Contractor’s risk. All radiographs from the qualification test shall be made available to the Engineer for review. If the casting selected for qualification fails to qualify, a plan of action including details of how failed material will be handled shall be included in the qualification test report. After a design is qualified and accepted by the Engineer, no changes shall be made in the casting pattern, technique, heat treatment, or material composition without requalification in accordance with the requirements of this Section. [CDRL 17-007]

17.5.3 Quality of Structural Castings

All structural castings supplied shall be equal to or better than the design qualification castings in all respects. The casting supplier or Contractor shall test, inspect, and accept castings in accordance with procedures described in AAR Specification M-201. For stainless steel castings, the procedure shall be submitted by the Contractor for approval by the Engineer. In addition, the inspections below shall be performed and a written report of the results of the tests and inspections shall be furnished for each lot of castings produced. [CDRL 17-008]

17.5.3.1 Magnetic Particle Inspection

Magnetic particle inspections of all surfaces of each casting shall be conducted according to ASTM E 709 by personnel certified to MIL-STD-410. With respect to structural castings including coupler castings, the maximum permissible magnetic particle indications shall be not more than 1/4 inch in the direction transverse to the usual direction of loading and no more than 3/4 inch in the direction parallel to the usual direction of loading.

For martensitic and ferritic stainless steel castings, acceptance criteria shall be in accordance with ASTM A 903.

17.5.3.2 Radiographic Inspection

Radiographic inspection shall be conducted according to the requirements of ASTM Standards E-94 and E-142 using reference radiographs to ASTM E 446. Radiographic inspection of stainless steel shall be conducted in accordance with the requirements of ASTM Standards E-94, E-1742, and E-1030. A sampling frequency shall be proposed by the Contractor and submitted for approval by the Engineer. [CDRL 17-009]
Structural castings shall not exceed severity level 3 of ASTM E 446 in all critical areas of such castings and shall not exceed level 5 in all other areas of the castings. During a demonstration that the stated severity level requirements of ASTM E 446 have been met, successively produced castings shall be reinspected by radiography in the defective areas shown in the prior radiographic inspection. After such severity levels have been proved, the sampling frequency for structural castings shall be one (1) casting out of each ten (10) produced. If no castings are rejected by radiographic inspection, this frequency may be extended to one (1) casting in 25.

To control the internal solidity of the couplers, yokes, and knuckles castings, the sectioning method defined in the AAR M-211 Standard (Section 4.2.3.1) shall be used instead of doing radiographic inspection. The control plan for casting internal solidity shall be as follows:

a. Capability of meeting internal solidity requirement shall be established at the beginning of production and every six (6) months thereafter by sectioning three (3) specimens from each design group listed in paragraph 4.2.1 of standard AAR M-211. Each specimen shall be from a different heat. However if any design group production is less than 1,000 during this frequency period, no test is required. In any case, at least one (1) test is required per year for each design group. After two (2) years of successful sectioning results, the manufacturer may reduce the frequency of sectioning to one (1) casting each year per design group. Castings will also be sectioned whenever significant changes are made in foundry practices. If a test fails, the manufacturer will be required to reestablish the base of two (2) years of successful tests before going to the reduced frequency of testing.

Note: The solidity test shall be performed as per Standard AAR-211, Sections 4.2.3.2, 4.2.3.3, and 4.2.3.4. The inspection method for this test shall be as per AAR M-211 by comparison with acceptance criteria of paragraph 4.2.3.5 where the “F” type criteria shall apply for the coupler head, coupler shank, and yoke, and the “E” type criteria shall apply for the knuckle.

b. Fracture toughness tests and other tests on coupons shall be done once every two (2) months as per AAR M-211 Section 4.3.

c. Visual inspections on all couplers, knuckles, and yokes shall be done. Acceptance criteria shall be per AAR M-211 Section 13.2.

d. Hardness tests on each heat lot shall be done for couplers, yokes, and knuckles as per AAR M-211 Section 4.3.

e. Dimensional checks shall be performed on each piece with AAR gages.

17.5.3.3 Liquid Penetrant Inspection

For non-magnetic stainless steel castings, liquid penetrant inspections of all surfaces of each casting shall be conducted according to ASTM E 165 by personnel certified to MIL-STD-410. Acceptance criteria shall be established in accordance with ASTM A 903.
17.5.4 Repair Welding and Cast Weld Design

Repair welding of castings is permitted provided the casting supplier performs all repair welds according to the structural welding requirements of TS 17.22. Castings requiring repair or modification by welding after completion of heat treatment may be stress relieved locally by using electrically controlled heating not greater than 1150 degrees F and slow cooling. Manual torch stress relief shall not be permitted. For cast weld designs, the entire length of all assembly welds on any welded assembly of several separate castings selected for design qualification shall be radiographically inspected to ANSI/ASTM E94 and E142 using reference radiographs from the International Institute of Welding's "Collection of Reference Radiographs of Welds" quality level Green. Portions of assembly welds stressed in tension by service loads shall meet quality level Blue.

No repair welding of stainless steel castings shall be permitted without written approval by the Engineer.

17.5.5 Disposal of Non-Conforming Castings

If castings are found to be non-conforming to requirements determined by the design qualification castings, the material shall be repaired, retested, reinspected or destroyed at the Contractor's expense.

17.6 ALUMINUM

17.6.1 General

Aluminum alloy mill products shall be identified by the Unified Numbering System designations and shall conform to the Aluminum Association specifications contained in the Association's publication "Aluminum Standards and Data". Aluminum alloy castings used for door thresholds shall conform to ASTM B-26, B-85 or B-108, respectively, for sand, die, or permanent mold castings, respectively. Aluminum alloy forgings shall conform to ASTM B-247. Copies of all test reports for sheet, extrusion, and forgings used in the car structure shall be submitted to the Engineer. [CDRL 17-010]

17.6.2 Design Stresses

Any aluminum structural members shall be designed so that calculated stresses under the specified AW3 passenger load do not exceed the allowable stresses per APTA-PR-CS-S-015-99, listed in the latest revision of the Aluminum Association of America's "Specification for Aluminum Structures" for bridge and similar type structures and "Engineering Data for Aluminum Structures." Proper allowance shall be made for the effects of fatigue for column and plate stability effects and for strength reduction at welded regions. Permissible fatigue stresses under the specified AW3 passenger load shall be established with approval based on available relevant research data or on prototype testing under the variable load patterns expected to occur in service.
17.6.3 Fabrication and Fastening

The forming of aluminum parts, joining of parts by bolting, riveting, and welding, and the protection of contact surfaces shall, as a minimum, conform to the requirements of the Aluminum Company of America's Technical Report No. 524, "Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles", except as otherwise specified herein.

Fabrication techniques shall be such that the strength and corrosion resistance of the aluminum shall not be impaired or the surface finish permanently marred or discolored during construction.

17.6.4 Protection of Contact Surface

The specific measures to be taken by the Contractor to prevent the risk of direct metal to metal contact and resultant possible electrolytic corrosion shall be approved and shall depend upon the determination of the most suitable method which can be adapted to the design involved. The following instructions shall be the minimum protection:

a. Aluminum alloy surfaces shall not be secured to or make direct contact with the surfaces of copper, copper bearing aluminum alloy, brass, bronze, silver, nickel, nickel alloys, nickel plated parts, lead, tin, wood, or stainless steel.

b. The contact surfaces of aluminum alloy with aluminum alloy shall be painted with zinc chromate primer, or approved equal, before securing.

c. The surfaces of aluminum alloy parts secured to steel parts, where exposed to weathering or harsh environments, shall be protected with a one part polysulphide sealant, zinc chromate paste, mica insulation joint material, or an approved equivalent material which completely covers the faying surfaces. The insulating material shall be non-hygroscopic, and if fibrous shall be impregnated with bitumen or an approved non-corrosive, water, and moisture repellant substance. After driving, fasteners shall be primed and painted with red oxide or aluminum paint.

d. Stainless steel and carbon steel fasteners plated with zinc shall be coated with zinc chromate paste, or approved equal, before installation. Where possible, only the head and the shank of the bolt shall be in contact with the aluminum part when secured in place. Suitable bushings may be used in place of the zinc chromate paste.

17.6.5 Interior Trim

Where unpainted aluminum is exposed to contact by passengers, it shall have a clear (natural) anodic finish. The finish process shall be the Aluminum Company of America's "Alumilite 204" with a minimum coating thickness of 0.0004 inch and a minimum coating weight of 21 mg/square inch, or approved equal process.
17.7 ELASTOMERS

17.7.1 General

The elastomer shall be compounded and cured to perform satisfactorily in the temperature range specified and the SEPTA operating environment. The elastomers shall have high resistance to ultraviolet radiation, weather, all car washing and other cleaning fluids, and the longest possible life consistent with the other characteristics specified. All elastomeric parts shall be resistant to ozone, oxidation, heat, oil, grease, and acid.

All elastomeric parts shall be of neoprene unless otherwise specified. Silicone may be used for high and low temperature applications which require a more resistant material. These applications shall be approved by the Engineer. Specifically, long term exposure to temperatures lower than -35 degrees F and higher than +150 degrees F shall require the use of silicone.

All resilient mounts shall be of natural rubber. Synthetic rubber compounds may be substituted for natural rubber only when approved by the Engineer for a specific application.

The following elastomeric parts shall have a minimum service life of ten (10) years, unless otherwise specified and approved by the Engineer:

a. Window glazing securement seal
b. Door panel and door post seals
c. Door nosing
d. Cover and access panel gaskets and seals
e. Isolation pads and tapes

Elastomeric parts used with pneumatic and hydraulic equipment shall comply with this Section unless otherwise approved by the Engineer.

17.7.2 Tests

All tests shall be conducted according to the latest revisions of the specified ASTM test procedures, unless otherwise specified. All resilient natural rubber mounts and elastomeric truck suspension components shall be tested in accordance with the procedures outlined for elastomers in TS 17.7; the results of the testing shall be submitted to the Engineer for approval. [CDRL 17-011]

The test specimens shall be cut out from the proposed material, and at least one (1) tensile strength and elongation test and one (1) accelerated aging test shall be made on the material used for each order. If the compound or cure or both are changed during the production of material for one (1) order, at least one (1) test of each type shall be made for each different batch.
When testing the six (6) inches by 1/2 inch ASTM "dumb bell" type test specimen (or smaller size if the size of the part necessitates) by the methods specified in ASTM D3182, D3183, D3190, and D412, the tensile strength shall not be less than 1,500 psi and elongation shall be a minimum 350 percent. The tensile strength of the elastomer shall not be reduced more than 25 percent when subjected to accelerated aging by the methods specified in ASTM D573 for a period of 96 hours in an air oven at 158 degrees F.

The ozone resistance of the elastomer shall be tested in accordance with ASTM D1149 using an ozone concentration of 100 pphm, an exposure time of 100 hours at 100 degrees F, and a specimen elongation of 20 percent. The elastomer shall not exhibit any cracks during the test period.

17.7.3 Life Expectancy

For all parts made by vulcanizing an elastomer to metal, any premature failure, (less than six (6) years or less than ten (10) years as specified in this Section) between metal and the elastomer or in the elastomer occurring when the parts are used in normal service and according to the provisions of this Specification, shall be considered as having been caused by defect of design, materials, or workmanship.

17.7.4 Metal Parts

Metal parts to which elastomeric material is vulcanized shall be made of SAE 1020 or 1045 or equivalent hot-rolled steel, except for air brake components that use SAE Grade CA260 annealed brass, unless otherwise approved by the Engineer.

17.7.5 Bonding

The joining of elastomeric pieces shall be conducted by the hot vulcanization process. Bonding of elastomers shall not be allowed unless specifically approved by the Engineer. For an alternative bonding, the Contractor shall submit for review of the Engineer the proposed bonding procedure/process and technical data for all procedure/process components prior to purchase of any materials.

17.7.6 Truck Parts

Truck bumpers, snubbers, elastomeric components, and the exterior surfaces of air springs shall be made of natural rubber or approved equal. They shall be compounded to be resistant to abrasion when applicable, oil, grease, and acid.

17.7.7 Seals

Glazing strips shall be of neoprene conforming to ASTM C542 or approved equal material.

All door mating edges, door and window seals, and glazing strips shall be of neoprene material. The durometer hardness measured with a Shore Type "A" durometer at a temperature between 70 degrees F to 90 degrees F shall be 70 ± 5 unless otherwise required for the application and approved by the Engineer.
17.8  GLAZING MATERIALS

17.8.1  Safety Glass
Safety glass shall meet the requirements under Item 1, Table 1 of ANSI Z26.1, "American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways - Safety Code”, and 49 CFR 223 and 238 FRA Type I or II test as appropriate for the application.

17.8.1.1  Glass Type
All safety glass shall be of the laminated type.

17.8.1.2  Flatness
When an individual light of glass is laid on a truly flat surface such as a surface plate, the glass shall not indicate a bow of more than 0.030 inch per linear foot in any direction.

17.8.1.3  Dimension Tolerance
The overall dimensions of individual lights as supplied shall be held within 0.060 inch of the dimensions ordered. The thickness of individual lights shall be held within 0.020 inch.

17.8.1.4  Overlap Tolerance
The overlap of one (1) laminate of the light with respect to the other at an edge shall not exceed 1/32 inch. Corners and burrs shall be ground smooth, and all edges shall be treated in accordance with ANSI Z26.1, Section 6.

17.8.1.5  Color
The color of the glass shall be as required by TS 3.7. When new, there shall be no more than ± 4 percent variation in the color of individual lights of laminated sheet glass when examined over a white background.

17.8.1.6  Haze
All the laminates of the safety glass shall be so nearly free from haze that the glass shall have approximately the same clarity as a light of the same nominal thickness of plate glass when viewed against a north light.
17.8.1.7 Specks and Scratches
Occasional specks of foreign material and scratches are permissible provided such specks do not exceed 0.020 inch in greatest dimension and scratches do not exceed a total of three (3) inches in length and neither are within the central three quarters area of the light.

17.8.1.8 Bond Separation
The bond between two (2) sheets of glass and the membrane shall be of such quality that when the glass is broken by twisting or by direct impact, there will be no separation between the glass sheets. Lights that contain unbonded areas (let-go's) shall not be used.

17.8.1.9 Marking
All safety glass shall be marked with proper identification in accordance with ANSI Z26.1, Section 7, and appropriate FRA Type designation per 49 CFR 223 and 238 by the supplier. The identification marking legible 0.10 inch high lettering shall be located in the lower right hand corner as viewed from the interior of the car. The identification shall be no closer than 3/4 inch to the edge. The identification shall give the product name, manufacturer, serial number, and FRA Type I or II designation. Marking shall be legible and permanent for this application and shall be applied in such a manner so as not to reduce the integrity of the coating. The light shall be installed so that the marking can be read from the inside.

17.8.1.10 Light Transmission
Visible light transmission through safety glass shall be a minimum of 85 percent.

17.8.1.11 Documentation
The Contractor shall certify that the shipped material complies with the requirements in the Technical Sections [CDRL 17-012].

17.8.1.12 Quality Assurance
The Contractor shall be responsible for the performance of all inspection and test requirements. Except as otherwise specified, the Contractor may utilize the facilities of its supplier or any approved commercial laboratory.

17.8.1.13 Shipping
The material shall be carefully prepared for shipping and shall be properly protected to prevent damage. If a pressure sensitive masking is used, it shall be easily stripped from the material and not leave a gummy or sticky residue.
17.8.2 Plastic Glazing

17.8.2.1 General
This Specification establishes the material requirements, manufacturing process, properties, and quality assurances for abrasion resistant plastic glazing materials. The required tests shall be performed and test reports submitted as part of the product qualification documentation to be submitted to the Engineer for approval prior to use of the material. [CDRL 17-013]


17.8.2.2 Applicable Documents
The latest issue of the following documents in addition to those specified in this Section shall form a part of this Specification:

a. ASTM D673 – Mar Resistance Test


c. ASTM G23 – Recommended Practice for Operating Light - and Water - Exposure Apparatus (Carbon Arc Type) for Exposure of Nonmetallic Materials

d. ASTM D1499 – Recommended Practice for Operating Light - and Water - Exposure Apparatus (Carbon Arc Type) for Exposure of Plastics

e. ASTM D1003 – Recommended Practice for Determining Haze Factor

f. ASTM E162 – Radiant Panel Test for Determining Flame Propagation Index (I,)

g. 49 CFR Part 223 – Impact Requirements

h. ASTM E 662 – Test to Determine Smoke Emission Values (D,)

17.8.2.3 Material Physical Properties
Plastic glazing shall meet the following requirements:
a. Strength

Samples shall be prepared and tested according to 49 CFR Part 223 and 238 and Test No. 10, Article 5.10, of ANSI Standard Z26.1.

Samples shall not break or shatter when subjected to the falling dart impact requirements of Test No. 10. The dart tip shall be no more than 0.50 inch radius. Denting or marring of the surface of the test piece is permissible.

b. Light Transmission

Visible light transmission through clear plastic glazing shall not be less than 85 percent in 0.125 inch thickness, 82 percent in 0.250 inch thickness, 80 percent in 0.375 inch thickness, and 78 percent in 0.5 inch thickness. Visible light transmission through the tinted passenger side windows shall be 23 percent ± 4 percent.

c. Weathering Test

The materials shall pass the long arc Xenon lamp weathering Test No. 16 of ANSI Standard Z26.1.

d. Color

The color of the plastic glazing shall be as required by TS 3.7. The materials shall have UV stabilizer additives to inhibit fading and loss of properties due to extended exposure to direct sunlight. When new, there shall be no more than four (4) percent variation in the color between lights of plastic material of a specified color and thickness when examined over a white background and measured by the appropriate light transmission or color meter inspection and test instruments.

17.8.2.3.1 Abrasion Resistance

Plastic glazing materials shall be silicone coated on both sides to increase resistance to abrasion. The coated plastic shall meet the following specifications:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion Resistance</td>
<td>ANSI Z26.1 Test 17</td>
<td>Change in percent haze after 100 cycles shall be less than six (6)</td>
</tr>
</tbody>
</table>

The test shall be conducted initially and after 300 hours of weatherometer testing.
17.8.2.3.2 Chemical Resistance

Samples shall be prepared and tested according to Test 19, Article 5.19, of ANSI Z26.1. The exposed fabricated edges of the test samples may be coated with the same material as the face surfaces by the manufacturer. In addition to those chemicals specified in this test, the test shall also include, but not be limited to, such cleaning solutions as dilute oxalic acid solution (3 percent by weight), 1/2 strength NelecoProducts Subway Soil Solvent - Parts 1 and 2 and Electrosol. The exposure time of the test shall be increased to one (1) hour intimate contact with the test chemicals on the faces of the test sample. The contaminants shall be either wiped or sprayed onto the coated faces of the test sample. Any tackiness, crazing, or apparent loss of transparency shall be cause for rejection. After immersion, a change in percent haze greater than five (5), as measured by Test 17 of ANSI Z26.1, shall be cause for rejection.

To produce the specified one half strength solution of Subway Soil Solvent, mix parts 1 and 2 in the following ratio:

a. Part 1 – one (1) gallon (U.S.) liquid acid solution as received

b. Part 2 – two (2) pounds of the crystalline and catalyst mix dissolved in ten (10) gallons (U.S.) of water

17.8.2.3.3 Adhesion of the Coating Materials

The abrasion resistant coating materials shall retain adhesion to the substrate materials when subjected to Test No. 10, Article 5.10, of ANSI Standard Z26.1. The coating shall also pass a standard cross cut adhesion test. This test consists of scribing a grid of four (4) horizontal and four (4) vertical one (1) inch long lines through the coating with a sharp steel blade. Pressure sensitive tape, Scotch brand No. 335-2, is then pressed firmly over the scribed area and pulled away at a 90 degree angle to the sample sheet. The coating shall pass the test if no coating is removed from the substrate material.

17.8.2.3.4 Dimensional Tolerance

The overall dimensions of individual units as supplied shall be within 0.030 inch of the nominal dimension specified. The thickness of the plastic materials shall be within a tolerance of +5 percent of the nominal thickness.

17.8.2.3.5 Flatness

When an individual light is placed on a truly flat surface such as a surface plate, the material shall not indicate a bow of more than 0.031 inch per linear foot in any direction.

17.8.2.3.6 Edge Work

All edges shall be straight and perpendicular to the surface, and shall be sawed or routed and reasonably free of burrs in order to prevent cutting of the rubber glazing strips. Sharp corners shall be removed around the entire periphery.
17.8.2.3.7 Optical Quality

Optical quality of the plastic glazing materials shall be in accordance with Test No. 15, Article 5.15.2.2, of ANSI Z26.1. Under the specified procedure, no light and dark patches existent over the entire area shall appear in the shadow of the unmasked area of the specimen before the specimen shall have been moved a distance of at least 14 inches from the screen.

Protective covering shall be marked to permit orientation of extrusion grain for most favorable results at installation. This extrusion grain axis shall be horizontal in the installed light.

There shall be no detectable cracking of the coating as indicated by fine radial cracks at the point of impact when struck with 2 1/2 ft/lbs energy from a dart having a 1/2 inch radius tip. The impacted specimen shall be examined for radial cracks visible by transmitted light.

No detectable cracks in the coating shall develop when the specimen is strained two (2) percent. Stress may be applied by imposing 6,000 psi loading using a tensile testing machine.

17.8.2.4 Material Quality

17.8.2.4.1 Foreign Material and Inclusion Defects

The guidelines concerning foreign material and inclusion defects are as follows:

a. Less than 0.009 inch – allowed without population limit to the extent that they do not constitute a severe defect such as clustering

b. 0.010 inch to 0.019 inch – allowed up to ten (10) per ft² average over the area of the light

c. 0.020 inch to 0.050 inch – allowed up to three (3) per ft² average over the area of the light

d. 0.051 inch to 0.065 inch – allowed one (1) per ft² average over the area of the light

e. 0.066 inch to 0.150 inch – allowed one (1) per edge only in the outer 25 percent of the light

f. 0.151 inch and above – shall be cause for rejection

Note: There shall be no black speck clusters of three (3) or more above 0.019 inch in a one (1) inch diameter circle.

Defects occurring in those areas of the lights which shall be covered by the glazing strips shall not be cause for rejection.

In the basic material, there shall be no clusters of bubbles, no chain bubbles, and no bubbles larger than 0.030 inch in diameter.

Bubbles of 0.020 inch to 0.030 inch in diameter, if present, shall have a minimum separation of 3.0 inches.
In any 2.0 inch diameter area of glazing material, there shall be no more four (4) bubbles in the 0.011 inch to 0.20 inch diameter range.

**17.8.2.4.2 Fibers and Scratches**

Fibers and scratches less than 0.060 inch in length are allowable without population limit to the extent that they do not constitute a severe defect such as clustering. Fibers and scratches from 0.060 inch to 0.125 inch in length are allowed up to a maximum of two (2) per ft² average over the area of the light. Fibers and scratches from 0.125 inch to 0.250 inch in length are allowed up to a maximum of one (1) per ft² average over the area of the light. Fibers and scratches greater than 0.250 inch in length are not allowed.

Fine scratches, which are detectable only when viewed in bright back lighting, are acceptable.

**17.8.2.4.3 Apparent Runs**

The guidelines concerning apparent runs are as follows:

a. 0.125 inch and under - allowed without population limit to the extent that they do not constitute a severe defect such as clustering

b. 0.126 inch to 0.250 inch – allow four (4) per ft² average over areas of light but not to the extent that they constitute a severe defect

c. 0.251 inch to 0.500 inch – allow one (1) per ft² providing they do not constitute a severe defect

d. 0.501 inch to 1.00 inch – allow one (1) per edge only in the outer 25% of light area

e. 1.01 inch or above – shall be cause for rejection

**17.8.2.4.4 Orange Peel**

"Orange Peel" in the surface shall be cause for rejection of the material if it exceeds the standards to be established between the Contractor and the Engineer prior to manufacture.

**17.8.2.4.5 Quality Assurance**

The Contractor shall be responsible for the performance of all inspection and test requirements. Except as otherwise specified, the Contractor may utilize the facilities of its supplier or any approved commercial laboratory.
17.8.2.4.6  **Shipping**

The material shall be carefully prepared for shipping and shall be properly protected to prevent damage. If a pressure sensitive masking is used, it shall be easily stripped from the material and not leave a gummy or sticky residue.

17.8.2.4.7  **Identification**

Each light shall be marked for identification, in accordance with the requirements of ANSI Z26.1, Section 7, except tinted glazing, reference TS 17.8.2 and 49 CFR 223, by the supplier in legible letters 0.1 inch high in the lower right hand corner as viewed from the inside of the vehicle. This identification shall be no closer than 3/4 inch to the edge. The identification shall give the product name, manufacturer, and FRA Type I or II designation. Marking shall be legible and permanent for this application and shall be applied in such a manner so as not to reduce the integrity of the coating. The light shall be installed so that the marking can be read from the inside.

17.8.2.4.8  **Documentation**

The Contractor shall certify that the shipped material complies with the requirements in this Specification. [CDRL 17-014]

17.9  **WOOD AND PANELS**

17.9.1  **Lumber**

Lumber shall be sugar or black maple, sweet or yellow birch, only. Lumber shall be thoroughly air seasoned or kiln dried before using so as not to have a moisture content of greater than 12 percent. Lumber shall be dressed on all surfaces to full dimensions. Lumber shall be straight grained free from dry rot, knots, checks, and other defects which may impair its strength and durability or mar its appearance.

17.9.2  **Plymetal**

The term "plymetal," as used in this Specification, means metal faced plywood. All plymetal panels shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Mechanical Properties</th>
<th>Minimum Metal to Wood Average Shear Value or 80 Percent Wood Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry shear</td>
<td>250 lbf/in²</td>
</tr>
<tr>
<td>Boil shear, three (3) hr. boil, tested wet at room temperature</td>
<td>150 lbf/in²</td>
</tr>
<tr>
<td>Soak shear, 48 hr. soak wet at room temperature</td>
<td>150 lbf/in²</td>
</tr>
</tbody>
</table>
### Mechanical Properties

<table>
<thead>
<tr>
<th></th>
<th>Minimum Metal to Wood Average Shear Value or 80 Percent Wood Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creep or cold flow, under static load for 48 hrs., at room temperature</td>
<td>250 lbf/in²</td>
</tr>
</tbody>
</table>

The metal face of the plymetal panel that is faced with melamine shall be constructed prior to the melamine faced metal panel being laminated to the plywood core.

#### 17.9.3 Plywood

All plywood shall be manufactured to conform with the requirements of Group 1, Exterior or Exposure 1 durability, of U.S. Product Standard PS1/ANSI A199.1, and then stored under cover. Scarf or finger jointed panels shall not be allowed. All plywood shall be sealed with two (2) coats of epoxy paint on all edges and cutouts as soon as possible after fabrication. All exposed edges of panels, joints between panels, fastener heads, and openings of panels used in areas accessible to moisture shall be waterproofed and sealed with an approved coating prior to installation in the car.

#### 17.9.4 Honeycomb Panels

The term "honeycomb panels" as used in this Specification refers to an assembly of honeycomb material bonded to melamine faced metal panels or to metal panels. Honeycomb panels shall not be used for any load bearing surface other than ceiling panels.

All penetrations for fasteners and inserts must be sleeved and potted.

Aluminum honeycomb material shall be commercial grade meeting the requirements of MIL-C-7438G. Bonding shall be sufficient to develop the full strength of the honeycomb material.

Stainless steel faced stainless steel honeycomb panels shall be constructed in accordance with the requirements of MIL-A-9067. The adhesive bond strength of the honeycomb core to the stainless steel face shall not be less than 15 lb/inch climbing drum strength when tested in accordance with MIL-STD-401. The adhesive bond strength of the integral stainless frame to stainless steel face shall not be less than thirty 30 lb/inch climbing drum strength when tested in accordance with MIL-STD-401. Stainless steel honeycomb panels shall be tested in accordance with MIL-STD-401B to demonstrate the following requirements:

- a. Core shear yield at 200 degrees F 250 lbf/in²
- b. Flatwise tension at 200 degrees F 250 lbf/in²
- c. Beam flexure at 200 degrees F 75,000 lbf/in²
- d. Core shear fatigue at R.T. 150 lbf/in² @ 10⁶ cycles
- e. Flatwise tension at R.T. 250 lbf/in² @ 10⁶ cycles
- f. Beam flexure at R.T. 50,000 lbf/in² @ 10⁶ cycles

No other honeycomb materials are permitted.
17.9.5 **Panel Contour Tolerance**

Surfaces exposed to passengers shall not deviate from the specified contour by more than 3/32 inch in any 36 inch distance. The slope of any such deviation shall not exceed 3/32 inch in 12 inches.

17.9.6 **Melamine Faced Aluminum**

Melamine faced aluminum panels shall be constructed by laminating melamine to aluminum sheets. The melamine impregnated papers shall be directly molded to the aluminum sheets at temperatures of no less than 270 degrees F and pressure no less than 1000 psi. The surface characteristics after manufacture shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3 latest revision. The melamine and the required binder sheets shall be 0.015 +/- 0.005 inches thick. The aluminum sheets shall not be less than 0.025 inch in thickness when used as a facing on plywood. The aluminum sheets shall not be less than 0.081 inch in thickness when not laminated to a substrate such as plywood. Aluminum sheets shall be properly cleaned by etching, sanding, or other approved process to ensure full permanent adhesion.

The use of contact adhesives to bond the melamine sheets to the aluminum backing is prohibited.

The bond between the melamine and aluminum sheets shall, as a minimum, meet the following requirements:

a. **Internal bond (ASTM D952):**
   
   2,600 lbf/in²

b. **Flexural strength – (S) (ASTM D790)**
   
   - with grain: 26,500 lbf/in²
   - crossgrain: 25,300 lbf/in²

c. **Modulus of elasticity – (E) (ASTM D790)**
   
   - with grain: 2.8 x 10⁶ lbf/in²
   - crossgrain: 3.1 x 10⁶ lbf/in²

d. **Tensile strength (ASTM D638)**
   
   - with grain: 22,300 lbf/in²
   - crossgrain: 20,300 lbf/in²

17.9.7 **Phenolic Composite Floor Panels**

The phenolic composite floor panels shall be designed to withstand the following physical requirements with no visible or audible indications of delamination of the panel skin from the core and permanent deformation of the top surface and shall be less than 0.010 inch unless otherwise specified. There shall be no puncture or damage to fibers of the top surface. There shall be no separation of any internal core from the top or bottom skin. There shall be no fracture of the core. All test results are required to be submitted to the Engineer for approval. [CDRL 17-015]
a. Indentation Resistance

The floor panel shall withstand a concentrated load of 300 pounds applied to a test dowel that has an overall 0.375 square inch surface area with a 0.0625 inch radius on the bottom edge of the test dowel.

b. Static Load Test – Average Loading

A representative sample section of the flooring (without rubber floor covering attached) shall be supported on beams spaced at the maximum spacing used on the car using production bonding and fastening techniques. A uniformly distributed load in accordance with the crush loading requirements of TS 2 shall be applied to both sides of the joint (butt and/or shiplap). There shall be less than a 0.088 inch deflection.

c. Static Load Test – Maximum Loading

Using the identical floor panel-mounting configuration as described above, a uniformly distributed load of 200 lb/ft² shall be applied to both sides of the joint (butt or shiplap).

d. Small Area Static Load Test

Using the identical floor panel mounting configuration as described above, a 300 pound load shall be applied to a 1.0 inch x 3.0 inch contact area directly over the midspan six (6) inches from the outer carbody sidewall edge. The footprint shall be machined flat within 0.010 inch and the edges shall have a radius of not more than 0.125 inch. There shall be less than 0.200 inch deflection as a result of the load applied.

e. Small Object Impact Test

Using the identical floor panel mounting configuration as described above, a 16 pound standard bowling ball shall be raised directly over the mid-span 24 inches from the edge of the panel and dropped from a height of 60 inches. Permanent deformation of the top surface shall be less than 0.063 inch. Some core damage and some skin separation, radiating outward in a circular pattern with an approximate radius of 6.5 inches from the center of impact, shall be allowed.

f. Large Object Impact Test

Using the identical floor panel mounting configuration as described above, a 150 pound load shall be dropped upon a 3.0 inch x 8.0 inch contact “footprint” pad located directly over the midspan 24 inches from the edge of the panel and dropped from a height of 12 inches. The “footprint” pad shall have a rubber pad on the downside surface with a Shore D 70 minimum at a (one) 1 inch thickness machined flat within 0.060 inch with edges having a radius of not more than 0.030 inch. Permanent deformation of the top surface shall be less than 0.030 inch. Some damage to the top phenolic composite skin is allowed in a 6.5 inch diameter.
g. Rolling Load Test

Using the identical floor panel mounting configuration as described above, a four (4) wheeled cart with a load of 200 pounds per wheel shall be rolled on the panels laterally, longitudinally, and in a circular path with a 2.0 foot radius. The wheels shall be three (3) inches in diameter one (1) inch wide with a 0.125 inch radius on each edge with a Shore A durometer of 80.

h. Smoke and Flammability

When tested to ASTM E162-98, the maximum Iₐ ≤ 5. No flaming or dripping pieces are permitted. When tested to ASTM E119, latest version, a floor panel sample shall pass all test criteria and achieve an endurance rating of 30 minutes and in addition shall not exceed a surface temperature of the unexposed side (top surface) of 120 degrees F during the test. When tested to ASTM E662-97, the following maximum values shall be obtained:

1)  Dₛ (1.5) ≤ 0.4 (non-flaming) Dₛ (1.5) ≤ 4.5 (flaming)
2)  Dₛ (4.0) ≤ 16.5 (non-flaming) Dₛ (4.0) ≤ 55.4 (flaming)

i. Toxic Gas Generation

Composite floor panel samples shall be tested to BSS 7239 and meet the requirements of:

1)  HCN < 150 ppm
2)  CO  < 3500 ppm
3)  NO/NO₂ < 100 ppm
4)  SO₂ < 100 ppm
5)  HF  < 200 ppm
6)  HCL < 500 ppm

17.10 SEAT CUSHION MATERIAL

All padded seat cushions shall consist of one (1) piece molded or fabricated low smoke and flame retardant foam designed for long term rail vehicle service durability. All seat cushions shall meet the smoke and flammability requirements of TS 17.24. Seat bottom cushions shall be an open cell silicone foam, Magnifoam Delaware Inc. MF1 series bun stock, or approved equal, and shall meet the following test criteria:

<table>
<thead>
<tr>
<th>ASTM Test Method</th>
<th>Physical Property</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1056</td>
<td>Density</td>
<td>9.5 ± 1 lbs/ft³</td>
</tr>
<tr>
<td>D1056</td>
<td>Compression Set</td>
<td>0%</td>
</tr>
<tr>
<td>D412</td>
<td>Tensile Strength</td>
<td>15.0 lbs/in² minimum</td>
</tr>
<tr>
<td>D412</td>
<td>Ultimate Elongation</td>
<td>100 percent minimum</td>
</tr>
</tbody>
</table>
Seat back cushions shall be an open cell combination of chloroprene latex and polyurethane foam, Chestnut Ridge Foam, Inc. CR Safeguard series, or approved equal, designed for long term transit service durability. The foam shall meet the following test criteria:

<table>
<thead>
<tr>
<th>ASTM Test Method</th>
<th>Physical Property</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 3574 (A)</td>
<td>Density</td>
<td>7.5 lbs/ft³</td>
</tr>
<tr>
<td>D 3574 (D)</td>
<td>50 Percent Deflection</td>
<td>10 percent maximum</td>
</tr>
<tr>
<td>D 3574 (E)</td>
<td>Tensile Strength Ultimate</td>
<td>8 lbs/in² minimum150% minimum</td>
</tr>
<tr>
<td></td>
<td>Elongation</td>
<td></td>
</tr>
<tr>
<td>D 3574 (H)</td>
<td>Resilience</td>
<td>30 percent minimum</td>
</tr>
<tr>
<td>D 3574 (I3)</td>
<td>Pounding Fatigue</td>
<td>35 percent maximum IFD loss</td>
</tr>
</tbody>
</table>

In addition when tested to ASTM D1055, the back cushions shall have a maximum of ten (10) percent (deflection change) compression set in the suffix H flexing test and a maximum of 20 percent change in the 25 percent IFD value in the accelerated aging test (70 hours at 212 degrees F).

17.11 SEAT UPHOLSTERY MATERIAL

17.11.1 Cloth Fabrics

17.11.1.1 General
Cloth fabrics used for seat upholstery shall be made of woven transportation grade fabrics of wool, wool/nylon blend (90/10, 85/15), or an approved flame resistant polyester. The maximum fabric shrinkage shall be two (2) percent in either the warp or fill direction.

17.11.1.2 Physical Properties
Wool/nylon blend seat upholstery material shall be subjected to the physical tests of textile products required by the latest revision of the following ASTM methods, and the results shall not be less than the following values:

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3776</td>
<td>Fabric Weight</td>
<td>14.5 oz/sq yd without back coating</td>
</tr>
<tr>
<td>D3775</td>
<td>Fabric Count</td>
<td>Warp – (ends) 88 epi Fill – (picks) 40 to 72 ppi</td>
</tr>
</tbody>
</table>
### Test No. | Description | Criteria
---|---|---
D5034 | Breaking Strength and Elongation | Warp – 200 pounds Fill – 200 pounds
D2261 | Tear Strength (Tongue) | Warp – 20 pounds Fill – 20 pounds
D4034 | Yarn Slippage | Warp – 30 pounds Fill – 40 pounds
D3597 | Color Fastness | Water – Class 4 minimum Solvent – Class 4 minimum Crocking – Class 4 minimum Light – Class 4 minimum
D4966 | Martindale Abrasion Test | 20,000 cycles – no breaks

Flame resistant polyester seat upholstery material shall be subjected to the physical tests of textile products required by the latest revision of the following ASTM methods, and the results shall not be less than the following values:

### Test No. | Description | Criteria
---|---|---
D3776 | Fabric Weight | 12 oz/sq yd without back coating
D3775 | Fabric Count | Warp – (ends) 88 epi Fill – (picks) 40 to 72 ppi
D5034 | Breaking Strength and Elongation | Warp – 270 pounds Fill – 200 pounds
D2261 | Tear Strength (Tongue) | Warp – 20 pounds Fill – 20 pounds
D4034 | Yarn Slippage | Warp – 75 pounds Fill – 65 pounds
D3597 | Color Fastness | Water – Class 4 minimum Solvent – Class 4 minimum Crocking – Class 4 minimum Light – Class 4 minimum
D4966 | Martindale Abrasion Test | 20,000 cycles – no breaks

### 17.11.2 Fabric Backed Vinyl

All vinyl upholstery materials must meet the following Federal Test Method Standard test criteria with a permissible variation in weight and strength of 7 percent:
### 17.12 FIBERGLASS REINFORCED PLASTIC

#### 17.12.1 General

The fiberglass reinforced plastic (FRP) shall be a laminated engineered material consisting of a combination of reinforced fibers in a thermoset polymer resin matrix, where the reinforcement has an aspect ratio that enables the transfer of load between fibers, and the fibers are chemically bonded to the resin. FRP shall withstand, without any physical deformation or structural damage, the environmental conditions in TS 2 and be resistant to acids, alkalies, and cleaning solutions recommended by the Contractor or used by SEPTA.

The FRP shall be manufactured by an open molding or matched die molding process. Production techniques shall ensure that the glass fiber reinforcement is uniformly distributed throughout the final product in such a manner as to avoid resin rich or resin starved sections. An analysis shall be provided to confirm that the proposed construction method and laminate structure is adequate for its intended purpose and meets the strength requirements provided in this Specification.

FRP parts shall have a minimum thickness of 0.125 inch and shall have a greater thickness at attachment points and edges. If fasteners are used to attach or assemble FRP parts, the parts shall be reinforced in a manner approved by the Engineer to preclude the development of cracks. Exposed sharp edges shall not be allowed on any parts.

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Physical Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS-273-65</td>
<td>Total Weight</td>
<td>24.0 oz./sq. yard</td>
</tr>
<tr>
<td>FS191-5100</td>
<td>Tensile Strength (Grab)</td>
<td>110 x 100 pounds</td>
</tr>
<tr>
<td>FS191-5136</td>
<td>Tearing Strength (Trapezoid)</td>
<td>30 x 30 pounds</td>
</tr>
<tr>
<td>ASTM D751</td>
<td>Seam Strength</td>
<td>100 x 90 pounds</td>
</tr>
<tr>
<td>FS191-5304</td>
<td>Abrasion Resistance (5000 double rubs)</td>
<td>No wear through skin</td>
</tr>
<tr>
<td>CS-273-65</td>
<td>Coating Adhesion</td>
<td>8 x 8 pounds/2” width</td>
</tr>
<tr>
<td>FS191-5874</td>
<td>Cold Crack Resistance</td>
<td>Minimum 20 degrees</td>
</tr>
<tr>
<td>FS191-5872</td>
<td>Blocking</td>
<td>No sticking</td>
</tr>
<tr>
<td>CS-273-65</td>
<td>Flexing</td>
<td>No cracking or flaking</td>
</tr>
</tbody>
</table>
17.12.2 Construction

17.12.2.1 Resin

The resin shall be of good commercial grade thermosetting matrix selected to meet the physical properties of this Specification and the molding process requirements.

17.12.2.2 Reinforcement

The fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, spun roving, or swirl mat as required to meet the physical properties of this Specification and the molding process requirements. The proposed glass content shall be a minimum 20 percent by weight and shall be confirmed through testing to ASTM D2584.

17.12.2.3 Gel Coat

A gel coat shall be provided on all finished surfaces of the FRP. The gel coat shall be resistant to scuffing, fire, weather, and cleaning agents. The gel coat shall have a minimum thickness of 0.016 inch and a maximum thickness of 0.030 inch. If the surface of the FRP panel is to be painted, a primer gel coat shall be used, and the part shall be painted in accordance with TS 17.23. If the FRP panel does not receive paint, then the gel coat shall be pigmented to match the color scheme selected by SEPTA.

Finished gel coated surfaces shall have a minimum gloss value of 85 when measured with a 60 degree glossometer and shall exhibit no print through of the reinforcements or have any appreciable orange peel.

17.12.2.4 Additives

Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required physical, flammability, and smoke emissions characteristics of this Specification.

Antimony trioxide is prohibited.

17.12.2.5 Strength Requirements

Independent laboratory test reports shall be provided confirming that the production fiberglass reinforced plastic material complies with the requirements of the following standards. Test shall be conducted using final production parts and not the base laminate material. Test specimens shall be conditioned in accordance with ASTM D 618.

<table>
<thead>
<tr>
<th>Mechanical Property</th>
<th>ASTM Test</th>
<th>Class I Minimum Requirements</th>
<th>Class II Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>D 638</td>
<td>10,000 lbf/in²</td>
<td>18,000 lbf/in²</td>
</tr>
</tbody>
</table>
### Mechanical Property

<table>
<thead>
<tr>
<th>Mechanical Property</th>
<th>ASTM Test</th>
<th>Class I Minimum Requirements</th>
<th>Class II Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength</td>
<td>D 695</td>
<td>18,000 lbf/in²</td>
<td>24,000 lbf/in²</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D 790</td>
<td>15,000 lbf/in²</td>
<td>30,000 lbf/in²</td>
</tr>
<tr>
<td>Impact Strength</td>
<td>D 256</td>
<td>10 foot pounds per inch of notch</td>
<td>13 foot pounds per inch of notch</td>
</tr>
<tr>
<td>Hardness</td>
<td>-</td>
<td>45 Barcol</td>
<td>45 Barcol</td>
</tr>
</tbody>
</table>

Class I applies to items that are non-structural and will not be exposed to any loads such as window masks, destination sign shrouds, etc.

Class II applies to items that are structural or will be exposed to loads or impacts such as end bonnets, equipment enclosures, door pocket panels, wainscot panels, passenger seat shrouds, windscreens, stairwell, etc.

The Contractor shall submit proposed class designation for the FRP parts for approval of the Engineer. [CDRL 17-016]

## 17.13 THERMOPLASTIC SHEET

### 17.13.1 General

The thermoplastic sheet used in the construction of this vehicle shall withstand, without any physical deformation or structural damage, the operating environmental conditions and shall be resistant to cleaning solutions. The thermoplastic sheet shall be used as extruded or vacuum formed and shall not contain plasticizers in polymer blend.

The thermoplastic sheet shall be homogeneous and extruded from virgin stock which does not include any regrind of vacuum formed parts. The exposed surface of this material shall conform to the color, texture, and gloss characteristics of the approved color scheme described in TS 1.5. The applicable ASTM procedure, as approved by the Engineer, shall be used to measure each of the characteristics. Only UV stabilized pigments shall be used to create the specified color of the thermoplastic sheet. The color and surface finish of parts, manufactured from this material, shall be submitted and approved prior to the production run of any parts. [CDRL 17-017]

### 17.13.2 Quality

The finished parts shall be free of waves and quilting on both sides. Degraded polymer in the sheet shall not be allowed and if present shall be cause for rejection of the piece. Voids, lumps, and contamination shall also be cause for rejection of parts if the defects are larger than 0.010 inch and the population of these defects is greater than one (1) defect in four (4) square feet.
17.13.3 **Strength Requirements**

Independent laboratory test certificates shall be provided stating that the thermoplastic sheet complies with the requirements of the following standards. [CDRL 17-018] The extruded sheet in the surface finish specified shall be used for testing.

<table>
<thead>
<tr>
<th>Mechanical Properties</th>
<th>ASTM Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>D792</td>
<td>1.20 to 1.45</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D638</td>
<td>5,500 lbf/in2 minimum</td>
</tr>
<tr>
<td>Elongation</td>
<td>D638</td>
<td>50 percent</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>8,000 lbf/in2 minimum</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>D790</td>
<td>3.3 x 105 lbf/in2</td>
</tr>
<tr>
<td>Hardness Rockwell &quot;R&quot; Scale</td>
<td>D785</td>
<td>90 to 110</td>
</tr>
<tr>
<td>Heat Shrinkage -15 minutes at 350 degrees F</td>
<td>-</td>
<td>10 percent maximum in machine direction 5 percent maximum in transverse direction</td>
</tr>
<tr>
<td>Heat Deflection (annealed) @ 264 lbf/in2</td>
<td>D648</td>
<td>165 degrees F minimum</td>
</tr>
<tr>
<td>Impact Strength Fabricated Parts Gardener Dart Drop 0.5 inch dia. ball: at 73 degrees F at -20 degrees F</td>
<td>D3029</td>
<td>320 in/lb minimum 80 in/lb minimum</td>
</tr>
<tr>
<td>Toxic Gas Generation</td>
<td>BSS 7239</td>
<td>HCN &lt; 150 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CO &lt; 3500 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO/NO2 &lt; 100 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SO2 &lt; 100 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HF &lt; 200 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HCL &lt; 500 ppm</td>
</tr>
</tbody>
</table>

### 17.14 PIPING AND TUBING

#### 17.14.1 General

All piping valves, fittings, installation methods, and testing shall be in accordance with the Code for Pressure Piping, ANSI B31.1. All joints shall be easily accessible.

Following installation, all piping systems shall be cleaned to remove dirt, metal chips, oily contamination, and moisture. After cleaning, all piping systems shall be pressure tested in accordance with the latest edition of the "Code for Pressure Piping, ANSI B31.1. All leaks shall be repaired and the system recleaned and retested until leak free.
Pipes shall be supported throughout their length and at all connections to prevent vibration or noise and to limit stresses in the pipe to less than 50 percent of the pipe's fatigue endurance limit. Pipes and their connections shall not interfere with the removal of other components. Pipe routing and support shall be planned and accomplished in an efficient organized manner to keep the total length and number of fittings and bends to an absolute minimum. All changes in direction shall be accomplished by bending the pipe to a radius of not less than that specified by AAR Specification No. 2518, Standard S-400. Direction change fittings shall not be permitted in the trainline brake pipe or in the brake cylinder pipe. Support and clearances provided between adjacent pipes and between pipes and surrounding structure, equipment, or other appurtenances shall be sufficient to prevent chafing or contact due to any combination of car loading and deflection, car dynamics, and thermally induced movement. The minimum clearance shall be 1/8 inch.

At all locations where pipe or tubing passes through holes in the floor, bulkheads, structure, or any fixed member, it shall be rigidly clamped to protect against possible damage or noise due to bearing, abrasion, or car dynamics induced rattling. Clamps shall not be welded, brazed, or otherwise permanently fastened to any pipe or tubing. Pipe and tubing interfaces with clamps shall be insulated with an elastomeric or woven non-asbestos mineral fabric tape material to protect and sound insulate the pipe or tubing.

Wherever carbody piping interfaces with vibration isolated rotating equipment such as the air compressor and air conditioning compressor condenser unit, approved flexible vibration eliminators shall be used. The pipe connection at either end of the flexible elements shall be rigidly clamped no farther than two (2) inches from the flexible elements. All pipe clamps shall be inherently rigid and shall be firmly attached to the car structure. Cantilevered clamps or clamp supports that are weaker than service proven designs will not be accepted. All clamps shall be of a suitable material for the application.

Prior to constructing the cars, the Contractor, in cooperation with the manufacturers and suppliers, shall make a thorough analysis of the design of the pneumatic systems proposed for the cars to assure that every reasonable precaution has been taken in design and installation to prevent the cars from disablement in service as the result of adverse winter conditions. Before being granted permission to commence construction, the Contractor shall submit to the Engineer the details of his analysis and of any special preventative measures he proposes to incorporate in the design. [CDRL 17-019] The design layout, installation, hanging methods, etc., shall be jointly inspected and reviewed with and approved by the Engineer. [CDRL 17-020]

### 17.14.2 Air Piping, Tubing, and Fittings

The main reservoir pipe and brake pipe shall conform to ASTM A53, Schedule 80, seamless pipe. The application of the ASTM A53 pipe shall comply with the requirements of AAR Specification No. 2518 and Standard 400.
Type "K" annealed copper tube per ASTM B88, latest revision, may also be used provided it is installed no lower than two (2) inches below the floor sheet or structural member and is protected by means of equipment or approved steel guards from any potential impact damage from rail debris especially in the truck and outboard of the bolster areas. All copper piping shall be brazed. Where suitable protection in damage prone areas is not possible or practical, approved steel piping sections shall be provided. Where the use of copper tube is approved, its installation shall comply with the requirements of AAR Specification No. 2518.

All air pipes shall be sized in accordance with the function intended and may be either ASTMA 53 schedule 80 pipe or seamless copper tubing as described previously. All joints for copper tubing shall utilize fittings of wrought copper or non-porous cast brass in accordance with ANSI B16.22 and B16.18.

All air piping shall be installed with no low spots to trap moisture and pitched in a manner to provide drainage away from devices or branch pipes leading to devices.

All air hoses shall conform to the requirements of AAR Specification M-601 and AAR Specification M-618 with AAR approved reusable fittings conforming to the requirements of AAR Specification M-927.

All cut-out cocks shall be of the vented type except where function prohibits. All cut-out cock handles and their arrangements shall be as described in TS 12.13.

Air piping on the trucks shall be 1/2 inch ASTM A53, Schedule 80, or approved equal. Low spots (traps) are strictly prohibited. Truck piping shall not be run on the bottom of truck side frames, transom, or bolster.

Where steel piping is used, all connections and joints, where disassembly for service may be required, shall utilize swivel type butt welded flange fittings with an "O" ring type seal. The use of threaded fittings is expressly prohibited.

All air piping shall comply in all respects with the air brake supplier's design and installation requirements and AAR Standard S-400. Within 245 days of Contract award, the Contractor shall submit to the Engineer a preliminary report certifying approval by the air brake supplier of the Contractor's air brake piping fabrication, installation, and design concept. [CDRL 17-021] Within 450 days of Contract award (prior to the manufacture of the production cars), the Contractor shall submit a final report certifying approval by the air brake supplier of the Contractor's air brake piping fabrication, installation, and design concept. [CDRL 17-022] The following information shall be contained in the report:

a. All critical line sizes and materials including the main reservoir pipe, the brake pipe, and the brake cylinder piping

b. The installation details of all critical lines including routing, total length and volume, elevation and slopes, and major joint and direction change locations. A list of all proposed bend radii shall also be provided.

c. Pipe processing details including welding, brazing, cleaning, and fabrication methods, as required by TS 17.22
d. Locations of all major air brake valves and controls, relay, and emergency venting devices, and
the proposed location and volume of all reservoirs

e. An air consumption analysis justifying the proposed air storage system design

17.14.3 Air Conditioning System Piping, Tubing, and Fittings

Air conditioning refrigerant lines shall be of seamless copper tubing, Standard ASTM B280, and
condensate drain lines shall be seamless copper tubing, Standard ASTM B88 type K or approved stainless
steel tubing.

Joints shall be kept to a minimum and all inaccessible runs of tubing shall be without joints. Finned
tubing in evaporators and condensers shall be copper. Instead of elbows, tubing may be bent utilizing a
bending tool designed specifically for the bending of the tubing to be used.

Suction lines shall be designed and installed without traps. The suction line shall be sized for three (3)-
psi (gauge) maximum system pressure drop, and the liquid line shall be sized adequately to prevent
flashing due to pressure drop.

Lines subject to collecting condensation shall be insulated with an approved insulation and applied with
an approved contact cement. The liquid line shall be insulated in all areas where required to provide
additional mechanical or thermal protection. Insulation at all joints and fittings shall be mitered and
sealed with an approved material. The insulation, adhesive, and sealant shall meet the Specification
requirements for thermal, smoke emission, and flammability performance.

All piping and pipe subassemblies shall be deburred, cleaned, dried, purged with dry nitrogen, and
capped with tight fitting plastic caps or approved equal on all openings after fabrication. Caps shall
remain in place until immediately prior to incorporation into the final assembly.

Vibration eliminators shall be used in piping connections to the compressor. Tubing installations shall be
designed to allow any single length of tubing to be replaced without dismantling or removing
surrounding equipment, piping, wiring, or other appurtenances.

Maintenance requirements shall be analyzed when considering tubing installation and routing.

17.14.4 Brazing and Soldering of Piping, Tubing, and Fittings

All brazing and soldering shall comply with the applicable parts of TS 17.22 and the following
requirements. All refrigerant piping and air system copper tubing shall be joined using silver solder
conforming to Federal Specification QQ-B-654A, BAg-5 or BCuP-5. Refrigeration piping and tubing shall
be internally swept with a continuous flow of a non-oxidizing gas such as dry nitrogen during brazing.

Condensate drain tubing shall be joined using 95-5 solder or Silver Solder as above. Solder joints shall be
wiped and have flux cleaned from tubing and fittings after soldering. After fabrication, the refrigeration
and air systems shall each be cleared of all dirt and foreign matter, flushed with a degreasing agent and
dried, all according to a procedure prepared for each by the Contractor and submitted to the Engineer
for approval. [CDRL 17-023]
17.15 PRESSURE VESSELS

All pressure vessels shall conform to the latest revision of Section VIII of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels. Test reports shall be furnished for each pressure vessel, and each pressure vessel shall be stamped to record the test. [CDRL 17-024]

17.16 WIRE AND CABLE

17.16.1 General

Throughout this Section, the term "wire" shall be interpreted to mean any insulated single conductor, and the term "cable" shall be interpreted to mean any jacketed or bound together group of conductors except where otherwise described or defined within. The term "wiring" shall be interpreted to mean all wires and cables installed on the car or its components. This Section does not apply to high voltage pantograph and main transformer wiring. The Contractor's design and construction shall ensure that the minimum number of wire types and sizes shall be used in the vehicle.

Selection of wire sizes and insulations shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature, and flexibility requirements in accordance with applicable AAR, APTA, ICEA, ASTM, NEC, and MIL Specifications or other approved equivalent specifications. Special attention shall be devoted to circuits where performance of the load is strongly affected by supply voltage, and wire sizing shall be carefully chosen to ensure that performance requirements are met. However, in no case shall the properties of the wire and cable be less than those properties delineated in this Specification. Extra fine wire stranding shall be utilized on applications subject to repetitive motion.

If metric based wire dimensions are used, they shall in all cases be equal or larger in diameter than the AWG equivalent and shall be replaceable with AWG based wire or cable without requiring modification to the car or its components.

All wire shall be surface printed with the manufacturer's identification, conductor size, voltage rating, and temperature rating. For wire sizes number 1/0 AWG and larger, stranding shall also be indicated as part of the wire marking. The wire marking shall be spaced at maximum intervals of eight (8) inches.

The use of ribbon cable shall be minimized. If used, ribbon cable shall be secured to prevent degradation to the cable and the terminations. Ribbon cables shall be used only for internal connections within an enclosure housing electrical assemblies that are replaceable. They shall not be used to connect electrical equipment housed in separate enclosures. Ribbon cables shall be permanently identified with all circuit designations.

All applications of shielded cable shall be approved.
The Contractor and each manufacturer of equipment through the Contractor shall submit to the Engineer for approval samples (at least 12 inches long), specifications, and three (3) copies of certified qualification test documentation of each size and type of wire and cable specified before utilizing said wire and cable. [CDRL 17-025]

17.16.2 Conductors

Stranding and conductor construction for all wires and cables shall be in accordance with the Association of American Railroads Manual of Standards and Recommended Practices, Recommended Practice RP-585, Wiring and Cable Specification, except that conductors required to flex when the car is operating shall have stranding approximating the Insulated Cable Engineers Association, Inc. (ICEA) Standard S-19-81, Table L-7 (Class K) or Table L-8 (Class M) as appropriate. The use of solid wire is not permitted except for approved wire wrap applications.

Conductors for irradiated, cross-linked polyolefin wire shall be soft annealed tinned copper in accordance with ASTM B33.

Wiring shall be sized for the intended load voltage drop installation method and applicable codes. Maximum wire ampacities for irradiated cross linked polyolefin wire shall conform to APTA-PR-E-RP-009-98, Recommended Practice for Wire Used on Passenger Equipment. When the free air rating is used, the Contractor shall furnish data to show that the cables will not exceed their rated temperature at the rated current. Where more than three (3) conductors are routed in a raceway or conduit, the ampacities shall be derated as required. Wire ampacities shall be derated to meet the temperature requirements of all devices to which the wire connects. When short time ratings, short time overload temperatures, and thermal time constants are used to determine cable size, the parameters used shall be submitted for approval.

In no case shall wire smaller than the following sizes be used:

a. Wire which is pulled through conduits or wireways – AWG No. 16
b. Wire on electronic units, cards, and card racks – AWG No. 22
c. Wire within control compartments – AWG No. 18
d. Multiconductor cables where current is not a factor in wire size selection – AWG No. 18.
e. All other wire including that which is not pulled through wireways and conduits – AWG No. 16

The Engineer may approve smaller wire sizes for selected applications upon submission of appropriate applicable data for justification.
17.16.3 Insulation

17.16.3.1 General Wiring Insulation

Except as otherwise specified, all general car wiring shall possess flame retardant radiation irradiated crosslinked polyolefin insulation meeting the requirements of Underwriters Laboratories Specification 1581, Section 1080, VW-1 Flame Test. Insulation shall be of a minimum thickness consistent with voltage demands and may be of standard flexibility or extra flexibility configuration as appropriate for the application with the requirement that number 6 AWG and larger wire must use extra flexibility insulation. Alternate material may be proposed on a case by case basis for specific applications. The insulation shall be rated at 2000 volts for wires carrying a nominal voltage greater than 200 volts and rated at 600 volts for wires carrying a nominal voltage 200 volts or less. Insulation shall be capable of sustaining a continuous temperature state of 110 degrees C, but its operating temperature shall not exceed 90 degrees C. Insulation shall be in accordance with the Association of American Railroads Manual of Standards and Recommended Practices, Recommended Practice RP-585, Wiring and Cable Specification, and the following special requirements.

17.16.3.1.1 Insulation Flammability Requirements

Insulation shall meet the following flammability requirements:

a. Irradiated cross linked polyolefin shall be tested in accordance with test method ICEA S-66-524/NEMA WC7, Paragraph 6.12.5. After five (5) applications of 15 seconds each with a three (3) second rest period between applications, flame shall extinguish in ten (10) seconds or less.

b. Other insulation materials shall be tested in accordance with IEEE 383.

17.16.3.1.2 Irradiated Cross Linked Polyolefin Wire Insulation

The irradiated cross linked polyolefin wire insulation shall be constructed and tested in accordance with the following requirements:

a. Flexibility Tests for Cables – Flexibility tests for cable sizes up to AWG No. 2/0 shall be performed in accordance with AAR Standard RP-585.

b. Single Conductor Thermal Overload Test – Insulation shall meet the requirements of test method ICEA S-19-81, Paragraph 6.9.2, at 90 degrees F. Stability Factor shall be 1.0 minimum. Alternatively, stability factor difference, 1-14 days maximum, shall be 0.5 with a SIC (one (1) day) maximum of 6.0.

c. Ozone – Using test method ICEA S-19-81, Paragraph 6.8, there shall be no insulation cracks after 24 hours exposure to an ozone concentration of 0.03 percent by volume at 90 degrees C plus or minus 2 degrees C.
d. **Tension Set –** Insulation shall meet the requirements of test method ICEA S-66-524, Paragraph 6.4.11.4. As an alternative procedure, test method ICEA S-19-81, paragraph 6.4.13.4, may be used with the additional provision that the specimen shall be stretched until the gauge marks are four (4) inches apart and that the average of three (3) specimens not exceed a tension set of 30 percent.

e. **Corrosivity –** Using test method ASTM D267, there shall be no more than five (5) percent copper film removal after a test period of 16 hours at 175 degrees C, plus or minus two (2) degrees C.

f. **Moisture Absorption –** Wiring and cable shall be subjected to the gravimetric method at 70 degrees C plus or minus 20 degrees C for 168 hours per ICEA-S-66-524.

g. **Single Conductor Thermal Overload Test –** A continuous current of 115 amperes shall be applied to an 18 foot length of AWG No. 10 test wire in 25E C still air. A 3000 volt dc potential shall be maintained between the test wire and an AWG No. 18 bare copper wire wrapped snugly around the outer insulation surface of the test wire. Failure shall occur when a short circuit is established between the bare copper wire and the test wire. Minimum time to failure shall be three (3) minutes.

h. **Bundle Overload –** A bundle overload using a seven (7) wire bundle shall be performed in accordance with AAR Standard RP-585.

i. **Temperature Cycling Tests –** This test shall be performed on an eight (8) foot length of AWG No. 10 wire with 2 kV insulation.

Thermocouples shall be attached to the outer jacket surface and on the conductor under a small incision in the insulation approximately 12 inches from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

Prior to temperature cycling, the sample shall be conditioned for two (2) hours at a temperature of 150E C.

The sample shall then be temperature cycled between an ambient of 125E C and -30E C by transferring the sample between an air circulating oven set at 125E C and an air circulating cold box set at -30E C. The time during which the sample stays in each chamber shall be sufficient to allow both thermocouples on the sample to read the same temperature as the environment.

One cycle shall be defined as an approved dwell time at both 125E C and -30E C. The sample shall be subjected to a total of 250 cycles with a visual observation at the end of each cycle for cracks and other damage. After 250 cycles, the sample shall be immersed in water for six (6) hours with both ends out of the water, then subjected to a dielectric test of five (5) kVAC for five (5) minutes, and also examined by microscope to verify that no cracks exist.

Flame retardant flexible irradiated cross linked polyolefin insulation rated at 125E C may be used provided that it meets the requirements of all of the above tests and standards modified to reflect the temperature rating related characteristics. The revised values and the use of such wire must be approved by the Engineer. Cross linked polyolefin insulation shall not be permitted for use on wires connected to heater elements or any other high temperature device.
17.16.3.1.3 Other Insulation Parameters

All insulation other than irradiated cross linked polyolefin shall meet the following test requirements based on MIL-W-22759 and using the following parameters:

a. Dielectric – Test per MIL-W-22759/10B (for 1,000 V wire with tests at 9.5 KV impulse) or MIL-W-22759/6B (for 600 V wires with tests at 8 KV impulse)

b. Insulation Resistance – The minimum acceptable resistance to a solidly grounded carbody for each class of car wiring shall be as stated below when tested at the listed voltages using an approved megohmmeter. All wiring is assumed to be solidly grounded except the wire class under test:

<table>
<thead>
<tr>
<th>Wire Class Voltage</th>
<th>Minimum Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 volts 1000 volts</td>
<td>50 megohms</td>
</tr>
<tr>
<td>230 volts 1000 volts</td>
<td>25 megaohms</td>
</tr>
<tr>
<td>37.5 volts or below 500 volts</td>
<td>5 megaohms</td>
</tr>
</tbody>
</table>

All carbody wiring and cables shall be capable of withstanding a high potential test with a minimum duration of 60 seconds using an applied 60 Hertz voltage as listed below. The application and removal of the voltage shall not exceed a rate of 150 volts/second. During the test period, the current leakage shall not increase. All wiring is assumed to be solidly grounded along with the carbody except for the wire class under test:

<table>
<thead>
<tr>
<th>Wire Class Test Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 volts 2200 volts</td>
</tr>
<tr>
<td>230 volts 1400 volts</td>
</tr>
<tr>
<td>37.5 volts or below 500 volts</td>
</tr>
</tbody>
</table>

Inasmuch as the insulation resistance varies with the season and humidity, the Contractor shall ensure that these requirements can be met under the most severe climate conditions.

c. Spark Test – 100 percent of all single conductor cables and all single conductor cables being used in a multiconductors cable shall be inspected by impulse dielectric test or by chain electrode spark test. Spark test apparatus and procedure shall be in accordance with MIL-W-22759. Spark test voltages shall be equivalent to impulse test voltages by corresponding RMS value at 3 kilohertz.

<table>
<thead>
<tr>
<th>Impulse Test Voltage KV Peak</th>
<th>3 KHz Test Voltage KV RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>5.7</td>
</tr>
</tbody>
</table>
## Impulse Test

<table>
<thead>
<tr>
<th>Voltage KV Peak</th>
<th>KV RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5</td>
<td>6.7</td>
</tr>
<tr>
<td>10</td>
<td>7.1</td>
</tr>
</tbody>
</table>

### d. Air Aging – Test per ASTM D638. Age sample for seven (7) days at 302°F in air oven. Minimum tensile strength and elongation shall not be less than 85 percent of the unaged values. Also test per IEEE STD 383-1974 and ASTM D573 for extended life.

### e. Cold Bend – Test per NEMA WC3 except test temperature shall be -58°F.

### f. Weight Loss – Weight loss of the insulation material shall not exceed one (1) percent when subjected to an oven temperature of 266°F for 500 hours.

### g. Chemical Resistance – An appropriate length sample shall be measured for insulation diameter and total weight to record initial values. The wire shall be immersed to within three (3) inches of each end in the test fluid for 24 hours at 149 degrees F. During the immersion stage, the minimum bend radius of the wire shall be ten (10) times the diameter of the wire being tested. Upon removal from the test fluid, the specimen shall be cooled to room temperature for one (1) hour, and the diameter gauged and reweighed for comparison with the original values. The maximum diameter and weight increase shall not exceed 30 percent. Typical fluids for this test include:

1. Humble No. 2214 Railroad Diesel Lubricating Oil and lubricants (100 percent solution)
2. Humble Diesel 260 or Railroad T fuel oil (100 percent solution)
3. Mineral oil (100 percent solution)
4. Hydrochloric acid, nitric acid, sodium hydroxide, sulfuric acid (0.1 percent solution)
5. Potassium hydroxide (0.1 percent solution)
6. Petroleum distillates and other graffiti removers and cleaning compounds
7. Kerosene solvents (100 percent solution)
8. Trisodium phosphate solution (50 percent solution)
9. Skydrol 500 B hydraulic fluid (100 percent solution)
10. Water

### h. Temperature Cycling Testing – The test shall be performed on an eight (8) foot length sample of AWG No. 12 wire.

Thermocouples shall be attached to the outer jacket surface and on the conductor under a small incision in the insulation about (12) inches from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

The sample shall be conditioned for two (2) hours at a temperature of 150°C. The sample shall then be temperature cycled between ambients of 125°C and -30°C by transferring the sample between an air circulating oven set at 125°C and an air circulating cold box set at -30°C. The time during which the sample stays in each chamber shall be sufficient to allow both thermocouples on the sample to read the same temperature as the environment.
One cycle shall be defined as an approved dwell time at both 125E C and -30E C. The sample shall be subjected to a total of 250 cycles with visual observation at the end of each cycle for cracks and other damage. After 250 cycles, the sample shall be immersed in water for six (6) hours with both ends out of the water and then subjected to a dielectric test of five (5) kVAC for five (5) minutes and also examined by microscope to verify that no cracks exist.

i. Single Conductor Thermal Overload Test – A continuous current of 115 amperes shall be applied to an 18 inch length of AWG No. 12 test wire in 25E C still air. A 1,000 volt dc potential shall be maintained between the test wire and an AWG No. 18 bare copper wire wrapped snugly around the outer insulating surface of the test wire. Failure shall occur when a short circuit is established between the copper wire and the test wire. Minimum time to failure shall be three (3) minutes.

j. Seven (7) Wire Bundle Thermal Overload Test – A seven (7) wire cable bundle shall be formed by twisting six (6) insulated AWG No. 12 conductors around a center insulated AWG No. 12 conductor.

A 120 ampere current shall be passed through the center conductor for seven (7) minutes. After a test period, the cable bundle shall be examined for visible damage to the outer six (6) conductors. Failure shall occur if any of the outer conductors split, rupture, or melt and adhere to the center conductor insulation.

k. Production and Qualification Tests – The tests required for this Specification concerning qualification and production shall be in accordance with tests in MIL-W-22759 for all lots produced.

All test reports covering production and qualification tests shall be submitted to the Engineer for approval with samplings prior to any shipment of materials. [CDRL 17-026]

17.16.3.2 Wire Insulation for High Temperature Applications

High temperature insulation shall be used where wiring is connected to heat generating apparatus where the ambient temperature can exceed 125E C or where Teflon is specified as a requirement. The insulation shall be rated at 1,000 volts ac and dc in the case of wires carrying a nominal voltage greater than 100 volts ac or dc and rated at 600 volts ac and dc in the case of wires carrying a nominal voltage equal to or less than 100 volts ac or dc. The insulation shall have a continuous temperature rating of 150E C or greater and shall be in accordance with the following requirements:

a. For wire sizes AWG No. 16 and larger: abrasion resistant Teflon (Polytetrafluorethylene - PTFE) meeting MIL-W-22759/6B or 10B as appropriate for the voltage level used or silicone rubber meeting AAR Standard RP-587

b. For wire sizes AWG No. 18 and smaller: abrasion resistant Teflon (PTFE) meeting MIL-W-22759/6B or 10B as appropriate. When used for interconnecting of apparatus, this type wire shall be in bundles with a protective covering of high temperature rated low smoke generating insulation.
The Contractor may propose other insulated wire submitting specifications for approval in a specific high temperature application including the design ambient temperature, routing, RMS ampere value, worst case ampere value, worst case temperature rise, stranding, and insulation material.

No high temperature insulated wire shall be used in conduit or raceways without specific approval. The Contractor shall submit all applications of high temperature wire insulation for approval.

17.16.3.3 Wire Insulation within Equipment

All wires within replaceable modular units and electronic apparatus such as cards and card racks shall be insulated with either Kapton per MIL-W-81381/22 (AS) radiation crosslinked polyolefin or TFE (polytetrafluorethylene) Teflon Types EE per MIL-W-16878/5 or E (for number 12 AWG or smaller sizes) per MIL-W-22759/6/8.

17.16.3.4 Wire Insulation in Crowded Locations

Wire for connections to the control console or in other locations where there are crowded concentrations of low voltage control wiring may be insulated with Kapton per MIL-W-81381/22 (AS).

17.16.3.5 Wire Insulation in Protected Locations

Dual layer thin wall wire Rockbestos Surprenant EXANE 15, Spec. DAA1168A, or approved equal may be used in low voltage application in protected areas within the car when specifically approved by the Engineer. This wire, if approved by the Engineer, may be used where space and weight are factors and the location is in protected areas. The use of this wire shall be limited to sizes AWG No. 12 to AWG No. 22. This wire may also be used in multiconductor cables where it is protected by an outside jacket. The thin wall wire shall be tested to RP-585 with the currents, weights, and mandrel sizes adjusted to reflect its construction.

17.16.4 Multiconductor Cables

Multiconductor cables shall be constructed using wires as described above. All multiconductor cables shall have at least ten (10) percent spare conductors by design. Where required to obtain a circular cable cross section, fillers shall be made of non-hygrosopic materials compatible with the wire insulation and jacket and be of the same or of a higher temperature rating than the wire insulation. A binder tape shall be employed over the assembly of conductors in multiconductor cables if needed to assist in cable manufacture or if required to permit the cable to function as needed for its application. The binder tape material shall be non-hygrosopic and shall be of the same or higher temperature class as the wire insulation and shall be of a compatible material.
Shields for use in cables, if required, shall consist of either copper braid or aluminum/polyester tape with a drain wire as is appropriate for the application. Copper shields shall be made of either tinned copper strands which conform to ASTM B33 or silver coated copper strands which conform to ASTM B298 as is appropriate for the wire insulation. Shield coverage shall not be less than 95 percent. Shield strand size and application shall be as recommended by the cable manufacturer for the particular application. Aluminum/polyester tape shields shall consist of a helical wrap of aluminum/polyester tape with a nominal thickness of 0.0004 inch aluminum on a backing of 0.001 inch polyester. The tape shall have a minimum overlap of ten (10) percent of the tape width to ensure complete coverage. In contact with the aluminum side of the shielding tape shall be a number 22 AWG 7/30 tinned copper drain wire conforming to ASTM B33 and B174.

The overall jacket of multiconductor cables shall be of radiation crosslinked modified polyolefin or TFE Teflon to match the wire insulation and application. It shall be extruded and vulcanized over the cabled conductors and shall be well centered with a smooth appearance, without objectionable roughness or irregularities, consistent with good industry practice. Cables used to connect the coupler electric heads shall be specially constructed for the constant flexure of this service and shall have prior electric coupler service that has been satisfactory. This shall be verified by documentation to the satisfaction of the Engineer. [CDRL 17-027]

For high temperature applications, multiconductor cable shall conform to MIL-C-27072, latest revision, with type V conductors, style 4 sheaths, class D jackets (if needed), and shields (if needed).

Where required to obtain a circular cross section, fillers shall be made of non-hygroscopic materials compatible with the wire insulation and jacket and shall be of the same or of a higher temperature rating than the wire insulation.

### Nominal Jacket Wall Thickness in Inches

<table>
<thead>
<tr>
<th>Cable Diameter Under Jacket</th>
<th>Modified Polyolefin</th>
<th>Teflon or Tefzel</th>
<th>Neoprene</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000-0.250</td>
<td>0.045</td>
<td>0.010</td>
<td>0.072</td>
</tr>
<tr>
<td>0.251-0.500</td>
<td>0.045</td>
<td>0.015</td>
<td>0.087</td>
</tr>
<tr>
<td>0.501-0.750</td>
<td>0.060</td>
<td>0.021</td>
<td>0.1</td>
</tr>
<tr>
<td>0.751-1.000</td>
<td>0.080</td>
<td>0.021</td>
<td>0.1</td>
</tr>
<tr>
<td>1.000-1.500</td>
<td>0.080</td>
<td>0.025</td>
<td>0.115</td>
</tr>
<tr>
<td>1.501-2.000</td>
<td>0.11</td>
<td>-</td>
<td>0.135</td>
</tr>
<tr>
<td>2.001-2.500</td>
<td>0.13</td>
<td>-</td>
<td>0.152</td>
</tr>
<tr>
<td>2.501-3.000</td>
<td>0.14</td>
<td>-</td>
<td>0.195</td>
</tr>
</tbody>
</table>
17.16.5 Wire Wrap

The use of wire wrap connections shall be avoided. Wire wrap connections may be used only in selected electronic applications as approved by the Engineer on a case by case basis. In all such cases, the conductor shall be number 28 AWG soft or annealed oxygen free solid copper with a silver conductor coating having a minimum thickness of 40 micro inches. Wire shall have “MIL-ENE” insulation or approved equal and shall be manufactured to SAE AS-81822/1. The insulation shall have a minimum 300 volt rating, and a temperature rating of 135 degrees C. Wrapping shall be "modified" wrap nominal 7.5 turns including 1.5 turns for strain relief.

17.16.6 Insulation Smoke Test

17.16.6.1 Scope

This test method describes the equipment and the procedure for preparing insulated wire samples from which the specific optical density (Dₙ) of smoke generated can be determined in the Aminco-NBS Smoke Chamber. This method is used for wire sizes up to and including AWG No. 12. For wire sizes above AWG No. 12, the standard procedure outlined in ASTM E662 shall be used. Equipment calibration, standardization, and operation shall be in accordance with ASTM E662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials. The performance criteria shall be Dₙ (4.0) ≤ 200 (flaming) and Dₙ ≤ 75 (non-flaming).

17.16.6.2 Apparatus

a. Aminco-NBS Smoke Chamber and Recorder
b. Aminco six (6) tube 90 degree burner assembly for flaming mode testing. All burners shall be directed at the sample in one plane.
c. Notchless wire frame (Aminco AWG No. 20 wire frame with notches machined off)
d. Aminco troughless wire specimen holder assembly
e. Air oven
f. Humidification chamber
g. Heavy duty aluminum foil 0.001 +/− 0.0005 inch
h. Razor blade
i. Tape measure
17.16.6.3 Procedure

a. Determine the length of insulated wire required for testing. The individual sample length shall be calculated to produce a sample area of 35 square inches.

b. Calculate the sample length as follows:

\[ \ell = \frac{35}{3.1416 \times d} \]

Where:

- \( \ell \) = sample length
- \( d \) = diameter of insulated wire (inches)

c. Cut and identify a minimum of three (3) samples of the required length.

d. Condition samples prior to testing by predrying in an air oven for 24 hours at 140°F ± 5°F followed by humidification at 73°F ± 5°F and a relative humidity of 50 percent for a minimum of 24 hours.

e. After conditioning, wind a sample uniformly around the wire frame so that the frame opening is uniformly covered.

f. Cover the wire wrapped frame with aluminum foil across the back, along the edges, and over the front surface periphery with a single sheet of aluminum foil with the dull side in contact with the wire.

g. Place the foil wrapped wire in a troughless sample holder such that the wire is vertically oriented. Insert millboard backing, spring, and retaining clip.

h. Carefully trim the aluminum foil from the front opening of the sample holder.

i. Adjust wire turns, if necessary, to assure that the sample holder opening is uniformly covered.

j. Perform smoke testing in accordance with ASTM E662 noting any unusual behavior that occurs during the test; for example, self-ignition of the sample in the non-flaming test mode or any extinguishment of a burner triplet during the test.

k. Report the sample orientation, test conditions, results, and observations made during the test.
17.17 WIRING

17.17.1 General

All car wiring shall be in conformance with APTA-PR-E-RP-002-98, Chapter 3 of the NFPA 70, National Electric Code, and the AAR Manual of Standards, Section F S-538, “Wiring Practice and Rolling Stock Standard”, except where otherwise specified. Circuit protection shall be in conformance with Chapter 2 of NFPA 70, Article 240. The Contractor shall develop and submit for review and approval a wiring plan that addresses the approach to satisfy the requirements of this Specification. [CDRL 17-028] Parallel connection of conductors to achieve required ampacity is not permitted except under special circumstances as approved by the Engineer.

17.17.2 Wire Handling

All wiring shall be performed by qualified experienced wiring personnel using appropriate tools for stripping insulation, cutting, tinning, soldering, harness making, attaching terminals, and other wire fabrication tasks. All wiring tools and equipment shall be used as recommended by the tool and equipment manufacturer.

Wire shall be protected from damage during all phases of equipment manufacture. Wire shall not be walked on, dragged across sharp or abrasive objects, kinked or twisted, or otherwise mishandled. The ends of wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors.

When removing insulation, wire strands shall not be nicked or broken in excess of the limits of FAA Specification No. AC 43.13-1A, Section 449, "Stripping Insulation". Damage to wires shall not exceed the following limits:

<table>
<thead>
<tr>
<th>Wire Size (AWG)</th>
<th>Allowable Strand Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 or smaller</td>
<td>2 nicked, none broken</td>
</tr>
<tr>
<td>10 or 12</td>
<td>4 nicked, none broken</td>
</tr>
<tr>
<td>8 or larger</td>
<td>6 nicked, 6 broken</td>
</tr>
</tbody>
</table>

* Definitions:

a. A cutoff strand shall count as two (2) nicked strands.

b. A nick is defined as 25 percent or more of the strand area damaged or cut more than 33 percent of its diameter.

Longitudinal scratches in a copper strand are not considered cause for rejection.
17.17.3  Wiring Layout and Installation

17.17.3.1  Wire Harness

The layout of wiring for both car and equipment shall be designed in advance of its installation and in cooperation with the suppliers of the related equipment. Wiring shall be prefabricated into standard harnesses, wrapped or tied, and restrained. Harnesses shall be installed with identical arrangement and location in each car having similar equipment. Separate harnesses shall be provided for major circuit groups or types or as required for specified circuit separation. All circuits and branches shall be separated by means of terminal boards to isolate portions from others for troubleshooting and searching for undesired grounds. All circuits subject to periodic high potential tests shall be so arranged that they can be conveniently set up for the tests. No exposed wiring within the interior of the car shall be permitted.

Alternative methods for fabricating and installing wiring, which are standard Contractor practice, will be considered for approval by the Engineer.

Harnessed wires shall not be installed in conduit. Wires from different conduits or other openings shall not be harnessed together with wires running within the box or entering the box through another entrance point. Each harness or group of wires between equipment enclosures shall contain a minimum of ten (10) percent spares but no fewer than two (2) spares for each wire size. All spares for all wiring shall be submitted for approval by the Engineer. [CDRL 17-029] Unless specifically approved by the Engineer, no spare wiring shall be used by the Contractor. All spares shall be installed in connectors on terminal boards or other means as approved by the Engineer.

17.17.3.2  Circuit Separation

Circuits shall be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.

The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, and shall be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:

a. High voltage
b. AC
c. Communication
d. Battery voltage level
e. Semiconductor gating voltage level
f. Conductors carrying in excess of 100 amps

Wires in circuits with potentials differing by 50 volts or more shall be separated by a physical barrier. Whenever possible, the wires shall not be cabled together and shall not be placed in the same conduit, junction box, or enclosure. Where a raceway, duct, junction box, or enclosure is divided into two (2) or more distinct areas by metallic partitions, each area may be considered separately in the application of this rule.
Where it is impossible to avoid having wires at different voltages in the same equipment enclosure, the wires shall be physically separated, bundled, and secured separately such that physical contact between wiring is not possible. All wiring within an enclosure shall be insulated for the highest voltage in the enclosure unless approved otherwise. All wiring connected to apparatus shall be insulated for the highest voltage connected.

Wiring connected to transient generating apparatus such as unsuppressed contactor coils shall not be run adjacent to wiring carrying signals to, from, or between semiconductor circuits, logic circuits, vital no motion circuits, or communication circuits. In cases in which adequate physical separation is impossible, shielded wire shall be used for all conductors involved.

### 17.17.3.3 Wire and Cable Runs

Wire trays and ducts shall contain no protrusions that shall provide points for abrasion. Wire runs shall be continuous and unbroken between connection points, shall be supported at no greater than 24 inch spacing, and shall be protected at each support point against mechanical crushing and abrasion. A watertight bushing and drip loop shall be provided on all exposed cable entries. All cable bundles and wires shall be routed a minimum of one (1) inch above the bottom of equipment enclosures.

All undercar wiring shall be run in closed wire ducts or conduits in an approved manner and shall be securely clamped via a compression-type rubber sleeve in watertight strain relief bushings with insulated throat lines at entrance and exit points. Wire and cable shall be secured in the ducts to prevent chafing movement. The wire ducts and conduits shall be of drip proof construction unless exposed to car wash spray due to their location. In such cases, they must be watertight and of non-corrosive material.

Any enclosure, wireway, or duct containing wires (such as conduits and wireways) shall be sized such that the sum of the cross sectional areas of the wires (including conductors, insulation, jacketing, etc.), once calculated by number of wires, does not exceed 40 percent of the inside cross sectional area at any point. The actual lay of wires in their relaxed installed state shall not go more than 90 percent of the way to the top of the vertical walls. Bends in the ducts shall be avoided; however, if they are required, protection as approved by the Engineer shall be provided to avoid insulation chafing at the bends. Cables shall be laid in place with sufficient slack at the bends so that cables will clear the inside bend surface of the duct thereby preventing crushing of the insulation.

Only totally environment proof electrical connectors shall be used underneath the car. All jumpers, jumper heads, and jumper receptacles shall be sealed in an approved manner to prevent the entry of water at any operating speed of the car.

Lead wires to resiliently mounted electrical apparatus shall be carried in conduit to a point as close to the apparatus as possible. The length of the leads between the end of the conduit and each piece of apparatus shall be as approved. Short runs of cables or harnesses entering or leaving conduit and apparatus shall have an approved guard mounted to the carbody to protect the wires from mechanical damage. Lead wires to solidly mounted electrical apparatus and equipment enclosures shall run in conduit connected to the apparatus or enclosure.
Exposed harnesses, short cable runs, or harnesses entering or leaving exposed raceways shall have approved fire resistant flexible dielectric sleeving installed over the raceway edges and grommet type insulation at penetration holes. Wiring shall be retained to the sleeving with tie wraps.

Any wiring run from enclosed areas to areas exposed to the elements shall be run in ducts or conduit. Wiring even if enclosed in loom must not be run through partitions without suitable bushings at such points of passage.

Cables shall be laid in place with sufficient slack at the bends so that cables will clear the inside bend surface of the wireway/wire duct.

All wire and cable shall be free of kinks, insulation damage, insulation abrasions, and nicked strands. Wire installation shall not be subject to accumulations of water, oil, or other foreign matter.

Wires or cables shall not pass through or over the battery compartment and shall not pass over heat generating equipment such as acceleration and braking resistors even if the wires or cables are in conduit.

### 17.17.3.3.1 Cable Cleating and Support

Insulated wire and cables of adequate physical strength (number 1/0 AWG or larger) may be cleated in place at intervals of no more than 1.5 feet in place of use of conduit or raceways. In no case shall nylon wire ties be used as the means of supporting the weight of wire bundles and cables. All cable and wiring exiting raceways or cable which is not installed in conduit shall be cleated using split block cleats of molded neoprene rubber. The neoprene shall be a non-flammable insulating type with a durometer value of 50 to 60. Each cleat shall have a stiffener of at least ten (10) gauge corrosion resistant metal on the side away from the mounting bracket which shall act to spread the bolt clamping force over the entire length of the cleat. Bolts shall have lock nuts of approved design. Each lead in the cleat shall have its own cutout sized to the correct wire diameter to hold it snugly without the use of tape or additional materials. The cleat shall permit replacement wire in American wire gauge (AWG) to replace any metric-dimensioned wire originally installed. Cleat spacing shall be sufficient to prevent excessive wire sag. A minimum number of cleat block types shall be used.

Use of loop type supports may be proposed to the Engineer for use on an individual case by case basis provided that the clamp material is stainless steel, the cushion material is either ozone resistant neoprene or silicone, and a chart is provided to identify the proper size clamp for use with each size cable and for each mounting location. This size information must also be identified in all parts listings. A minimum number of different size clamps shall be used. The use of tape or other methods on cables to enable them to fit in an oversized clamp of any type is prohibited.

Wire splices shall not be permitted except with express written approval and in accordance with the wire splicing requirements of TS 17.18.8.

Concealed wires such as within conduits and wire ducts shall be such that wires may be replaced or added to without the removal of other than access panels. It shall not be necessary to disconnect or disassemble conduit to accomplish this task.
Wiring run in loom shall not be carried over potential chafing hazards.

Wires entering any removable box shall be harnessed and secured to facilitate removal of the box.

All wires and cables shall be fully protected against contact with any surface other than that designed specifically to support or protect them. This applies to all current carrying wires, cables, or buses on the vehicle.

**17.17.3.3.2 Wire Securement and Termination**

All wiring shall be secured and protected against movement, chafing, and contact with conductive, sharp, or abrasive objects including the inside surfaces of wire runs and conduits.

All wiring shall be located and secured such that normal equipment motion, maintenance access, heat sources, and the environment do not damage or reduce the life of the wiring.

Junction boxes with terminal boards shall be used, as required, for wire terminations. Harness connections to the boxes, as well as internal wiring to terminal boards, shall be as specified in TS 17.18. Exterior junction boxes shall be weathertight.

In cases where it is necessary to anchor wires or cables to metallic parts of the car, cleats or approved stainless steel bottle clamps shall be used. Wires and cables shall not be allowed to chafe or rub against any part of the car or each other.

Wire and cable dress shall allow for sufficient slack at equipment terminals to provide for movement induced by shock and vibration, equipment shifting, alignment, cover removal, and component replacement. Sufficient lengths shall be provided at points of termination for additional reterminations without applying tension to the wire, without disassembly of the wire harness, and without splicing as follows:

a. AWG No. 10 and smaller – three (3) reterminations
b. AWG No. 8 and larger – two (2) reterminations

A drip loop shall be provided on all exposed wires and cables to prevent fluid runoff into connected equipment.

Spare wires, which are part of a wire harness, shall be bundled separately inside of the equipment box to which the harness is being terminated. Spare wires shall have enough length to reach any location within the box including sufficient slack for the required number of reterminations. The spare wire “break-out” bundle may be ty wrapped to the main harness but shall be easily removed from the main harness without disassembling it. The ends of the spare wires shall be insulated against inadvertent contact with any nearby conductive surfaces or terminals. Each wire routing shall have a minimum of ten (10) percent spare wire runs.
Wire tying devices shall be of approved ozone and ultraviolet resistant material and shall adequately retain the wires for the life of the wiring. Those used within enclosures shall be designed for enhanced ozone resistance. Where possible, the wiring shall be prefabricated into standard harnesses, wrapped and tied with a high strength tie designed not to invade the wire insulation, and include spare wires within unit compartments. Generally, wires shall be installed and marked with the same arrangement and location with all identifications visible in each car having similar apparatus. Spare wires shall be so marked on each end. Wire tying devices shall be mechanically fastened to the permanent structure. Adhesives are not permitted.

All wire bundles and cables within an enclosure shall be supported by the use of tape rails, shall be spaced away from the equipment box structure, metal edges, bolt heads, and other interference points, and shall have electrical clearance from the covers regardless of the insulation properties of the covers. Wire bundles shall be located above or alongside the apparatus rather than at the bottom of the box wherever possible. In all cases, wire shall be a minimum of one (1) inch above the bottom of the box unless otherwise approved by SEPTA. Wire entry into control or junction boxes shall not be permitted through the bottom of the box.

Truck wiring shall be designed to ensure sufficient slack and shall be provided with clamp supports and abrasion protection. T-splices shall not be permitted.

All jumpers, jumper heads, and jumper receptacles shall be sealed in an approved manner to prevent the entry of water at any operational speed of the car.

Any wiring needed to calibrate and test car functions shall be part of the permanent car wiring to enable SEPTA to conveniently maintain the equipment. This wiring shall terminate in approved connectors in the respective control groups and cabinets.

Wiring and cabling shall be readily accessible for inspection and maintenance. Extensive wiring and cabling in the vehicle interior is contrary to accessibility, even though access panels, false floors, and other portals may be provided. To control this requirement the Contractor shall submit a complete wiring plan for approval. [CDRL 17-028]

Wire and cables that are subject to high currents in fault conditions or normal operation shall be secured against secondary damage from high magnetic forces. Propulsion inverter circuits are an example. This requirement shall include damage to bus bars or devices at which the cables terminate.

17.17.3.4 Circuit Shielding

Wire and cable shields, where used, shall be continuous up to the car’s electrical coupler contacts. The wire shields shall be connected through all applicable connectors and junction boxes. Coaxial cables used as constant impedance transmission lines shall be terminated as dictated by the circuit termination design and shall not be considered to be shielded conductors. Triaxial cables may be used as coaxial impedance transmission lines with the outer conductor employed as an RF shield.
The Contractor shall carefully categorize each circuit. Shields contained in one circuit category shall not be interconnected with shields contained in another category. Shields used to protect against interference shall not carry signal current. Shields on low level signal wires shall not be interconnected with shields on high level signal wires in the same category. Each group of shields (other than at the electric couplers) shall be carried through on a connector pin or pins or on terminal strips which shall be in the immediate proximity of the categorized group of circuits. Loops due to interconnections of shields shall not be permitted.

The following three (3) guidelines shall be applicable in so far as possible but are not requirements:

a. Shields used to suppress electromagnetic interference (EMI) at all frequencies shall be terminated only at the low potential side of the interference circuit at the termination which exhibits maximum susceptibility.

b. Shields used to protect against the effect of or to exclude EMI at frequencies below 150 kHz shall be terminated either to the low potential side or at the balance point of the protected circuit at the termination which exhibits maximum susceptibility.

c. Cables requiring both audio frequency (AF) and radio frequency (RF) shields shall be electrically isolated from each other. The resistance between these circuits shall be at least 500 Megohms when 500 volts dc is applied. Double shielding shall be required on circuits that are both AF susceptible and RF susceptible.

17.17.4 Insulation Resistance

Refer to TS 17.16.3 for insulation resistance requirements.

17.17.5 Marking and Designation

As part of the wiring plan, the Contractor shall devise and submit for approval a wire and terminal marking and designation system that shall coordinate all electrical circuits in the car into a unified system. [CDRL 17-028] The system shall identify all wiring including circuit return wiring and terminals according to their respective circuit function(s) and shall accurately correlate these designations with the car schematic diagrams. Common designations for return circuits are not permitted.

White or yellow permanent type identification marker sleeves with black printing shall be used to plainly and suitably identify all wires (including spares) on the car regardless of location and all terminal blocks or strips subject to the approval of the Engineer so that circuits may be easily identified. The technique used shall produce clear legible identification markers that are highly abrasion resistant and immune to dirt, grease, and oils. Marking materials and inks shall not be adversely affected by normal electrical cleaners and solvents. Hand printing is prohibited. The wire markers shall be double printed 180 degrees apart to permit reading the marker despite rotation about the wire. The use of adhesive on the inside of the sleeve is prohibited. The sleeving shall be UV protected to withstand exposure to the elements without discoloration. The marker sleeves shall be sufficiently robust to prevent any damage or dislocation during wire installation including pulling wires through conduit and grommets.
Each circuit shall be individually designated and each wire shall be individually designated from point to point. All wire smaller than number 6 AWG which is external to equipment enclosures shall have its circuit identification number or other nomenclature stamped on it at 12 inch intervals. Wiring connected to polarity sensitive devices within any enclosure or assembly must be identified sufficiently to permit the device to be removed and be properly installed. All battery box wire identification markers shall also clearly identify the positive and negative connections as well as provide red and black color codings. Wires attached to terminals shall also have a marker indicating both the terminal board and the individual terminal to which it is attached. Whether connected to a male or female side, all wires connected to quick disconnects shall have identification markers affixed, shall be color coded, or shall have their identity stamped on them at three (3) inch intervals over the last 12 inches of the wire using the same methods as required above.

A wire designation system shall be submitted for approval which will coordinate all electrical circuits in the car in a unified systems approach. Individual designations shall be provided for all spare wires. There shall be no common designation for return circuits in either power or control circuits. All male and female quick disconnects shall carry approved identification and shall be keyed wherever the design used offers this possibility so that improper connections cannot be made. In locations with six (6) or more disconnects, a locator chart shall be provided to aid in location and reconnection.

### 17.17.6 Pulling Compound

Pulling compound shall be non-conductive, non-hygroscopic, non-odorous, shall not support bacterial activity, or attract vermin.

### 17.17.7 Solder

Solder shall be ASTM B32, Grade 60B. A non-corrosive flux shall be applied immediately before soldering. An automatic temperature controlled solder pot shall be used.

The use of lead free solder shall be subject to approval by the Engineer. The Contractor shall demonstrate that the type of lead free solder proposed has board level reliability equal to that of the specified leaded solder. This shall include documented testing of board level thermal cycling. No more than one type of lead free solder shall be approved. If special equipment is required for use with the approved lead free solder type, the Contractor shall supply five (5) sets of soldering and desoldering equipment.

### 17.17.8 Tape

Usage of electrical tape shall be subject to the approval of the Engineer and in all cases shall be minimized. Electrical tape shall be polyvinyl chloride as specified by the Association of American Railroads Manual of Standards and Recommended Practices Standard S-540, Section F, and in addition shall be Underwriters Laboratories listed and a minimum of 0.007 inch thick.
17.18 WIRE AND CABLE CONNECTIONS

17.18.1 General

As part of the wiring plan, the Contractor shall submit the proposed design and product line of all connections for approval. [CDRL 17-028] Terminal boards with M4 or Number 6 or smaller screws and quick disconnect terminals other than those stated herein shall be permitted only with prior approval by the Engineer.

Unless otherwise specified, all wires and cables shall be enclosed in raceways or conduit having sufficient junction boxes and pull boxes to permit easy replacement of wires and cables. Wherever removable apparatus, components, and equipment are provided, a quick disconnect shall be provided. Unless otherwise specifically approved by the Engineer, connectors shall comply with the acceptability criteria provided in IPC/WHMA-A-620.

Insofar as practicable, all wiring shall be fabricated into convenient units ("harnesses") on a bench and installed in standardized locations. Each branch of each circuit shall be easily separable from others for troubleshooting. Conductors which operate at potentials differing by 50 volts or more shall not be cabled together and shall not be placed in the same conduit, junction box, or enclosure. Each area of a raceway, duct, junction box, or enclosure divided into two or more distinct areas by metallic partitions may be considered separately in the application of this rule. Where it is impossible to avoid having wires differing by more than 50 volts in the same equipment enclosure, the wires shall be physically separated and bundled separately. All wiring connected to a piece of apparatus shall be insulated for the highest voltage connected.

Wiring connected to possible transient-generating apparatus shall not be run adjacent to wiring carrying signals to, from, or between semiconductor, logic, cab signal, or communications circuits. In cases in which adequate physical separation is impossible, shielded wire of an approved design shall be used for all conductors involved. All wires connected to a circuit breaker or any other protective apparatus shall be able to cause that apparatus to operate and remove power without suffering thermal damage to the wire. A drip loop shall be provided in each wire or cable where water could otherwise run along the wire or cable to the point where it enters a box or enclosure.

All wire and cable including that in ducts and conduit shall be handled to be free of kinks and insulation abrasions. Wire installation shall not be subject to accumulation of water, oil, or other foreign matter. All wire and cable shall be protected by grommet material at ends of wire ducts and at other locations where cables enter the ducts. All wire and cable shall be fully protected against any contact with any surface other than that designed specifically to support or protect the wire. Protective edging and similar material shall be applied wherever any possibility exists for a wire to contact a sharp edge for any reason.

Fiber optic cables shall be provided with a minimum of ten (10) percent spares on a point to point basis. Wires from different conduits or other openings shall not be harnessed together with wires running within the box. Each harness or group of wires between equipment enclosures shall contain a minimum of ten (10) percent spares but no fewer than two (2) spares for each wire size. All spare wires shall be individually identified.
Wire and cable dress shall allow sufficient slack for removal and reapplication of the wire terminations at least twice (three times on 10 AWG and smaller wire) as well as permit the replacement of switches and contactors without excess tension. Wire splices will not be permitted except with the expressed approval of the Engineer.

Wire and cable ties shall be snug but shall not be so tight as to cause indentation and cold flow damage to the insulation. Adhesive installed mounting bases shall not be used for ties or cable support.

The layout of wiring shall be designed in advance of its installation and in cooperation with those furnishing the related equipment. No wire or cable shall be located within six (6) inches of the side of the car as measured at the side sill whether in open run or contained within conduit duct or wireway. All circuits and branches shall be separable by means of terminal boards to isolate portions when troubleshooting. All circuits requiring as part of regular maintenance a high potential test shall be so arranged that they can be conveniently set up for the tests.

All wire bundles and cables within an enclosure shall be supported by the use of tape rails and shall be free from the enclosure structure, metal edges, bolt heads, and other interference points and shall have electrical clearance from the covers regardless of the insulation properties of the covers. Wire bundles shall be located above or alongside the apparatus rather than at the bottom of the enclosure wherever possible. In all cases, wire shall be a minimum of one (1) inch above the bottom of the box. Wire entry into control or junction boxes shall not be permitted through the bottom of the box. Wires shall avoid exposure to contactor arcs. All similar equipment boxes shall have identical wire routing, location, and termination.

Wiring needed to calibrate or test any car function shall be a part of the permanent car wiring in order to enable SEPTA to maintain the equipment. This wiring shall be properly identified and terminate in connectors in the respective control groups and cabinets.

Wire shall be protected from damage during all phases of equipment manufacture. All wire including that in ducts and conduit shall be handled to be free of kinks and insulation abrasions and shall not be exposed to accumulation of water, oil, or other foreign matter. The ends of the wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors. Wire shall not be walked on, dragged across sharp edges or abrasive objects, twisted, or otherwise mishandled.

### 17.18.2 Terminal Boards and Terminal Points

Where approved by the Engineer, molded case modular terminal blocks, which utilize a spring clamp to hold the wire, may be used for low voltage circuits. Where cage clamp terminal blocks are approved, wire shall receive a ferrule strain relief support and acceptable locking tab. Each terminal block shall be properly identified with a permanent marking and each assembly shall be secured to the mounting (DIN) rail by end clamps which incorporate metallic hardware. Plug in style (split) terminal blocks will only be permitted if as part of the design these plugs will be used as a connector when performing maintenance, testing, or replacement of a line replaceable unit. All molded case modular terminal blocks are subject to review and approval by the Engineer.
All wiring shall be run from main terminal board assemblies to main terminal board or to final terminations at equipment. No inline “floating terminations” shall be allowed in harnesses or equipment connectors. Multiple circuit connections shall be performed by jumpers at the main terminal board blocks.

Stud type terminal points and terminal boards shall have brass studs and connections each of which shall be locked using a single brass nut with brass flat washer and a plated spring type lock washer except for 480 V cables. Stainless steel hardware may be used for 480 V cable. Studs, nuts, and washers may also be made of corrosion resistant plated steel where approved. Each board or connector shall have the necessary number of terminations plus a minimum of ten (10) percent spares but not fewer than one (1) spare unless otherwise approved. Binding head screw type terminal boards will be permitted only where approved. All terminal boards shall be in accordance with Military Specification MIL-T-55164A.

Threaded studs shall have a minimum of 2 1/2 threads exposed beyond the final nuts. Adequate space shall be provided to permit connecting wire terminals with standard tools. All terminals shall be properly torqued to assure sound connections. Spacers shall not be used.

Jumpers between terminal board points shall be brass or plated steel. Wire jumpers between adjacent terminals of terminal boards will not be permitted.

An approved permanent marking strip on each terminal board shall be provided and attached adjacent to the wire junction point to identify the wires attached thereto, and the wires connected to terminal boards shall have the terminal point location printed on the wire.

A maximum of two (2) terminals shall be connected to any one (1) binding screw. A maximum of four (4) terminals shall be connected to any one (1) threaded stud provided that there is no interference among terminal barrels. On terminal boards, the wiring shall be arranged so that no more than two (2) terminals are connected to a stud from each side.

**17.18.3 Wire Terminations**

The method used for wire terminations used throughout the car such as terminals, terminals blocks, and connections shall be the mechanical solderless type made by an approved domestic U.S. manufacturer with a comprehensive line of available components and application tools. Several types of terminal systems are acceptable to the Engineer as specified herein, but it is SEPTA’s intention that the Contractor select one of these systems which shall then be the only system used throughout the car or to the greatest extent possible. The Contractor may propose use of terminal blocks of either the screw clamp or spring clamp type or use mechanically crimped ring type terminals along with stud or screw type barrier strips. All "Faston" type terminations used on the car shall be composed of either beryllium copper or phosphor bronze. There shall be a maximum of two (2) wires connected to each terminal of any piece of electrical equipment or device except where noted elsewhere. The proposed terminal system along with complete technical details shall be submitted to the Engineer for approval. [CDRL 17-028] All stranded wiring used for spring clamp or screw clamp connections must be ferruled.
Terminal blocks shall be of the molded unit type and shall comply with the requirements of UL 1059, "Standard for Terminal Blocks". The terminal block shall be either of the screw clamp type which compresses the wire between two surfaces without the clamping screw being in direct contact with the wire or of the WAGO Cage Clamp, or approved equal type, where a clamping spring mechanically secures the wire against a contact. Regardless of the type, all metal parts shall be held captive in the molding of the terminal block and live parts shall be recessed so as to prevent their being touched. Terminals shall be of dead front design or furnished with protective covers. Assemblies of individual terminal blocks shall be of the unit form suitable for mounting collectively on a standard mounting rail to give the required number of connection points. Each single unit must be spring retained in the mounting rail and shall be close fitted to avoid the accumulation of foreign matter between adjacent units and with the capability of replacing single blocks without removing adjacent terminal blocks. The open side of the last terminal of an assembly shall be closed by an end barrier. Different sizes of terminal blocks in an assembly may be fitted in a sequence as required. Both ends of the assembly shall be supported by an end bracket. Screw retention for any component from the rear of the mounting rail is not acceptable. Terminal blocks shall be of a size permitting wire sizes as required. The size of the terminal block may be determined by the spacing requirements of UL 1059, Table 7.1. Each individual terminal shall be identified by a secure terminal marker bearing identification as indicated on the circuit diagram. Terminal blocks shall have an approved snap in terminal identification method capable of at least two (2) digits on two (2) alpha characters which are molded in. Identifications shall not dislodge or fall out due to normal maintenance and assembly activities. Terminal blocks with isolating devices shall be of a design which gives a positive indication of an open circuit. Terminal blocks shall be marked permanently with the manufacturer's name or trademark, the maximum voltage rating and the maximum current rating, or maximum wire size.

The terminal block molding shall be either a polyamide or nylon material which will not support combustion and shall be self-extinguishing according to UL Standard 94. The comparative tracking index of the molding must be at least 500. The molding shall be non-hygroscopic. For screw clamps, the clamping yoke and clamping screws shall be made from high grade heat treated alloy steel protected against corrosion by zinc or cadmium plating and dichromated and be so designed as to furnish positive locking action when the screw is tightened. For spring clamps, the clamping spring shall be made from high quality austenitic chrome nickel steel with contact surfaces of tin coated electrolytic copper. The internal current carrying parts of all terminals shall be made from copper or copper alloys and shall be tin/lead electroplated. Mounting rail retaining springs shall be made from non-corrosive materials such as stainless steel. All accessories to the terminal blocks shall be made from similar materials as the terminal block itself. WAGO Cage Clamp connectors shall be limited to those on the 264, 280, and 281 block series with previous successful railcar applications.
Only a single conductor shall be applied to each terminal connection. Terminals shall be attached to the wiring with the proper crimping tools and dies recommended by the manufacturer. Where possible, the terminal used shall be of the type which securely grips and holds the insulation. Wires connected to screw clamp terminal blocks shall be ferruled as recommended by the subsystem manufacturer but as a minimum shall be applied to wires smaller than number 14 AWG. Conductors, which may be subjected to motion relative to the terminal, shall be protected by suitable means to prevent breakage of the conductor at or near the terminal. A minimum of ten (10) percent spare terminals shall be provided on each terminal assembly with at least one (1) spare terminal being provided if there are nine (9) or less active terminals. Number 6 and smaller screw type terminal boards shall only be permitted with the approval of the Engineer. Terminal boards in accordance with MIL-T-55164A matching the voltage range of the circuits involved may be proposed where physical conditions favor the use of such and where redesign of equipment would be otherwise required.

Where mechanically crimped wire terminals are used, they shall be high quality devices as supplied by AMP, Thomas & Betts, or approved equal. Terminals shall be ring lugs equal to SAE Standard AS-25036. Use of spade and hook type terminals are prohibited. Terminals shall be attached to the wire with the proper crimping tools and dies as recommended by the terminal manufacturer. The Contractor shall minimize the total number of crimping tool types needed for crimp connections. All crimping tools shall be of the ratcheting type that locks at each advance until a full crimp is achieved only at which point they will release. Where possible, the terminal used for number 10 AWG wire and smaller shall be of the type whose barrel securely grips and holds the insulation. Conductors, which will be subject to motion relative to the terminal, shall be protected by suitable means to prevent breakage of the conductor at or near the terminal. Terminals fitting wire sizes number 10 through 22 AWG shall require no more than three (3) tool models to provide certified crimp connections. The Contractor shall submit the proposed product line for approval including documentation that each series of proposed terminals have been tested to a level equal to Military Specification MIL-T-16366F for temperature rise, voltage drop, vibration, current overload, and corrosion. When a mechanically crimped wire termination is applied to a solid wire lead on an electronic component such as a diode or MOV, the termination crimp shall also be soldered to prevent long term vibration effects. Wherever several wires are connected to terminals of a terminal strip on a device which is removable from the car for maintenance, the wires shall be terminated with separate ring terminations which shall be screwed to an insulating fanning strip that shall serve to keep the terminations in the correct relative locations while removed from the device, unless otherwise approved by the Engineer. A maximum of one (1) wire shall be crimped to any one (1) terminal.

Power cables shall be terminated with an approved compression terminal. Sufficient cable slack shall be provided to preclude breaking or pull out from bushings or terminals and to allow two (2) terminal changes. Cable conductors shall be cleaned prior to installation of terminals. Compression terminals shall be applied using tools and procedures recommended by the terminal manufacturer for that purpose. Swaging tools shall be of a type that ensures complete swaging in every case.
All barrier strip terminals shall have brass studs or zinc chromate plated steel, and connections shall be locked using double nuts, single nut with brass flat washer and plated spring type lock washer, barrel nuts, or approved elastic stop nuts. Barrier strip terminals shall be of dead front construction with no exposed energized parts or be provided with removable covers. Studs and washers may also be made of corrosion resistant steel. Each barrier strip shall have least ten (10) percent spare terminals with a minimum of one (1). Binding head screw type terminal boards will be permitted only where approved. All barrier strip terminals shall be in accordance with Military Specification MIL-T-55164A or equivalent standard. Brass studs must be capable of withstanding the force applied to elastic stop nuts when removing or replacing nuts. Threaded studs shall have a minimum of 2.5 threads exposed beyond the final nut. Adequate space shall be provided to permit connecting wire terminals with standard tools. All terminals shall be properly torqued to assure sound connections. Spacers shall not be used. Jumpers between barrier strip terminals shall be brass, plated steel, tin lead electroplated copper, or zinc chromate plated steel. Wire jumpers are not permitted. An approved permanent marking strip shall be provided and attached at each barrier strip terminal adjacent to each wire. A maximum of two (2) wire terminals shall be connected to any one (1) binding screw. A maximum of four (4) terminals shall be connected to any one (1) threaded stud provided that there is no interference between terminal barrels. The wiring shall be arranged so that no more than two (2) terminals are connected to a stud from each side of the terminal board. The use of adhesive mounted terminal board identification labels in the car is prohibited.

17.18.4 Power Cable Terminations

Power cables shall be terminated with an approved compression terminal. Sufficient cable slack shall be provided to preclude breaking or pull out from bushings or terminals and to allow two (2) reterminations. Cable conductors shall be clean prior to installation of terminals. Compression terminals shall be applied using tools and procedures recommended by the terminal manufacturer for that purpose. Swaging tools shall be of a type that ensures complete swaging in every case.

17.18.5 Cable Connectors

All cable connector applications shall be approved by the Engineer. All cable connectors shall conform to MIL-C-5015 or an equivalent standard as approved.

With the exception of specific specialized applications approved by the Engineer, all cable connectors shall be of the same style and of the environmental watertight variety with removable crimp contacts of the correct size for the wire being terminated. Connectors proposed for such specialized applications must meet the quality and life cycle criteria given below. Cable connectors shall be equipped with sealing gaskets on the front (so that the connector interface is sealed) and on the back where the cable enters. A grommet shall be provided in the backshell to cover the interface of the wires to the connector pins to prevent shorts between adjacent circuits.
Cable connectors shall be equipped with sealing gaskets on the front so that the connector interface is sealed and on the back where the cable enters. Extension bodies shall be used if necessary to ensure that there is sufficient room to both terminate the cable wires and have the cable jacket extend within the body, be held by a clamp, and have a gasket seal the entrance. Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose. Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections.

All cable connectors shall conform to MIL-C-5015 and be a positive locking quarter turn bayonet coupling with metal shields, waterproof seals, and crimp style gold or silver plated contacts. The coupling mechanism shall be spring loaded with stainless steel locking pins at the peak of the receptacle bayonet ramp to provide extended coupling life of a minimum of 2000 operations. Audible, visual, and tactile indications of full coupling shall be given, and lockwires shall not be required. Where necessary, EMI shielding shall be provided. All connectors shall be Litton-Veam CIR series or approved equal heavy duty electrical connectors as approved by the Engineer.

Unused connector pin positions shall be plugged in accordance with IPC/WHMA-A-620. Male contacts shall be mounted on the equipment side with female contacts mounted on the power side. Adjacent connectors shall be identified and keyed.

Connectors shall employ removable crimp contacts of the correct size for the wire being terminated. Except as noted below, the connector contact area shall be plated with a minimum of 0.000030 inch of gold over a minimum of 0.000050 inch of low stress nickel. For high current applications, the connector contact area shall be plated with a minimum of 0.00010 inch of silver. Adjacent connectors shall be unique by being separately keyed or use either different inserts or different insert orientations to prevent erroneous connections. The receptacle portion of all cable connectors shall be rigidly mounted. Both the receptacle portion and male portion of the cable side connector shall be permanently identified in a manner acceptable to SEPTA.

Plastic bodied connectors shall not be used in exterior locations. Quarter turn bayonet-lock quick disconnect type connectors shall not be used on trainline jumper cables.

Connectors in high vibration or high motion areas such as speed sensors and trainline jumpers shall have the wire connections soldered and potted and shall have a watertight jacket molded over the cable and connector to form a unitized assembly. Trainline jumper connectors shall be as manufactured by Pyle-National or approved equal. The Contractor shall conduct an approved vibration test on the unitized assemblies.

Non-metallic body non-environmentally sealed connectors may be used for use on non-vital interior applications that are in waterproof locations such as ceiling lighting and speaker connections. These connectors must be threaded or include a positive locking mechanism. All such connectors must include a suitable means of strain relief for the wires. If a spring clamp is used to terminate the wire within the connector body, a properly sized ferrule must be applied to the wire. The receptacle half of each connector assembly shall be rigidly mounted. Proposed connectors shall have a minimum of two (2) years of successful service in similar applications and are subject to approval by SEPTA.
17.18.6 Quick Disconnect Terminals

Approved quick disconnect terminals may be utilized to facilitate maintenance and inspection. They shall provide positive terminal engagement and be shock and vibration proof. All terminals shall be provided with insulation equal to that of the wire. No “push-to-fit” (FASTON) type terminals shall be permitted unless specifically approved by the Engineer.

17.18.7 Grounding

17.18.7.1 Connections

All grounding and bonding jumpers and straps shall be installed with sufficient slack to prevent any damage while in service. Where required, they shall be sized to handle fault current and lightning discharge current for which the voltage drop shall not exceed 25 volts. The bonding method employed shall not produce a DC resistance in excess of 0.0025 ohms or more than 0.025 ohms at 150 kHz for any applied AC voltage. Grounding connections to the carbody shall be made through copper or bronze pads of adequate area and silver soldered or brazed to a steel plate which is welded to the carbody structure. Alternatively, the connection may be made directly to a permanent part of the stainless steel carbody structure provided that the above resistance requirements are met.

The Contractor shall ensure that all possible conditions of ground loop current are eliminated between any communications port of car microprocessors and the PTU’s. All equipment enclosures and shock mounted equipment shall be safety grounded with flexible insulated copper grounding wires with insulation rated for 2000 volts and green or green/yellow in color. All grounding connections shall have special attention given for strain relief and vibration protection.

All ground pads shall be visible and accessible for inspection and troubleshooting. The ground connections shall be attached by a bolt, washer, and nut designed for the purpose. Anticorrosive grease shall be applied over the connection.

The Contractor shall submit for approval a complete grounding plan which shall indicate the means by which it is proposed to prevent currents from passing through journal bearings and truck center bearings. [CDRL 17-030] Refer to other sections of this Specification for ground brush and related requirements. Low voltage and high voltage circuits shall not be grounded at the same connection.

17.18.8 Wire Splicing

Splicing of conductors shall be avoided and will be permitted only with the expressed approval of the Engineer on a per item basis. Under no circumstances will splicing of conductors in conduit be permitted. In the event a splice is approved, it shall be in a junction box and the spliced joint shall be both as mechanically strong and as conductive as any other part of the conductor. The splice shall be an insulated permanent crimp splice in accordance with SAE Specification AS-7928, Type II, Class 1, and shall be installed with the crimping tool and die of the splice manufacturer. All splices shall be window splice style and insulated with a self-sealing weathertight seamless shrink tubing. The outside diameter of the spliced portion of the cable after the insulation is applied shall not exceed the outside diameter of the unspliced portion by more than 40 percent. Splices shall be identified in the integrated schematic.
17.19  CONDUIT

All conduits and fittings shall be galvanized steel with a minimum size of 0.5 inch. Rigid steel conduit shall be mild steel in standard lengths with threaded ends and hot dipped zinc coated exterior and interior surfaces. It shall be free of burrs and projections, circular in cross section, of uniform wall thickness, and shall conform to the requirements of ANSI C80.1. Threads shall conform to ANSI B2.1. All conduit fittings shall be steel which shall be treated, coated, and threaded according to the requirements for zinc coated rigid steel conduit and shall conform to UL 6. The open ends of conduit shall be provided with strain relief type fittings with extended rubber cushions, bell-mouth fittings, or insulated throat box connections as approved.

When sheared or sawed, all conduit ends shall be deburred inside and out to remove sharp edges and all pieces blown out with compressed air to remove all filings before installation. Conduit shall be securely clamped and metallic conduit shall be electrically grounded. All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes. All clamps shall be inherently rigid and shall be firmly attached to the support point. Flimsy or excessively cantilevered clamps or clamp supports will not be accepted. Conduit clamps and supports shall be attached to carbody or truck brackets; the use of other pipes or conduit as a sole support for a conduit clamp is prohibited. The conduit arrangement and installation shall be subject to approval by the Engineer.

Conduit shall be color coded: red for those carrying circuits above 100 volts and yellow for those carrying circuits under 100 volts.

17.19.1 Types

Aluminum conduit and flexible non-metallic nylon conduit, which meet the requirements of this Section, may be proposed to the Engineer for approval for carbody interior locations on a case by case basis. Use of flexible conduit for enclosure connections may be submitted to the Engineer for approval on a case by case basis. Flexible conduit (Sealtite) shall be used only where absolutely required and shall be subject to the approval of the Engineer. Flexible covering on conduit shall not contain polyurethane or PVC vinyl.

17.19.2 Size and Fill

Conduit shall be sized such that the sum of the wire cross sectional areas (including conductors, insulation, jacketing, etc.) does not exceed 40 percent of the inner cross sectional area of the conduit for three (3) or more conductors. For two (2) conductors, a limit of 31 percent shall be used while for a single conductor a limit of 53 percent shall be permitted. Where conduits having a length not exceeding two (2) feet and without bends of more than 15 degrees are used between enclosures, a maximum fill of 60 percent shall be permitted.
17.19.3 Installation

A run of conduit between junction boxes and/or pulling outlets shall not contain more than the equivalent of four (4) quarter bends (360 degrees total) including the outlet fittings. Bend radii at the inner edge of the bend shall be no less than eight (8) times the nominal inside diameter of the conduit. Where a conduit extends for longer than 15 feet, it shall have a "tee" fitting with a drain plug at the midpoint.

All conduit bends and offsets used shall be made by the use of special forms or tools and shall have the largest radius possible so that wires can be pulled without the use of tackle or power.

Conduit shall be securely clamped with all runs electrically grounded to make a continuous ground. Conduit installation shall not create situations of dissimilar metals.

All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes except that all open ended conduits shall be installed in such a manner as to ensure gravity drainage out of the end. The conduit arrangement and installation shall be subject to approval by the Engineer. [CDRL 17-031]

17.20 CONDUIT FITTINGS AND JUNCTION BOXES

17.20.1 General

All fittings and junction boxes for car wiring shall be metal as manufactured by the Contractor or by a supplier of a comprehensive line of fittings and boxes. The Contractor shall submit the proposed product line to the Engineer for approval [CDRL 17-032]. All junction boxes including pull boxes are to be orientated so as to be directly accessible for maintenance.

17.20.2 Boxes

All exterior junction boxes shall be fabricated of a minimum 14 gauge steel. All exterior junction boxes shall be weatherproof and shall be connected in such a way that drainage from equipment groups will not pass through conduit into the junction boxes. Interiors of all junction boxes shall be primed and then protected with a white insulating coating as specified in TS 17.23. The bottom of all exterior junction boxes shall be sloped to allow drainage. Drain holes shall be equipped with stainless steel cotter keys with the ends turned up or similar system as approved by the Engineer.

All covers shall be provided with gaskets using approved materials and shall be retained with captive screws.

17.20.3 Conduit Interface

The open ends of conduit shall be provided with strain relief type fittings with extended rubber bushings, bell mouth fittings, or insulated throat box connections as approved by the Engineer. All conduit entries into removable equipment boxes shall be secured by means of a bolt on the watertight access panel.
17.20.4 Covers

Covers shall be completely removable. All junction box covers that access equipment or terminals shall be dust proof retained by compressive spring type latches or captive screws as approved on a location by location basis. All fasteners used in junction boxes shall be stainless steel. Screws and other hardware shall be zinc plated or stainless steel. All covers shall be designed to accept or mate with a bulb type clamp on seal.

All pull boxes that facilitate pulling of cable shall be a neoprene sealed and bolted design.

17.21 Wireways

All wireways, raceways, cable trays, or cable ducts (referred to as "wireways" hereafter) may be used in underfloor locations or in the car interior ceiling area or electrical lockers. Wireways in underfloor locations shall be constructed of either uncoated stainless steel or rigid carbon steel with a permanent low smoke elastomer coating to minimize the risk of oxidation and rust formation. Wireways used in the car interior shall be constructed of either corrosion protected carbon steel or aluminum, stainless steel, or polycarbonate. Proposed wireway locations shall be submitted to the Engineer for approval. [CDRL 17-033]

All wireways shall be adequately supported throughout their entire length in a manner approved by the Engineer. [CDRL 17-034] There shall be absolutely no sharp edges, and all trays shall be completely deburred before installation on the vehicles. Grommet clamps shall be provided at all locations where cables or wires enter the wireways. Under no circumstances shall leads be dropped over the edge of the wireways with or without wireway edge protection. In underfloor locations, covers shall have sufficient engagement to prevent the entry of car washer chemicals. Wireway elbows, couplings, and similar fittings as well as all internal fastener heads shall be flush with the interior surface. Fasteners shall not be directed toward the interior of wireways. All metallic wireways shall be grounded.

All wireways shall be routed such that they avoid sources of heat, wheel splash areas, and areas along the vehicle where the trays may be subject to foreign object damage. The wireways shall be located such that it will be possible to reach the harnesses contained within for maintenance activity. Wireways may be perforated without jeopardizing their strength to permit ventilation and drainage but shall prevent the accumulation of leaves. All wire and cable shall be securely fastened within wireways to eliminate movement and resultant chafing.

Wireways shall not contain more than 30 current carrying (i.e., power source as opposed to signaling) conductors at any cross-section. The sum of the cross sectional areas of all conductors contained at any cross section of a wireway shall not exceed 40 percent of the interior cross sectional area of the wireway as measured by cross sectional volume of conductors and insulation and not more than 60 percent of loose fill.

All wire and cable shall be securely fastened within wireways to eliminate movement and chafing. Circuit separation shall be maintained as required by TS 17.17.3.2.
WELDING AND BRAZING

17.22.1 General
The Contractor shall be responsible for the quality of its welding and brazing as well as that of its suppliers and subcontractors. Cleaning prior to welding shall be in accordance with applicable parts of MIL-HDBK-132, Section 2, "Protective Finishes."

17.22.2 Structural
All structural welding practices shall be according to the requirements of the AWS D1.1, "Structural Welding Code-Steel"; AWS D1.2, "Structural Welding Code-Aluminum"; AWS D1.3, "Structural Welding Code - Sheet Steel"; AWS D1.6, "Structural Welding Code - Stainless Steel"; AWS D15.1 "Railroad Welding Code"; and the AWS Handbook. Requirements for dynamically loaded structures shall be applied. Cast steel welding shall be according to ASTM A488/488M, "Steel Castings, Welding, Qualification of Procedures and Personnel". Resistance welding shall be in accordance with AMS-W-6858B. AWS D1.1 and shall apply to steel of 1/8 inch and greater thickness. AWS D1.3 shall apply to steel less than 1/8 inch thickness.

Structural welding of ferritic and austenitic stainless steel shall be governed by AWS D1.6 and ASME Section IX, and ASME, Section VIII, Part UHA, shall apply as appropriate. AISI 201L and 301LN stainless steels shall be treated as P-No. 8 Group-No. 3 category for reference to ASME requirements. The ferrite number for welds shall be between WRC4 and WRC10 or as proposed by the Contractor and approved by the Engineer. Weld heat affected zones (HAZ) and weld metal shall be limited to maximum allowable stress values in ASME Section VIII, Table UHA-23, for UNS S20100 stainless steel and Table UW-12 rating of welds. Fatigue allowable stresses shall not exceed the lesser of fatigue limits in AWS D1.1, Section 2.20.6, or 50 percent of the joint strength level calculated from ASME maximum allowable stress values. Higher values shall only be used if qualified by Contractor tests and approved by the Engineer.

The use of AWS-B2.1 shall not be permitted and shall not be included or referenced in Welding Procedure Specifications (WPS) and Procedure Qualification Records (PQR). The use of any WPS purchased from AWS shall not be permitted. All welding procedures specifications (WPS) shall be fully qualified by test by the Contractor. Qualification shall be documented by procedure qualification records (PQR). WPS and PQR shall be prepared by the Contractor, reviewed and accepted by a certified welding inspector, and submitted to the Engineer for approval. [CDRL 17-035]

17.22.3 Welder Qualification
Welders shall make only those welds for which they have been qualified according to the requirements of the AWS, ASME Section IX, ASTM A488/A488M or other approved qualifying procedures. Records of welder qualification tests shall be made available for review.

17.22.4 Inspection
The Contractor shall visually inspect all structural welds in accordance with AWS D1.1 requirements.
In addition to the visual inspection specified for all welds, non-destructive surface inspection (dye penetrant or magnetic particle methods as appropriate) shall also be used to inspect all first-production welds. The Contractor shall specify a sample non-destructive inspection rate for all subsequent welds. A record of all NDT inspections shall be included in the Car History Book.

On the first structure, all full penetration welds shall be non-destructively volumetrically inspected (ultrasonic or radiographic methods) according to AWS D1.1 requirements. The Contractor shall specify a random sampling plan for volumetric inspection of subsequent full penetration welds for approval. [CDRL 17-035] The minimum acceptable inspection plan shall require inspection of one (1) portion of a full penetration weld for every 200 production welds. The proposed test welds shall be selected from among welds that are most critically loaded as determined by calculation or load test. With approval, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements for production welds.

If ring welds are used on the first structure, all ring welds shall be non-destructively inspected by magnetic particle or dye penetrant methods. Sample ring welds shall be sectioned and examined metallographically to determine HAZ hardness which shall not exceed 400 VH (Vickers Hardness). The Contractor shall submit a random sampling plan for additional metallographic examinations of ring welds for approval. [CDRL 17-035] The minimum acceptable sampling plan shall require inspection of one (1) ring weld sample for every 300 production ring welds.

17.22.5 Post Weld Cleaning Requirements

All welds exposed to passengers or on sliding contact surfaces of truck frames and bolsters shall be completely cleaned of spatter.

17.22.6 Contractor Documentation

All welding procedures and documents including Welding Procedure Specifications, Procedure Qualification Records, and Resistance Spot Welding Schedules, shall be submitted for approval before application. [CDRL 17-035]

Specifications for purchase of welding electrodes, welding wires, and cover gases shall be submitted for approval before their application.

17.22.7 Special Welding

Procedures and qualification records for structural welding of stainless steel to LAHT or other combinations of metals or conditions not covered by AWS specifications or codes shall be submitted for approval.

Austenitic stainless steel electrodes or wire shall be used to join carbon or LAHT steels to stainless steels. Galvanized steel shall not be welded to stainless steel.

As part of the qualification of all dissimilar metal welds, sample welds shall be sectioned and examined metallographically to determine HAZ hardness. The HAZ hardness shall not exceed 400 VH.
17.22.8 Resistance Welding

Resistance welding of stainless or carbon steels shall be according to MIL-W-6858, Class B, for structural applications and Class C for non-structural applications. All resistance welding procedures shall be qualified per AMS-W-6858B; procedures and qualification records shall be submitted for review and approval. [CDRL 17-035]

Contractor proposed deviations from AWS-W-6858 including, but not limited to, weld nugget diameter, tension shear strength, and minimum spacing shall be submitted and approved before application in production.

Design strengths higher than standard certification and production strength requirements shall be qualified according to AWS-W-6858, Figure 11b, for one (1) thickness. This shall require a test lot size of 180 spot welds. Additional thickness combinations with the same increased strength ratio may be qualified by 25 spot weld shear tests plus three (3) macro-sections. 20 of the 25 shear test specimens may be recorded from production witness tests taken from 20 consecutive production days (not calendar days). The Contractor shall submit records of the settings, ultimate shear strength, weld diameter, and weld penetration for approval. [CDRL 17-035]

Surface indentation shall not exceed 20 percent of material thickness (t) or 0.01 inch whichever is greater. However for exterior resistance welded areas exposed to passenger view, indentation shall not exceed ten (10) percent of t or 0.005 inch whichever is greater. For exposed welds, the Contractor shall vary welding parameters and conditions within their acceptable ranges to minimize indentations. Surface burn and discoloration shall be removed by chemical cleaning or an approved equal method and sanding or polishing to match the surrounding surface.

Production witness welds shall be made and tested once each day and in addition whenever otherwise necessary such as by change in any of the following:

a. Operator
b. Material, material thickness, or combination of thicknesses
c. Electrodes
d. Settings

17.22.9 Resistance Spot Weld and Intermittent Weld Spacing

Spacing of resistance and spot welds shall be according to approved structural drawings. Spacing shall not exceed two (2) inches plus twice the weld nugget diameter for any structural application including carbody side sheets, roof sheets, and corrugation. Intermittent fusion weld spacing pitch shall not exceed five (5) inches for two (2) inch (minimum) weld lengths (i.e., 40 percent minimum of length welded).

For any corrugation application if the pitch of the corrugation nodes does not allow the above weld spacing, there shall be two (2) spot welds between each node.
17.22.10 Toughness of Welded Assemblies

The Contractor shall prove all welded steel structures are above the ductile brittle transition temperature for the specified environmental exposure. Specifically, the weld heat-affected zone (HAZ) and base metal shall resist service impact loads at the lowest specified operating temperature without brittle failure. In the absence of prior operating history and if the Contractor’s approved design does not require greater toughness, the minimum impact value for Charpy V-notch specimens shall be 15 ft/lbf of absorbed energy at the lowest specified operating temperature or -20 degrees F whichever is lower.

The Engineer shall have the right to require impact tests to verify the specified toughness. If tests are required, verification of HAZ toughness shall be done on a test sample welded according to PQR parameters. Base metal toughness shall be certified on a heat basis by the steel manufacturer or steel supplier; if this data is not available, the Contractor shall perform tests on each heat of as received base metal.

17.22.11 Torch Brazing

All brazing defined as heating above 840° F shall follow the recommendations of the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who perform brazing work shall be qualified in accordance with AWS B2.2, Standard for Brazing Procedure and Performance Qualification.

17.22.12 Torch Soldering

All structural (not electrical) soldering defined as heating below 840° F shall follow the recommendations of the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who perform torch soldering shall be qualified through the preparation and testing of samples of production torch soldering. Test samples shall be prepared and submitted for approval before production torch soldering. [CDRL 17-036]

17.23 PAINTS AND COATINGS

17.23.1 General

The painted portion of the carbody or any of its components shall be painted as required by the Specification and in accordance with the specified color scheme. Austenitic stainless steel portions of the carbody shall not be painted unless otherwise specified by the Engineer for cosmetic reasons. Where stainless steel is painted, procedures shall be as recommended by the paint manufacturer for the application, and surfaces shall be properly prepared by sand/bead blasting or chemical etching to ensure adhesion.

All painting on the carbody or any component shall be performed in accordance with the paint manufacturer’s recommendations. The Contractor and its paint supplier shall submit a touch up procedure and assure that a continuing supply of touch up paints in colors used on the car suitable for spot application by spray, roller or brush will continue to be available in the United States. [CDRL 17-037]
17.23.2 Materials and Preparation

Preparation of the substrate surface and application of painting materials by roller, brush, or spray shall be in accordance with the paint manufacturer's recommendations. Only primers recommended and approved by the paint manufacturer shall be used. All paint materials shall be used at the consistency recommended by the paint supplier. If thinners are necessary, they shall be approved by the paint manufacturer and shall be used only to the extent recommended. Painting shall be performed by experienced labor using proper equipment under competent supervision following documented and approved procedures.

Painting materials for all surfaces shall provide a high quality finish resistant to corrosion, chipping, and fading and shall retain the gloss level. The coating shall be a two part high solids low VOC Desmodore polyurethane paint system with a solids content between 50 to 70 percent. Alternate paint systems such as waterborne coatings, base coat clear coat systems, or direct to metal paint systems will be considered if the paint performance equals or exceeds that of two part polyurethane. All paint and filler materials, which are to be superimposed to form a finish system, shall be mutually compatible and shall be warranted for use as a system by the manufacturer of the components.

Metal portions of the carbody not constructed of austenitic stainless steel shall after fabricating be prepared for painting by grit blasting and immediately painted with an approved epoxy primer or washed with an alkaline solution properly rinsed, phosphate coated, or painted with a coat of wash (etch) primer, and then coated with an approved epoxy primer. After erection of the framing structure and body sheets, all undercar metal except stainless steel shall receive a polyurethane finish as specified above. The color of the underframe paint shall be black. The exterior finish shall have a gloss level of 85 +/- 5 as measured with a 60 degree glossmeter. The supplier shall submit color samples and corresponding gloss and tri-stimulus values for approval. [CDRL 17-038]

17.23.3 Exterior Painting

All exterior surfaces that are to be painted shall be prepared as specified, and the paint shall be applied according to the paint manufacturer’s recommendations. The paint shall be uniformly applied over all surfaces to be covered and shall be free from runs, sags, or other application defects. Painting shall be performed in a clean dry atmosphere at an ambient temperature as recommended by the paint manufacturer.

Before painting any non-stainless steel car surface that is exposed to view, all dents, gashes, nicks, roughness, or other surface imperfections or depressions shall be removed in so far as possible by straightening and shall then be properly prepared to receive a filler material. These surfaces shall be properly cleaned and wash primed following straightening. Any remaining dents or other surface imperfections shall then be filled with an approved filler and sanded smooth. The maximum allowable filler thickness shall be as recommended by the filler manufacturer for the environment and service to which it is to be exposed but in no case shall it exceed 0.125 inch.

The final painted surface shall be tested on the first car to the following criteria:

a. Hardness
Pencil hardness tests shall be performed according to ASTM D3363. The range of acceptance shall be between H and 2H and shall be the average of ten (10) readings taken from typical surface locations. This is a destructive test and will require the tested surfaces to be repaired.

b. Adhesion

Adhesion shall be tested per ASTM D4541 and achieve a minimum rating as provided by the paint manufacturer. This is a destructive test and will require the tested surfaces to be repaired.

c. Thickness

The minimum and maximum dry film thicknesses shall be provided by the paint manufacturer. Dry film thicknesses beyond the manufacturer’s recommendations will not be accepted. Non-destructive testing shall be performed to verify final dry film thickness.

d. Paint Cure

A solvent rub test shall be performed per ASTM D5402. The test procedure requires no less than 50 double finger rubs with a cloth wetted in acetone or methyl isobutyl ketone to the painted surface. No paint color shall transfer to the cloth. After 72 hours, the painted surface must retain all original characteristics such as gloss and hardness.

**17.23.4 Apparatus and Underfloor Equipment**

All underfloor and overhead mounted apparatus (motors, control boxes, junction boxes, brake valves, and other equipment as specified) shall be primed and painted in accordance with the following requirements unless otherwise indicated. All other apparatus shall be painted in an approved color.

The exterior surfaces of undercar equipment enclosures and apparatus other than propulsion control equipment made from carbon steel shall be prepared, primed, and painted as specified. The interior and exterior surface of all electrical equipment enclosures shall be coated with an approved insulating thermosetting resin based powder coating or polyurethane paint system. The interior of the boxes including insides of covers shall be white, and the exteriors shall match the undercar paint scheme. The interior and exterior paint will be reviewed on a case by case basis.

Parts of undercar equipment enclosures made from plastic or fiberglass shall be painted in accordance with the above requirements for metal portions except that the paint system shall be compatible with the plastic used and an insulating coating need not be applied.

**17.23.5 Painting Restrictions**

Any equipment or parts of equipment which can be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant.

a. The following items shall not be painted:

1) Copper tubing, piping, and fittings
2) Wearing surfaces  
3) Couplers  
4) Wire and cable  
5) Power resistors  
6) Heat transfer surfaces  
7) Electrical insulators  
8) Elastomeric parts  
9) Grounding pads  
10) Fittings  

b. The following truck related items shall not be painted:

1) Wheels  
2) Axles  
3) Elastomeric parts  
4) Grease fittings  
5) Threaded adjustment parts  
6) Electrical equipment (except where painted by OEM)  
7) Wearing surfaces  

17.23.6 Interior Painting

All exposed interior surfaces, including molding and trim, shall be as specified in TS 4.4, or powder-coated, or metal not requiring paint. Interior surfaces requiring painting shall be coated with an approved thermosetting powder coating. Parts which are to be powder-coated shall be cleaned and prepared in accordance with the recommendations of the powder supplier. Aluminum surfaces shall be anodized to accept powder coating.

All non-roof non-skid surfaces such as thresholds and step treads shall be a chemically bonded vinyl based anti-skid coating system with integral grit such as Darkar or approved equal.

The Contractor and its powder supplier shall provide a touch up procedure and assure that a continued supply of touch up paint in the proper colors suitable for spot application will continue to be available in the United States. [CDRL 17-037] The information and technique shall be included in the maintenance manuals.

17.23.7 Corrosion Protection

Concealed surfaces that can rust or oxidize shall be properly cleaned, receive a wash primer, shall be primed with epoxy paint, and shall be painted with an approved finish. Where arc welding is performed on joints between stainless steel and other materials, the joint shall be descaled, cleaned, receive a wash primer coating, and shall be painted per this Section.
17.23.8 Acoustic Insulation

Acoustic insulating materials shall be applied to properly cleaned underframe, sides, ends, and roof and floor sheets as required in TS 3.6.3 to the supplier’s recommendations. If the upper level floor is part of the car structure, provision shall be included for sound dampening and sound attenuation requirements.

The materials shall be resistant to dilute acids, alcohols, grease, gasolines, aliphatic oils, and vermin. The material shall be unaffected by sunlight and ozone and shall not become brittle with age. It shall be Daubert Chemical Company’s V-Damp No. 3680 sound deadening compound, Aquaplas No. DL-10, 3M 2552 Damping Foil, or approved equal.

17.23.9 Paint Process Documentation

The Contractor shall prepare detailed paint coating and application documentation containing the manufacturer's product data sheets, procedures for surface cleaning and preparation, priming, surfacing, and painting for the carbody and all equipment that is to be painted or powder coated, as well as touch up and repair procedures. A detailed paint schedule showing the equipment painted, paint type and manufacturers’ recommendations for thickness, and other pertinent parameters shall also be included. This document shall be submitted for approval prior to painting of any surfaces or components and shall be made part of the maintenance manuals. [CDRL 17-039]

17.23.10 Truck Painting

All truck components to be painted shall be given a full coat of primer prior to assembly. Following assembly, all exposed surfaces of each truck including machined mounting surfaces not used shall be cleaned with compressed air and solvent wiped to remove all dirt and grease. These surfaces shall then be sprayed with one (1) coat of an approved black truck paint of a type which will not conceal cracks that may develop in service and air dried.

17.23.11 Decals

Preparation and application of decals shall be in accordance with the decal supplier’s recommendations. Where appropriate, decals may be embedded in the paint system and shall be processed so as not to void any warranties from the paint or decal manufacturers. Edge seal shall be used as required by the manufacturers of the decal.

17.24 FLAMMABILITY, SMOKE EMISSION, AND TOXICITY REQUIREMENTS

17.24.1 General

All combustible materials used in the construction of the cars shall satisfy the flammability, toxicity, and smoke emissions’ requirements of this Section and 49 CFR 238 and NFPA 130. In the case of a conflict, the most restrictive requirement shall apply.
The Contractor shall comply with all provisions of 49 CFR 238.103 (c), Fire Safety Analysis for Procuring New Passenger Equipment, and APTA-PR-PS-RP-005-00. The Contractor shall prepare and submit a Fire Safety Analysis of the design and materials of construction of the vehicle as part of the design phase of the Contract to be submitted to Engineer for review and approval prior to construction of the first pilot car vehicle. [CDRL 17-040] The fire safety analysis shall be based on a quantitative assessment of the total fuel content of the vehicle as determined by the heat release rate data developed using ASTM E1354 for all of the combustible materials of construction and their respective quantities that are intended for use in the proposed vehicle. The Contractor shall use this heat release rate (HRR) data to predict the most likely fire scenario and the time available for passengers to evacuate the railcar to a place of safety. All materials with a surface area greater than 16 in² shall be tested at flux radiance of 50 kW/m².

Test results from an independent laboratory indicating successful testing and demonstrating compliance with these requirements for all materials shall be submitted to the Engineer for approval. [CDRL 17-041] Testing shall be conducted within the Contract duration period and on a production batch of material intended to be used on the vehicle. Each laboratory shall have tested a standard test sample no greater than 30 days prior to performing the tests which shall be submitted to the Engineer. The Contractor shall be responsible for complete conformance with the requirements for itself and its subcontractors and suppliers. The Engineer may at his discretion require that the current batch of material provided for this Contract be retested for conformance with these requirements.

17.24.2 Combustible Content

The design of the vehicle shall minimize the total combustible material content of the vehicle. A matrix showing the total weight of all materials, where they are used, flammability, smoke emissions, test identity, test facility, test requirements, test results, nature, and quantity of the products of combustion, heat content, and heat release rate per ASTM E1354, shall be submitted by the Contractor during the detailed design review for the Engineer’s approval [CDRL 17-042] As a minimum, the following materials shall be tested: seating materials, wall coverings, window masks, fiberglass components, insulations, plymetal walls, flooring, equipment boxes and covers, flooring surface, window glazing, lighting lenses and diffusers, window gaskets, door seals, HVAC in air stream components, grills, gaskets, and filters.

17.24.3 Flammability and Smoke Emission

All materials used in passenger vehicles shall be tested to demonstrate compliance with the requirements set forth in 49 CFR 238.103 and NFPA 130. The complete reports shall be provided for all materials tested for all tests. The Contractor shall submit to the Engineer for approval test reports for all materials tested and a summary table. The summary table shall include the description of each material test and its use in the car, description of the test procedure used, the name and location of the test facility, performance criteria, and actual test results. [CDRL 17-043]
17.24.4 Floor Assembly Fire Resistance Testing Criteria

The Contractor shall test the lower and the intermediate floor assemblies in accordance with ASTM E119 to demonstrate a 30 minute endurance rating. The comprehensive test report, which shall include the test procedure, test facility, test results, and “before and after” photographs, shall be submitted for review and approval by the Engineer prior to procurement of any flooring material for vehicle production. [CDRL 17-044]

The following test criteria shall be met:

a. The test specimens shall be a full width vehicle section of each level including side sills or that portion of the wall which extends below the floor. Each specimen shall have a minimum exposed area of 100 square feet. If approved, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 11 feet. No less than one (1) typical penetration of each type spaced at a distance from each other no greater than that which will exist in actual construction shall be included in the test specimen. The specimens shall include typical floor splice configurations.

b. The test specimens shall be loaded to simulate "crush" passenger loading conditions. Concentrated loads shall be applied to simulate underfloor and overhead mounted equipment as applicable.

c. The test specimens shall include at least three (3) typical transverse supports for each level.

d. The test specimens shall represent the actual construction utilized in production. This shall include the floor covering, floor boards, floor structure, thermal and acoustic insulation, and floor pans.

e. The conditions of acceptance for this test shall be those required for unrestrained assembly.

Drawings of the floor fire test sample shall be submitted to the Engineer for approval prior to construction and testing of the sample. Any deviations from the approved configuration shall require approval and retesting. [CDRL 17-045]

17.24.5 Toxicity

Materials and products identified by state agencies, federal agencies, and the American Conference of Governmental Industrial Hygienist (ACGIH) as containing toxic properties or to emit toxic products of combustion in excess of the limits defined in the Specification shall not be used. Materials and products generally recognized to have highly toxic products of combustion shall not be used.

All materials used in the car construction, except for materials used in small parts such as knobs, rollers, fasteners, clips, grommets, and small electrical parts that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall be tested for toxicity using Boeing Specification Support Standard BSS-7239. Materials shall meet the following maximum toxic gas release limits (ppm) as determined per BSS-7239:

a. Carbon Monoxide (CO)  3500 ppm
b. Hydrogen Fluoride (HF) 200 ppm  
c. Nitrogen Dioxide (NO₂) 100 ppm  
d. Hydrogen Chloride (HCL) 500 ppm  
e. Hydrogen Cyanide (HCN) 150 ppm  
f. Sulfur Dioxide (SO₂) 100 ppm

The tests shall be conducted in the flaming mode after 240 seconds using the NBS Smoke Density Chamber for sample combustion. The gas sampling may be conducted during the smoke density test. The test report shall indicate the maximum concentration (ppm) for each of the above gases at the specified sampling time and shall be submitted to the Engineer for review and approval. [CDRL 17-046]

17.24.6 Electrical Fire Safety

Electrical equipment shall conform to NFPA 130 except where more restrictive requirements are imposed by this Specification.

17.25 AIR FILTERS

17.25.1 General

Where possible, the air filters provided shall be the same as those used by SEPTA for similar applications. The Contractor shall make every attempt to minimize the number of different filters required for the vehicles.

17.25.2 HVAC and Equipment Ventilation Filters

Filters shall be selected in accordance with the manufacturer's recommendations for the specific equipment involved. Filters shall be the throw away type with integral frames except that reusable filters may be approved for specific applications where throw away filters are not available. Filters shall be secured in place using spring loaded toggle. Filters shall be designed to meet the performance requirements of each installation and shall be approved by the Engineer. [CDRL 17-047] All filters shall be freely accessible for replacement and maintenance. Filters shall meet the requirements of UL 900, Class 2.

17.25.3 High Pressure Air Filters

Air filter assemblies with replaceable filter elements shall be provided in the line that connects each subsystem to the main air supply system. The filtering capability, flow rate, and overall size shall be appropriate for the application so that the filter replacement interval is greater than one (1) year. It shall be possible to gain access to filter elements for replacement without disconnecting or loosening pipe fittings. Filters shall be provided for each of the following systems and any others if operated from the air supply system:

a. Each air brake control assembly  
b. Input and output of each leveling valve
c. Door controls  
d. Horn and bell

17.25.4 Low Pressure Air Filters  
Replaceable media type filters shall use resin bound spun glass fiber materials having an uncompressed thickness not less than 3 1/2 inches. They shall be non-absorptive of fluids and gases, shall be processed in such a manner that material density increases progressively from inlet to exit side, and shall be coated with not less than 24 grams per square foot of a dust-retaining viscous adhesive film. This film shall be stable at temperatures up to 150 degrees F. The filter medium shall be cut not less than 1/2 inch oversize to ensure adequate sealing between the edge of the pad and its integral frame.

17.26 ELECTRICAL AND ELECTRONIC DESIGNS

17.26.1 Design Criteria  
All low voltage apparatus shall function satisfactorily for any duration at any continuous voltage between 55 and 80 volts measured at the battery, shall not be damaged or operate in an unsafe manner by the continuous application of voltages between 0 and 74 volts, and shall withstand the application of 74 volts for one (1) second. All hardware shall be protected against moisture, oxidation, and common air borne contaminants. Use of any locking compounds or antiseize compounds on threaded electrical connections is prohibited. Conveniently located near any removable printed circuit board or group of such boards shall be a primary power switch whose opening shall make it possible to remove and replace such boards without injury to them. This switch may have multiple functions relating to troubleshooting and diagnostics as required. Equipment containing devices that are sensitive to electrostatic discharge (ESD) shall have provisions for hookups properly identified for attaching grounding devices. Equipment shall be designed to reduce or eliminate the need or requirement that maintenance crews be grounded during the maintenance of the cars. All circuits on the car shall be designed to impose sufficient current load to positively eliminate any problems from "dry circuit" conditions to the satisfaction of the Engineer.

The need for adjustments shall be avoided wherever possible by the use of appropriate circuitry, stable components, and high tolerance drift compensation and temperature compensation circuits. Where adjustments on printed circuit boards are necessary, they shall be accomplished without the use of specialized (i.e., non-catalog U.S. supplier) test equipment unless this equipment is furnished by the Contractor.

In general, all return circuits for any one system shall return to a single terminal point without any connections to returns from other systems. Circuit design shall minimize both circuit complexity and number of components and shall annunciate component failures in a safe manner by responding or not responding, as appropriate, to commands for changes of state. Use of diodes shall be minimized and when used their failure shall not allow an unsafe condition to be created.
Electronic equipment shall utilize stock components and shall function properly with the component manufacturer's full range of tolerances such that after purchase screening or testing of components shall not be required. Matching of components is permitted only if the components are normally available from the manufacturer in matched sets.

Equipment design consideration shall include separation of high voltage from low voltage devices. Components shall not be located near or above high voltage contactors. All low voltage components, controls, circuits, and mounting hardware near or in the arc path of contactors shall be adequately protected against damage either by insulating material or by adequate distance.

All fiber optic cables shall be installed in accordance with the cable manufacturer's instructions, shall be adequately protected from damage of any kind, and shall be readily accessible for maintenance and inspection. Fiber optic terminations shall be designed to prevent degradation due to the car environment including vibration and variation in temperature and shall be capable of inspection and repair without removal from the car. Fiber optic cables shall be provided with a minimum of ten (10) percent spares on a location to location basis. Samples and technical details of all proposed fiber optic cables and connectors shall be presented to the Engineer for approval. [CDRL 17-048]

Capacitors shall be derated at least 20 percent for voltage based on the nominal supply voltage and maximum case temperature except for the DC link capacitors in the propulsion system which shall be derated at least ten (10) percent. Hermetically sealed metal cased dry tantalum capacitors shall be used in place of aluminum electrolytic capacitors except for very high values which are not commercially practical or available or where otherwise not appropriate in which case long life grade aluminum electrolytic capacitors shall be used or in cases where tantalum is technically inappropriate. Alternates with equivalent service life may be approved on a case by case basis. Commutating capacitors shall be a paper or plastic film type and incorporate a non-toxic impregnant and shall be chosen to give a service life of at least 20 years. Filter capacitors shall have a high ripple rating for long life, and the sum of the DC and AC ripple voltage shall always be less than the capacitor's voltage rating at a maximum case temperature of 185 degrees F. All high voltage filter capacitors except for the APU shall make use of bleeder resistors and/or other techniques to ensure their reduction to less than 50 volts within one (1) minute in the absence of car motion and externally supplied power. For the APU, the reduction shall be to less than 50 volts within two (2) minutes under the same conditions. The methodology details and expected results shall be submitted to the Engineer for approval during design review. The resistors and their installation method shall be such as to ensure long life.

Except for accelerating and braking power resistors (unless determined to be necessary), all resistors shall be derated 50 percent for power dissipation. Transformers (other than the main transformer) and inductors shall be derated at least ten (10) percent for current or other appropriate approved factor based upon the duty cycle.

The circuit design shall employ protective techniques such that failures in power semiconductors shall fail safe or fail open and not cause consequent failure of components or major devices following them in the circuit. Except for the case of integrated circuits or where environmental conditions make it a necessity as exempted by the Engineer, no module employing multiple components shall be made non-repairable by potting.
17.26.2 Reliability Standards

A standardized MIL-HDBK-217F reliability part stress prediction shall be performed on all electrical and electronic control systems. This reliability prediction shall be based on the "ground Mobile" environment. Use of alternative reliability database information may be permitted for parts not contained in MIL-HDBK-217F subject to approval. Submittal of the reliability prediction shall be identified in the Reliability Program Plan described in TS 2.7. The prediction shall be used during design and development to compare competing designs, perform design tradeoffs, detect overstressed parts, and identify high failure rate items.

A documented closed looped Failure Reporting and Corrective Action System (FRACAS) (per Reliability Toolkit: Commercial Practices Edition) shall be established and maintained to provide for the identification, tracking, and repair of all product/process failures. Early elimination of failure causes or trends will contribute significantly to reliability growth and continuous process improvement.

All semiconductor devices shall be derated to operate within the acceptable region for electrical and temperature stress as specified in "Reliability Toolkit: Commercial Practices Edition”. If there is a conflict between guidelines given elsewhere in this Specification and the Reliability Toolkit, the more restrictive condition shall govern.

All electronic assemblies shall undergo environmental stress screening (ESS). The temperature cycling regimen shall be in accordance with Table 7.5-2, Unit Column, of the Reliability Design Toolkit: Commercial Practices Edition, from the reliability analysis center except as indicated below. The temperature extremes may be limited to -13 degrees F to +158 degrees F at the discretion of the supplier. A minimum of 20 complete temperature cycles shall be conducted. The ESS shall be performed with the equipment operational, powered, and oriented as per the ultimate application. Input signals and output loads to simulate the maximum power dissipating condition in the equipment shall be applied during the rising temperature and maximum temperature portions of the temperature cycle. The equipment shall be given a full functional test before and after the ESS and monitored for failure and anomalous operation throughout the ESS. In the event of equipment failure, the repaired equipment shall be given another complete ESS test. Alternatives to this baseline ESS may be acceptable but any alternative shall be approved by the Engineer prior to commencing the ESS. Assemblies consisting exclusively of components rated at 50 amperes or greater are exempt from this requirement.

17.26.3 Ability to Repair

Where practical, all electrical assemblies including such items as PC boards shall be designed for repair by SEPTA in their electronics laboratory. Bench test equipment shall support such repairs.

Assemblies shall not be sealed, potted, or constructed to prohibit repair by SEPTA. Assemblies that must be potted or sealed by design shall have a minimum ten (10) year warranty.

17.26.4 Hardware

Refer to TS 17.2.2 for general hardware requirements. All hardware associated with electronic and electrical control systems shall be protected against moisture, oxidation, and common airborne contaminants.
### 17.26.5 Enclosures/Racks

All circuit boards that are rack mounted shall plug into racks containing the mating half of the circuit board connector. The circuit board rack shall mount in an enclosure conforming to the requirements in this Specification. The rack, circuit board, and circuit board hardware shall be designed as an integrated system.

The rack and enclosure shall provide environmental and EMI shielding as required to meet the requirements of this Specification.

Printed circuit boards shall be positively retained by means of keeper bars or other approved method. The enclosure or rack cover shall not be used to retain the circuit boards unless specifically designed to do so. Hinges and latches shall be of stainless steel.

Each circuit board shall be fitted with an ejector or hand grip to assist in board removal. The rack and the edge of each board or the card ejector shall be labeled with corresponding numbers to identify board location within the enclosure. A brief functional designation shall also be included on each label. The enclosure/rack shall not be connected to the power supply return or signal common.

Where it is necessary to use printed circuit boards that are not plug in and not mounted in an enclosure, the following additional requirements shall apply:

- a. The PC board shall be protected from mechanical damage and hostile environments such as arc discharge or contact with high voltage.
- b. If the PC board is part of a high voltage circuit, special care shall be used in its design with regard to strike distance and creepage in the transit vehicle environment. This shall include the distance between PC board components and with respect to any grounded mounting surfaces.
- c. Any test points required in routine testing or fault isolation to the user replaceable level shall be easily accessible without disassembly or tools.
- d. If replacement of the PC board is required (as part of secondary maintenance), no special tools or soldering shall be required.
- e. Each PC board use and application of this type is subject to SEPTA’s approval.
- f. If replacement of a printed circuit board is required, no special tools or soldering shall be required. Each printed circuit board use and application of this type shall be subject to approval by the Engineer.

### 17.26.6 Optical Fibers

Any application of optical fibers shall be approved prior to implementation. This approval is not intended to discourage the use of optical fibers; rather it is meant to verify reliability and maintainability of the proposed application. In no case shall the on car repair of an optical fiber require sophisticated or complex polishing and alignment. The connections between optical fibers and car replaceable units shall be via approved "quick disconnects".
17.26.7 Electrostatic Discharge

Protection shall be provided against electrostatic discharges (ESDs) in compliance with EN 50121-3-2, 2000 Table 9. The discharge is to be delivered to the enclosure in which the equipment is housed (if an enclosure exists), to the enclosure of each line replaceable unit, and to all surfaces and controls that are accessible to operating staff and passengers (e.g., knobs, switches, fasteners, printed circuit board faceplates, handles). The equipment shall function properly after such testing.

This requirement is not intended to apply to the contacts of electrical connectors that are exposed in the course of removing, replacing, and/or handling a line replaceable unit. ESD sensitive equipment shall be labeled. The label shall be affixed in a location that clearly indicates the ESD concern to maintenance personnel.

17.27 SEMICONDUCTOR STANDARDS

17.27.1 General

The Contractor shall be responsible for ensuring that all electrical and electronic circuitry, whether of its own design and manufacture or of those of its manufacturers and suppliers, shall meet, as a minimum, the criteria listed in this Section with regard to the use of semiconductors. Semiconductors for electronic circuits shall be adequate in current, power (both continuous and peak) and PIV rating and performance characteristics for the application intended.

17.27.2 Ratings

Discrete semiconductors shall have the following minimum voltage breakdown ratings:

a. Semiconductors except diodes (see below) operated from the battery supply or those connected to trainlines shall have minimum breakdown ratings of four (4) times the maximum achievable circuit voltage. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.

b. Diodes operated from the battery supply used as suppression devices or connected to trainlines shall have a minimum breakdown rating (PIV) of 1,000 volts. Diodes with less than 1,000 V PIV rating may be used if adequate circuit transient protection is also provided.

c. All discrete semiconductors operated from inverters or other isolating devices shall have a minimum breakdown rating of two (2) times the maximum circuit voltage except where specifically detailed otherwise. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.
All semiconductors other than high power devices shall be operated at less than 50 percent of the maximum continuous current rating or 50 percent of the maximum continuous power rating with the more restrictive rating being the controlling value. Circuits shall be designed to limit excessive current to semiconductors, to prevent damage from high discharges (spikes), and to limit excessive temperatures through properly designed heat sinks where required. Power semiconductors shall be applied with ample thermal margins which can be shown to be such as to ensure no less than 15 years of service life in the application and shall have overcurrent, overtemperature, and overvoltage protection provided. Semiconductors shall be placed in a clean environment which shall favor easy replacement and ventilated as necessary. All power semiconductor circuits shall be passive air cooled. The electrical conducting surfaces shall be in dustproof waterproof containers. Germanium semiconductors shall not be used. All semiconductor junction temperatures shall be limited to the maximum rated temperature for the device or 150 degrees C, whichever is lower, at maximum ambient temperature and rated output power.

Integrated circuits operated from the battery supply through inverters or other isolating devices shall be operated within the voltage and current ratings specified by the manufacturer and derated to less than 50 percent of the maximum stress level at the maximum operating temperature of the device as specified by the manufacturer. Where the supply to the integrated circuits is regulated and surge protected, the voltage rating shall be 15 percent below the manufacturer’s recommended maximum. In addition, the maximum power shall be limited to 50 percent of the manufacturer’s specified maximum at the maximum operating temperature. Decoupling capacitors shall be distributed no less than one (1) for every five (5) integrated circuits.

All semiconductors shall be supplied in their hermetically sealed version and other than microprocessors and other approved exceptions shall be rated for operation over the temperature range of at least minus 40 degrees C to at least 85 degrees C. If a device is available from at least one (1) supplier with a 125 degree C rating then that version shall be used. Non-hermetically sealed packages will be considered provided comparable reliability can be documented. All gallium arsenide and similar optical semiconductors shall be packaged in a manner suitable for the application and shall be rated for operation over the temperature range of at least minus 40 degrees C to at least 85 degrees C.

All semiconductors shall be Joint Electronic Device Engineering Council (JEDEC) registered and numbered and must be available from at least two (2) different manufacturers who market them in the U.S. However, non-JEDEC registered devices may be used provided that the Contractor obtains prior approval based on submission of complete procurement specifications defining each such device and evidence of availability based on those specifications from two (2) or more manufacturers who market them in the U.S. Semiconductor devices carrying greater than 100 amperes which are either non-registered, have single sources, or have no domestic sources may be exempt from this registration and supply requirements as approved by the Engineer.
All plastic semiconductors shall be burned in and screened for defects to a level equivalent to MIL-STD-883, Method 5004, Reliability Class B, or approved equivalent. The method used must be submitted to the Engineer for approval. [CDRL 17-049] As a minimum, the supplier shall have had a proven effective component screening and burn in program in effect for five (5) or more years. Alternative methods based on a minimum 100 hour burn in for the completed device which uses the semiconductors will be considered. The burn in must be performed with the equipment operational (power on) and with the necessary input signals and loads to simulate the maximum power dissipating condition in the device at the maximum ambient temperature. Hermetic semiconductors shall receive screening and burn in to procedures that can be documented to have produced assembled product reliability in accordance with the overall system requirements in this Specification.

17.27.3 Availability and Identification

All semiconductors shall be available from at least two (2) manufacturers and available from U.S. distributors. Single source devices such as high voltage power devices, microprocessors, ASICs and related support chips shall be used only if approved by the Engineer. Such devices shall be essential to the proposed equipment, shall meet the proven service requirements, and shall be supplied by veteran manufacturers committed to support the device.

Each device shall be labeled to identify both the manufacturer and the complete part number. Operational characteristics of the device shall be published and available to SEPTA.

17.27.4 Burn In

Refer to TS 17.27.2.

17.27.5 Interference and Transient Suppression

All electrical devices and wiring shall be carefully planned and selected to avoid electrical interference in the operation of the propulsion and braking system, train radio, public address and any other frequency sensitive systems. This shall include the use of shielded cables, chokes, filters, and capacitors, as required by good design standards, to avoid possible interference with these systems. Adequate voltage transient suppression shall be provided for the protection of panels and circuitry involving semiconductor devices. Low voltage circuits shall be capable of withstanding 1.5 joules, unless otherwise approved by the Engineer.

Apparatus creating EMI emissions shall be designed to contain these emissions within their package area. Suppressors shall be incorporated across inductive devices to minimize switching transients. All suppression devices shall be selected on the basis of their ability to absorb the amount of energy available in the connected circuit for the number of cycles of operation expected in service without requiring replacement prior to scheduled overhaul. All magnet valves and relay/contactor coils shall have freewheeling diode or metal oxide varistor voltage spike suppression or other suppression means except where this results in deterioration of performance. Coil suppression devices shall be located physically on or as close as possible to the coil it protects (preferably directly at the coil terminal). Wherever possible, the suppression of transients shall be at the source.
17.27.6 Other Prohibitions

Electronic equipment shall utilize stock components and shall function properly with the component manufacturer's full range of tolerances such that after purchase screening or testing of components shall not be required.

Matching of components shall be permitted only if the components are normally available from the manufacturer in matched sets.

Germanium semiconductors shall not be used.

17.28 PRINTED CIRCUIT BOARD STANDARDS

Each circuit board shall be designed, constructed, and inspected to the latest revision of MILSTD-275 or approved equal unless more stringent requirements are noted here. Traces shall be made as wide as practical with the minimum width being based on a 10 degrees C temperature rise.

All printed circuit boards shall be of the "glass epoxy" type with the majority of the components mounted only on one side. The conducting copper laminate may be on both sides if required by component density or space constraints. In such cases, plated through holes shall meet the requirements of the Institute for Interconnecting and Packaging Electronic Circuits Specification IPC-D-320 or approved equal. The copper foil laminate shall be firmly attached to the board and be resistant to blistering and peeling when heated with a soldering iron. Run spacing shall conform to the latest revision of MIL-STD-275 or approved equal. The circuit board material shall comply, as a minimum, with the requirements of the latest revision of MIL-S-13949/4 type GF (NEMA Grade FR4) or approved equal with a minimum thickness of 0.0625 inch.

Each printed circuit board shall be identified by part or model number in addition to serial number. The component side of the board shall be printed with the component references consistent with system schematics and such other information as may be required to repair and troubleshoot the board. Alternate methods of providing this information in a manner suitable for repair shop use may be submitted to the Engineer for approval. Either the component or wiring sides of the board shall be marked to indicate capacitor polarity and at least two (2) leads of all transistors and thyristors. Diode polarity shall be indicated with an anode and cathode symbol. Integrated circuits and other multiterminal devices shall have an index mark on the board visible with the component inserted to indicate proper keying and insertion; the number 1 pin on round packages and the first pin on dual in line packages shall be identified as well. All equipment shall be fastened to the board in such a manner as to withstand repeated exposure to the shock and vibration encountered in a railcar environment. Sufficient clearance shall be provided between components to allow testing, removal, and replacement without difficulty due to lack of space. Large components shall be supported in addition to the solder connections. Power resistors shall be mounted in standoffs so that the resistor bodies do not contact, discolor, or damage the board.
All EPROMs and programmable read only memories (PROMs) that cannot be reprogrammed in circuit and central processor units (CPUs) shall be mounted in sockets. In addition, they shall be mechanically restrained such as by use of a ty wrap. This requirement shall also apply to any integrated circuits with more than 28 pins per package which are not of the VLSI "gull wing" configuration unless otherwise approved by the Engineer. The sockets shall comply with MILS-83502 and MIL-S-83734 or approved equal as is applicable for the device. The bodies shall be molded from diallyl phthalate, TFE Teflon, or similar material as approved by the Engineer. The contacts shall be fabricated from beryllium copper, shall be plated with a minimum of 0.00003 inch of gold over a minimum of 0.00005 inch of low stress nickel in the area of contact with the integrated circuit pins, and shall be of precision machined four (4) finger inner contact construction. Other service proven designs may be proposed for Engineer approval.

Both sides of an assembled printed circuit board shall be coated with an insulating and protecting coating which can easily be removed with a brush applied solvent. The coating solvent shall not adversely affect board mounted components and must be approved by the Engineer. [CDRL 17-050] The coating material shall be per MIL-I-46058, latest revision, or approved equal.

Provisions shall be made on all plug in printed circuit boards for "keying" to prevent insertion into the wrong socket. All wires, straps, and functionally similar devices that are used to configure a standard circuit board for a specific circuit location shall be permanently affixed or be located such that hand tools are needed to gain access, and the circuit board shall be keyed for the specific location. Spare multiuse circuit boards may be supplied unstrapped and unkeyed. The documentation shall provide full information for configuring and keying the circuit boards for each location in which they are used. All circuit boards in basic safety control systems such as doors, propulsion, braking, or any other system which can cause unsafe operations if the car is operated with a card removed shall be connected through a safety circuit to disable the vehicle if a circuit board is removed.

Printed circuit board connectors shall be heavy duty high reliability two part type with successful service in railcar applications. The connector contact area shall be plated with a minimum of 0.00003 inch of gold over a minimum of 0.00005 inch of low stress nickel. Tin plated contacts may be used if it can be shown that they are equivalent in long term reliability. Connectors, which comply with MIL-C-55302, latest revision, and which have plated contacts as described above, are considered to comply with the Specification requirements. Wire wrap connections shall not be used except as approved in back plane locations. Approval will be predicated on demonstration of prior performance in railcar applications. Ribbon (flat) cables and their connectors will only be allowed if a documented successful service history in railcar applications is demonstrated to the Engineer. Alternate materials may be proposed for specific applications for approval by the Engineer.

Test points shall be provided in appropriate locations on modules and printed circuit boards. Exceptions may be made with approval of the Engineer. A negative return test point shall be provided. The test points shall be a turret lug with sufficient clearance to permit it to accept a standard oscilloscope probe clip and shall be identified by appropriate markings.
Printed circuit boards and modules shall be positively retained by means of keeper bars or other approved means, and printed circuit boards measuring greater than seven (7) inches on a side shall be equipped with side rails or reinforcing bars to minimize board flexing and to protect components during maintenance and handling of the circuit boards. Printed circuit boards shall not exceed nine (9) by 14 inches in linear dimension or 126 square inches in area. Each rack mounted printed circuit board shall be fitted with an ejector or hand grip to assist in board removal. The circuit board card rack and the edge of each board or the card ejector shall be labeled with corresponding numbers to identify the circuit board location within the rack.

Printed circuit board extenders (50 sets of each type) shall be provided by the Contractor for all rack-mounted circuit boards. [CDRL 17-051] The Contractor shall provide detailed maintenance and bench test troubleshooting procedures for each board in the maintenance manuals including wave forms and voltages at critical locations of the circuitry.

Non-repairable or "throw-away' circuit boards may be supplied only by approval of the Engineer. In making this request for approval, the Contractor shall focus on the advantages to SEPTA of this approach. Where use of non-repairable circuit boards is granted, the Contractor shall supply to SEPTA spare circuit boards of each type in number either equal to 15 percent of those employed on the equipment of one (1) married pair multiplied by the number of married pairs supplied under this Contract or equal to a percentage determined by the failure rate through the warranty period prorated to the number of failures predicted over 20 years of service, whichever is greater, in order to compensate for the lack of repairability.

### 17.29 ELECTRICAL DEVICES AND HARDWARE

#### 17.29.1 General

All electrical devices shall be transit industry proven.

#### 17.29.2 Contactors and Relays

All contactors and relays used shall meet or exceed the requirements of IEC Recommendation Number 77 for current breaking apparatus. Contactors shall be tested for proper functioning in orientations up to 30 degrees from the orientation in which they are mounted in the car in each of the three (3) possible rotations: pitch, yaw, and roll. All high voltage contactors shall be suitable for 1000 volts AC service. All contactors and relays shall be utilized such that failures to respond shall be in a direction so that neither the passengers, the Operator, the train crew, nor the car is placed in jeopardy. All devices shall be installed such that they are fully accessible for inspection, repair in place, or removal and replacement. There shall be a maximum of two (2) wire terminations on any one (1) contact of a device.

All coils shall be suppressed to protect against transients generated on the low voltage network. Under no circumstances shall main or auxiliary contact tips be placed in parallel for the purpose of carrying a current load at or above the manufacturer’s tip rating. Installation shall be such that arc spray is directed by an arc chute away from ground and any other nearby electrical devices.
Devices shall be constructed in a very heavy duty fashion suitable for use in railcar service. Those which are in dusty areas or air streams shall be of an appropriately sealed type. Relays shall not be affected by the accumulation of airborne dust. All contactors shall be constructed such that the main tips make and break with a motion that prevents deposits and/or pitting. Blow out coils shall be used as required. Contactor tips and arc chutes must be directly accessible for repairs with the contactor as installed in the car and without the need to move other equipment. Contactors shall incorporate means of visually determining whether they are energized or deenergized.

The number of different relay types employed shall be minimized. Where practical, there shall be interchangeability of coil and contacts to minimize the number of spares needed. Bifurcated contacts shall be provided in low voltage applications whenever necessary due to dry circuit switching requirements or low current switching unless test data shows that it is not required. All time delay relays shall be of the keyed R-C delay type for safety related applications and of the electronic type for other applications. Mechanical or pneumatic time delay devices shall not be utilized. Solid state electronic timers shall be of proven quality with extensive successful experience in railcar service. All relays shall be capable of at least 1,000,000 electrical operations at rated contact capacity. Plug in relays shall be keyed to prevent incorrect installation relative to voltage rating or function and be secured in their sockets by a mechanical restraint. This restraint shall be captive, of rugged construction, and easily positioned for relay installation and removal without the need for special tools. When the relay is removed, the restraint shall not come in contact with devices which may have exposed energized electrical circuits, and it shall not interfere with the operation of any other device when in this position. Plug in relay bases shall allow for testing of each interlock by the use of a meter probe. Magnetic latch relays shall have integral reverse current protection, be insensitive to vibration and shock expected at the location, and be oriented so as to minimize vibration and shock exposure. All relay sockets shall have clearly visible identification. Any location that has six (6) or more relays in close proximity shall have a locator chart to aid in location. All devices shall be readily identifiable by means of a permanent durable marking strip giving the device circuit designation. No identifications shall be obscured or partially obscured by wire routing.

17.29.3 Switches

All switches provided shall be of the highest quality procurable and shall be fully suitable for the rigors of a railcar service environment. They generally shall be of 1,000,000 minimum cycle life unless otherwise approved. The design and selection of all switches shall be subject to review and approval by the Engineer. [CDRL 17-052] There shall be a maximum of two (2) wires connected to any terminal of a device and shall include sufficient wire slack to permit the replacement of an individual switch. Cab console and Conductor door control switches and any other switches subject to water splash shall be environmentally sealed except as otherwise approved by the Engineer.

Switch contacts shall have a maximum resistance of 0.10 ohms at 3.0 volts DC with a ten (10) milliamp load when closed, and an open contact resistance of 50 megohms. They shall be rated for inductive loads and have a contact material of silver, silver with a gold flash, or gold plate and be normally a break before make type. Switch terminals and connection points shall be silver or tin plated. All safety critical switches such as those that can cause door openings shall be designed to withstand a high potential test of 1,500 volts for one (1) second in a clean dry condition without false conduction. They shall have all exposed energized wire connections insulated in an approved manner to prevent false activation if bridged by foreign material.
Under no circumstances shall poles of switches be placed in parallel in order to carry currents equal to or in excess of the contact pole rating given by the manufacturer. Rotary switch orientation and function shall be such that handle movement from the normal position shall be clockwise, and normal shall be the 12 o'clock position. Non-rotary and non-pushbutton switches shall be mounted in a vertical position with the "up" position being "ON". No secondary mechanical means shall be utilized to achieve this. Switches shall be provided with a "keying" feature such that after installation, the body of the switch will be constrained from mechanical rotation. Switches shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the switches to be replaced. Momentary contact pushbutton switches shall be limited to those having a positive indication of switch state. Pushbuttons, which alternate between the on and off states with each successive actuation, shall not be used.

17.29.4 Circuit Breakers

All circuit breakers shall be extremely rugged molded case devices with a frame size fully suitable for the service intended. They shall be the highest quality procurable, of trip free design, dustproof, have moisture and fungus resistant cases and components, and capable of withstanding the shock and vibration requirements of the railcar service environment. Design and selection of all circuit breakers shall be subject to review and approval by the Engineer. [CDRL 17-053] Each circuit breaker shall have a TRIPPED position (unless otherwise approved by the Engineer on an individual item basis), as well as an ON and OFF position, all being permanently marked on the handle or case of each circuit breaker and easily seen as installed.

A separate circuit breaker shall be provided for each branch circuit as well as for each major assembly and function. No circuit breaker shall protect more than one (1) circuit or shall any one (1) circuit be protected by more than one (1) circuit breaker except as specified otherwise. Circuit breaker terminals shall not be used as junction points. All circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the minimum size wire used for power distribution within the protected circuit and shall be sized to at least 20 percent greater than the full load of the protected circuit. Their performance shall not be affected by ambient temperature. Each pole shall be equipped with a trip mechanism consisting of an inverse time element for overload protection and an instantaneous magnetic element for short circuit protection. Circuit breaker poles may be connected in series if necessary to achieve the stated voltage interruption requirements. Each circuit breaker pole shall be equipped with adequate means of arc extinction to prevent flashover.

The continuous current rating of thermal magnetic trip circuit breakers shall be selected in accordance with ANSI C37.16 for the load and type of service specified. All thermal magnetic trip circuit breakers shall conform to the requirements of ANSI C37.13 and ANSI C37.14. Circuit breaker current rating shall be clearly and permanently visible after installation. Electrically operated circuit breakers shall be arranged for operation from the low voltage DC supply. If circuit breakers are used to switch lighting loads, the circuit breaker shall be UL listed for "SWD" duty. Circuit breakers utilized in DC circuits shall be tested and rated for such applications.
Circuit breaker panels shall be of an approved safety "dead front" type conforming to Article 384 of NFPA Specification 70 (National Electric Code). All live portions of the protected circuitry shall be completely concealed so that no danger of electrocution exists from the accidental touching of the panel or any appurtenances or devices mounted thereto. Circuit breakers shall be mounted in a vertical position with the "up" position being "ON". No secondary mechanical means shall be utilized to achieve this. Circuit breaker grouping or separation shall be based on operating voltage level.

Each panel shall be completely lined with a moisture proof electrically insulating material such as fiberglass or approved equal. Asbestos shall not be used. There shall be provided a wiring gutter along the top, sides, and bottom for the routing of wires to their designated circuit breakers. The panel cover shall be configured for easy removal so that maintenance and repair action is not impeded. All circuit breakers should be individually replaceable.

17.29.5 Fuses

The circuit protection function performed by fuses shall normally be performed by use of appropriately rated circuit breakers. Fuses shall only be used where specifically called for in this Specification or where use of circuit breakers is not technically feasible. All fuses used shall be standard catalog items commercially available from several U.S. sources. All fuse holders shall be readily accessible and contain fuse retention devices at both ends. The type and rating of each fuse is to be clearly and permanently marked on both the fuse itself and adjacent to the fuse holder. Rejection lugs or other methods shall be used to prevent over fusing if possible. Air gap and creepage distances shall be suitable for the application. Blown fuse indication shall be provided. All live portions of the protected circuitry shall be completely concealed so that no danger of electrocution exists from the accidental touching of any appurtenances or devices mounted thereto.

17.29.6 Bus Bars

Bus bars shall be fabricated from OFE (Oxygen Free Electronic CDA C10100) or ETP (Electrolytic Tough Pitch CDA C11000) copper. Bus bar conductivity shall be 100 percent IACS. All bus bar joints shall be silver or tin plated.

Current densities other than at joints shall not exceed 1,000 amperes per square inch and in any case shall not exceed a value which would cause a bus bar temperature rise greater than 30 degrees C. Current densities in brazed joints shall not exceed 150 amperes per square inch.

Bus bars shall be properly brazed together at joints unless bolted connections are found to be absolutely necessary for maintenance purposes and have been approved. The overlap at bus bar joints shall be no less than ten (10) times the thickness of the bus material. Bus bar connection bolts shall be torqued to obtain a uniform bus bar connection pressure of 200 psi. Bolting hardware shall be plated steel with Belleville washers to maintain connection pressure. Current densities in bolted joints shall not exceed 300 A/square inch for a minimum bolt size of 5/16 inch. The bus temperature rise including joints shall not be greater than 30 degrees C above 40 degrees C ambient.

Except for connection areas, bus bars shall be safety insulated using a high dielectric powder coating, heat shrink tubing, or other approved means. Tape is not acceptable. Bus bars that are behind insulating panels are exempt from this requirement.
17.29.7 Capacitors and Resistors

Hermetically sealed dry tantalum capacitors in metal cases shall be used in place of aluminum electrolytics except for very high values which are not commercially practical or available in which case long life grade aluminum electrolytics shall be used.

Commutating capacitors shall be of paper or plastic film type, shall incorporate a non-toxic impregnant, and shall be chosen to give a service life of at least 20 years. Filter capacitors shall have high ripple current rating for long life.

Capacitors shall be derated 20 percent for voltage based on the nominal supply voltage and maximum case temperature. If filter capacitors are exposed to low ripple voltages, lesser values of derating may be accepted if it can be shown that reduced operating temperatures can be achieved due to reduced dissipation. However, the sum of the dc and ac ripple voltages shall always be less than the capacitor's voltage rating at a maximum case temperature of 85 degrees C.

Except for braking power resistors, all resistors shall be derated 50 percent for power dissipation. Other power resistor applications may be submitted for approval of less derating on a case by case basis.

17.29.8 Transformers and Inductors

Inductors and reactors in power circuits and transformers above 100 watts (other than the main transformer) shall have copper windings with Class H solventless polyester synthetic resin vacuum pressure impregnated or other approved insulation compatible in all respects with DOLPHON CC-1105 resin as manufactured by the John C. Dolph Company of Monmouth Junction, NJ. Use of other resins will be permitted upon demonstration to the satisfaction of the Engineer that subsequent applications of DOLPHON CC-1105 resin will be fully effective and that in the dipping process no tank contamination or other undesirable side effects will occur, or in such cases where the Engineer is in agreement that the unit may be considered unrepairable. They shall have minimum core losses and be of high efficiency design. Transformers and inductors shall be rated to withstand at least twice the maximum peak to peak voltage to which they are subjected in operation and shall be derated a minimum of ten (10) percent for maximum current. All equipment and connecting cables shall be totally enclosed and shielded from flying ballast and debris and from snow, rain, dust, and dirt. Audible noise for power frequency devices shall not exceed 65 dB referred to 20 micropascals at a distance of two (2) feet when operating at rated voltage and load.

17.29.9 Switch, Circuit Breaker, and Fuse Panels

All switch, circuit breaker, and fuse panels shall be of the dead front type mounted in the specified equipment enclosures.

Each switch and circuit breaker panel shall carry the necessary apparatus, arranged to be easily accessible to connections and designed to prevent operating or maintenance personnel from coming in contact with energized parts when operating the switches or circuit breakers. Furthermore, all energized portions of the protected circuitry shall be completely concealed so that no danger of shock exists from touching the panel or any appurtenances or devices mounted thereto.
Each switch, breaker, fuse, and indicating light shall be provided with a nameplate of raised or recessed lettering on the dead front clearly identifying the circuit to which each applies and its circuit designation. The dead front panel shall conform to NFPA 70, Article 384. The dead fronts shall be made of moisture proof electrically insulating laminated phenolic or fiberglass of approved quality suitable for switchboards. Asbestos shall not be used.

A wiring gutter shall be provided along the top, sides, and bottom for the routing of high voltage leads to their designated circuit breakers.

The panel shall be secured by approved captive fasteners and shall be configured for easy removal so that maintenance is not impeded.

Power distribution to circuit breakers and switches shall be from a bus bar or bus circuit. Distributing power by successive or "daisy-chained" connections between device terminals shall not be permitted.

17.29.10 Battery Backup Circuits

With the exception of lighting, backup batteries shall not be permitted unless specifically approved by the Engineer.

17.30 SOFTWARE AND MICROPROCESSOR BASED SYSTEMS

17.30.1 General

All computer hardware and software to be provided under this Contract, whether resident within a microprocessor controlled intelligent subsystem, provided as part of test or interface equipment, provided for the purpose of post download data analysis and processing, or incorporated within training technology and non-generic bench test equipment (BTE), is subject to the requirements provided in this Section. Systems that include data files and/or configurable and/or customizable components, such as field programmable gate arrays and complex programmable logic devices, are included in this Section.

All hardware and software shall comply with the requirements of the SEPTA software safety plan in accordance with 49 CFR Part 238.105. The cab signal system shall comply with the requirements, unless otherwise approved by the Engineer, of IEEE Standard 1483-2000, Standard for Verification of Vital Functions in Processor-Based Systems Used in Rail Transit Control.

The Contractor shall be responsible for the overall design and integration of the individual systems into the complete system: subsystem level, car level, and train level. Even though each system shall be designed and documented by the individual supplier, the Contractor shall be responsible for reviewing and approving the supplier’s design, test reports, and supporting documentation prior to submittal to the Engineer. The Contractor shall be responsible for testing and documentation of the complete integrated system.
All system features and functions shall be testable. For features and functions that are testable only with the use of special equipment, all such equipment shall be supplied at no cost by the Contractor as part of the test equipment requirement.

Hardware and software requirements depend on the degree to which the hardware and/or software is custom designed for or applied to this Project. Microprocessor based control systems shall be based on an established family of microprocessors and shall support a full range of software development languages and diagnostic programs.

All system input and output signals shall be through isolated buffers. High voltage inputs and outputs shall be isolated external to the microprocessor rack. Low voltage (battery and logic voltage level) inputs and outputs shall be isolated via a buffer card in or external to the microprocessor rack. Details of the buffers shall be included in the design review packages and approved by the Engineer.

"Commercially available" hardware or software shall be readily available in the U.S. through retail and wholesale sources and shall be subject to the documentation and training requirements of this Section. "Non-commercially available" hardware, software, and commercially available single circuit boards shall be developed or modified according to the requirements of this Section. It shall be subject to all of the design, documentation, and training requirements of this Section.

The software requirements shall be considered as an integral component of the overall system design and shall be part of the design review process for each system.

Software shall sample all input conditions and hardware status at rates sufficient to detect and remedy all unsafe and damaging conditions. Sampling rates and program execution time shall be such that the control system is not the limiting factor in response to unsafe and damaging conditions.

Software shall perform self-diagnostic routines and respond promptly, safely, and predictably to detect faults. Self-diagnostic routines shall incorporate tests for program corruption and for integrity in read/write memories. Software shall permit thorough interrogation of all input, output, and internal conditions by external diagnostic equipment.

System functional descriptions (SFD) shall be prepared and maintained for each system. The SFD shall provide all of the engineering information related to the structure, capabilities, functionality, and interfaces of the system. It shall serve initially as a design review document and shall be developed into a permanent reference as the Project progresses. Each SFD shall be updated for each design review and design change thereafter as changes are incorporated through the end of the warranty period. The system functional description shall identify each revision and its effectivity.

All references to industry standards shall be taken to refer to the latest editions at the time of award.

17.30.2 Supplier Qualifications

The supplier’s software development process including proprietary or internal procedures shall be available for inspection and/or review by the Engineer or its designee during any regularly scheduled site visit such as QA audits, design reviews, FAIs, or routine hardware inspections.
17.30.3 Non-Commercially Available Software

The Contractor shall utilize a software quality assurance plan in accordance with ANSI/IEEE Standard 730. The plan shall describe a mechanism for orderly software development. Software QA, design process, and documentation shall be fully integrated with the corresponding hardware process. Notwithstanding the above requirements, the development and delivery of software documentation shall be in accordance with IEEE Standard 1558-2004 which shall prevail over ANSI/IEEE Standard 730 in the event of differences. The plan shall include the submittal and approval of the following documents [CDRL 17-054]:

a. System Functional Description (SFD)
b. Software Requirements Specification (SRS) in accordance with ANSI/IEEE Standard 830
c. Software Design Description (SDD) in accordance with ANSI/IEEE Standard 1016
d. Software Verification and Validation Plan (SVVP)
e. Software Verification and Validation Report (SVVR)
f. Software Configuration Management Plan (SCMP)
g. User Documentation

With the exception of the System Function Description, these documents are those required by ANSI/IEEE Standard 730. In addition, the final Software Design Description shall include details required by Air Transport Association of America (ATA) Specification Number 102, "Specification for Computer Software Manual" through all levels to Level 6. The levels defined in ATA Number 102 are summarized below only for information:

Level 1: Computer description and operation
Level 2: Software architecture, basic program, and functions
Level 3: Detailed flow information
Level 4: Annotated compiler/assembly listing
Level 5: Detailed memory map and listing
Level 6: Input/output port map

Software shall be reviewed as an integral part of each design review for any system which utilizes software. The correlation between design reviews and required software documentation submittals shall be correlated by the Contractor in the form of a table. The correlation between subsequent software related activities, software revisions, and required software documentation submittals shall be included within the table.

Software QA shall be part of all applicable QA audits or inspections. Software revision control shall be treated the same way as drawing revision control.

In addition to the requirements of this Section, any software, firmware, processing device, or computer providing a safety critical function shall comply with the requirements of the system safety program and in particular software safety.
The software design and development processes and procedures required used in the development of the software shall remain in place through the duration of the Contract and shall apply to all software revisions through the end of warranty period.

17.30.3.1 Software System Functional Description (SSFD)

17.30.3.1.1 Overall Requirements

An overall Software System Functional Description (SSFD) meeting the following requirements shall be provided by the Contractor [CDRL 17-055]. The SSFD shall:

a. Clearly define the subsystems which make up the overall system.

b. Clearly describe and graphically depict the interfaces between the subsystems. Where the interfaces between subsystems are extremely complex, the interface may be generally described in the SSFD, but the details must be described in an Interface Control Document which is appended to the SSFD.

c. Describe how the requirements of the Specification are allocated to the subsystems, including the possible decomposition of single requirements into multiple requirements which are allocated to multiple subsystems.

d. Define a common terminology for all subsystems which is to be used by all suppliers.

e. Define the system’s LRUs and LLRUs.

17.30.3.1.2 Subsystem Requirements

A Software System Functional Description (SSFD) meeting the following requirements shall be provided for each subsystem [CDRL 17-056]. The SSFD shall:

a. Clearly describe and graphically depict the subsystem hardware components and the interfaces between these components.

b. Describe the allocation of the Specification requirements, which have been allocated to the subsystem, including derived requirements among the subsystem components. Where the subsystem components are further divided into subcomponents, it shall describe the allocation of requirements to these components down to the level of the LLRU.

c. Clearly describe the allocation of requirements to hardware and the allocation of requirements to software including the allocation of requirements to all programmable logic devices used in the system.

d. Provide a technical description of the hardware and of the software used to execute each function that implements the allocated hardware and software requirements.
e. Provide a technical description of all key algorithms used to implement allocated requirements.

f. Contain a table which links each Software Configuration Item (SCI) to a specific subsystem component and to the specific processor in which the SCI runs. The table shall link each SCI to its design documentation (SRS, SDD) by document number. Each SCI shall be identified by assigned part number and each processor shall be identified by manufacturer’s part number and descriptive name.

g. Contain a table which identifies all programmable logic devices (PLD) including, but not limited to, CPLDs and FPGA. The table shall identify the device by manufacturer’s part number and shall identify by part number the data used to customize the device to the specific application. It shall also identify the means used to program each PLD and the documentation by document number which shall be provided to describe the design of the PLD.

h. Contain a description of each programmable logic device used in the subsystem which includes a description of each function performed by the PLD.

After original approval, changes to the software shall be formally submitted for approval by the Engineer prior to implementation. The software documentation shall be revised concurrently with software changes.

17.30.4 Commercially Available Software

Some software supplied under this procurement may be commercially available to a wide variety of users. Examples include operating systems supplied by chip manufacturers and database software for wayside fault analysis. The Contractor shall submit a list of software which is commercially available to the general public. The Engineer shall determine which software will be classified as commercially available software.

For commercially available software, software documentation requirements are limited to the following:

a. The original data storage/transfer media (CD-ROM) functional and usage details
b. All provider manuals
c. All licenses required for railroad site use

The Contractor shall incorporate training on how the software is to be used in the specific situation for which it was provided as part of the training program.

17.30.5 Software Systems Functions and Features

17.30.5.1 Hardware Platform

Carborne and custom computer hardware shall be designed and constructed in accordance with the general electronic design principles.
Any computers (other than laptops and personal computers) and microprocessor hardware supplied under this Contract shall be readily available through retail and/or wholesale outlets in the U.S. for 15 years or a 15 year supply separately provided. They shall be from approved domestic manufacturers. If they are not available for 15 years, they shall be supported with replacement parts or be capable of being replaced with form/fit/function compatible direct replacements with replacement to be identified by the Contractor. The Contractor shall secure all necessary documents (including schematics, diagrams, interface requirements, printed circuit board artwork, firmware, custom component designs, software, and documentation, etc.) to assemble the microprocessor based hardware into an escrow account so that SEPTA may have the hardware made by others in the event it becomes non-commercially available within 15 years.

The hardware, software, data repository, and firmware delivered or developed under this Contract shall be able to process data (including, but not limited to, calculating, comparing, and sequencing) from, into, and between centuries including leap year calculations. All software and hardware delivered or developed under this Contract shall be capable of handling dates in the range of 2000 to 2099. The date data processing shall not experience abnormal ending and/or invalid or incorrect results from the hardware, software, data repository, or firmware in operation on SEPTA. Each hardware, software, data repository, or firmware’s date data interface shall support a four (4) digit year format.

The microprocessor based systems shall be based on an established family of microprocessors in wide use in the control system industry and the rail industry. They shall be supported by a full range of software development languages and diagnostic programs similar to that available for the Intel 80XXX and Motorola 68XXX family of devices. Should the Contractor elect to use multiprocessor bus architecture, the architecture shall be based on the Intel Multibus, Motorola VME, or similar bus used widely in industrial process control equipment. Alternative bus structures may be submitted for Engineer review.

Any use of commercially available computer boards must be specifically approved by the Engineer on a case by case basis. Such approval will be based upon a technical review of the product, product documentation, and a commercial assessment of product availability.

The computer shall be powered by dedicated transformer isolated power supplies driven from the low voltage system (LVS) if carborne. A special algorithm shall be provided to ensure that computer shutdown and restart occur in a safe and predictable manner; that spurious faults are not generated during shutdown or restart; that stored diagnostic data is not lost during shutdown or restart; and that time stamp integrity is maintained on all diagnostic data through any shutdown and restart process including immediately after restart.

Program code and fixed data shall be stored in the most appropriate form of PROM. SEPTA’s preference is for flash PROMs.

Any EPROM windows shall be covered with labels that are opaque at the UV erasing wavelengths.

Software upgrades shall be performed using a password protected function on the PIU. This requirement is not applicable to systems which are not reprogrammable by PIU. The time required to upload the entire software complement for a given system including time to replace firmware embodied in FPGAs, CPLDs, and the like shall be no more than one (1) hour.
The Contractor shall provide for approval by the Engineer a plan for carrying out software upgrade campaigns fleet wide on an expedited basis. [CDRL 17-057] The plan shall incorporate provisions in individual systems, in the PIUs, and/or in onboard networks that will permit individual technicians to upload new software to multiple processors in a simultaneous or overlapping manner. The purpose of this requirement is to eliminate the idle or waiting time of each technician and thus to maximize use of the SEPTA’s resources when a software upgrade must be implemented urgently.

17.30.5.1.1 Isolation Buffers

All processor system input and output signals shall be through isolation buffers. High voltage inputs and outputs shall be isolated external to the microcomputer card rack. Low voltage (battery and logic voltage level) inputs and outputs shall be isolated via buffer cards in or external to the microcomputer card rack. The isolation buffers shall accomplish the following:

a. Protect and isolate the system from damage due to overvoltage, undervoltage, transients, shorts, and open circuits

b. Perform necessary voltage translations

c. Remove noise and undesired signals

d. Preprocessing to limit, discriminate, and format those signals that would otherwise require excessive processor time

Isolation buffers shall consist of optical isolators, transformer isolators, and other circuits appropriate to the application

17.30.5.1.2 Battery Backup

To minimize the number of individual batteries that must be maintained, the use of battery backup shall be limited to the extent practical and shall be subject to approval by the Engineer. Where permitted, backup or standby batteries shall meet the following requirements:

a. Battery backed RAM may be used only to store fault information. Rechargeable batteries shall be sized to retain data for at least six (6) months without charging and shall be located such that leakage cannot damage any control system components.

b. Battery life shall be no less than five (5) years regardless of type.

c. Systems using standby or backup batteries shall annunciate the need for battery replacement such that the battery continues to perform its function until it can be replaced at the next periodic maintenance. A "low battery" condition shall be provided to the local and central diagnostic systems. The Contractor shall install a fresh set of all such batteries in each car at the time of completion of car final assembly along with a date of installation sticker.

d. Batteries shall not be connected by soldering.
17.30.5.1.3 Expandability and Capacity Requirements

The hardware shall be designed to allow program expansion without hardware modification. Expandability and capacity requirements are as follows:

a. The memory needs of the installed software shall not utilize more than 50 percent of the installed memory capacity at critical design review. This requirement applies individually to each type of memory installed whether it is EPROM, EEPROM, Flash PROM, RAM, or other types.

b. Peak processing time demands shall not be greater than 50 percent of the available processor capacity.

c. The hardware shall include spare input and output channels of each type used within the system except for major output drivers where the quantity is fixed by the overall system design (e.g., traction motor semiconductors and sign character drivers). In addition, the architecture and assembly construction shall allow for the installation of additional I/O hardware.

17.30.5.2 General Features

All software, whether interrupt based or polled, shall always assign the highest priority to safety related tasks. Software shall perform the following basic functions:

a. Implement the desired control scheme such that the specified performance is achieved

b. Monitor all inputs for unsafe, erroneous, or unknown conditions or combinations of conditions

c. Sample all input conditions in real time at rates sufficient to detect and remedy all unsafe or damaging conditions in the shortest possible time. Sampling rates and program execution times shall be such that the control system is not the limiting factor in response to unsafe or damaging conditions.

d. Limit all output commands to safe levels regardless of any combination of input conditions

e. Perform self-diagnostic routines and respond promptly, safely, and predictably to detected faults

f. Respond safely and predictably when powering up or recovering from power interruptions. All power interruptions likely to have corrupted temporary storage shall be detected and cause the system to reinitialize all affected routines and temporary data. Detection of power interruptions may be by hardware.
g. Permit thorough interrogation of all input, output, and internal conditions by external diagnostic equipment. A software schematic diagram shall be supplied where all variable names are shown as inputs and outputs to code sections, and the function of each section is explained. [CDRL 17-058]

h. Display the software revision level

The Contractor shall be responsible for any false information generated, transmitted, or processed in any subsystem and shall provide a corrective resolution in a reasonable time period. Software version numbers shall be included within the firmware code and shall be accessible to the PTU’s.

17.30.5.3 Isolation and Interfacing

The control system shall be powered by dedicated transformer isolated power supplies driven from the car battery system. All control system input and output signals including power supply voltages shall be through isolation buffers. The buffers shall:

a. Protect and isolate the control system from damage due to overvoltage, undervoltage, transients, shorts, and opens

b. Perform necessary voltage translations

c. Remove noise and undesired signals

d. Limit, preprocess, discriminate, and format those signals that would otherwise require excessive processor time

Signals, which come from locations where there is proximity of 230 volt or above apparatus, shall either be galvanically isolated or use another approved protection method that prevents logic damage if the signal is raised to the high voltage level.

17.30.5.4 Programming

Programming of microcomputers shall be divided into two (2) classifications subject to Engineer review. [CDRL 17-059] The first classification shall be programs which are application independent and can be considered an inherent part of the controlled subsystem. The second classification application dependent shall include all programs which are specifically written for the operation and control of the car.

The application independent programs shall include the inverter or chopper controller safety related systems such as the friction brake controls, ATC, PTC, and other functions as reviewed by the Engineer. These programs shall be documented by the identification and description of all I/O functions, functional descriptions of the interfaces with all vehicle systems and subsystems, and all information required to ascertain the safe operation of the vehicle in response to any failure. The source code for these programs may be retained by the Contractor but full documentation must be supplied. [CDRL 17-060]
The application dependent programs shall include the vehicle logic, subsystem integration, and fault and diagnostic routines related to application dependent programs. These programs are usually tailored to meet the requirements of the application. The Contractor shall recognize that SEPTA may at a future date have a need to change elements of these programs and shall provide SEPTA with sufficient information to alter this vehicle software without the Contractor’s assistance.

The application dependent programs shall be programmed in a high level language such as C+ or PL/M. The language and its implementation for the selected microprocessor system shall be commercially available in English. All languages and operating systems must have an acceptable customer base (widespread use) and be approved by the Engineer. [CDRL 17-061] All operating systems including those of PTU’s and other test equipment shall be able to communicate in a common language. The compiler used shall be commercially available. Proprietary compilers shall not be used. Compilation of the application dependent programs shall be performed on an IBM compatible computer. The source code and all necessary files for the linking, locating, and conversion to hexadecimal object and/or executable binary code shall be supplied to SEPTA on CD-ROM by the delivery of the 50th production car. [CDRL 17-062]

The Contractor and its suppliers shall use the current versions of all software and of all operating systems available at the time of final design review (FDR). Obsolete operating systems shall not be used. In the event that an operating system becomes obsolete (defined as no longer supported by its supplier) during the life of the contract, the Contractor shall supply to the Engineer a migration plan to a current operating system which describes the consequences to all affected hardware and software.

Proprietary compilers shall not be used. Compilers shall be commercially or freely available.

The use of proprietary communications protocols must be approved by the Engineer. Proprietary protocols shall only be permitted if they are fully described in an interface control document and if SEPTA is granted full rights to the use of the protocol.

17.30.5.5 Testability and Testing

All system or subsystem level features and functions of software systems, which implement system or subsystem level requirements of the Specification that are allocated to software, shall be testable on a system or subsystem level in the field using portable test equipment and procedures provided under this Contract. Specific approval by the Engineer is required for any system or subsystem level feature specifically required by the Specification which is not testable on a system or subsystem level.

For features which are only testable off the car with special equipment, all such equipment shall be supplied by the Contractor as test equipment and become the property of SEPTA. This equipment shall provide the logic, sequencing, and emulation necessary to verify that the software functions as intended. In lieu of separate equipment, appropriate test functions may be provided within the PIU.
Type tests of all processor systems shall verify the proper operation of all software features including diagnostics. The type tests shall demonstrate that the system under test can successfully recognize and report all faults or events reported to the monitoring and diagnostic system. Fault criteria for triggering faults and system response including the number of cycles to equipment lockout shall be evaluated based upon the documentation approved by the Engineer. Where such tests may result in damage to the system hardware, the fault or event may be simulated to avoid damage to the hardware. Such testing shall be performed any time the software is changed prior to putting it into service.

Software validation (testing) shall be part of the total project testing process. Test procedures, testing, and test reports shall be subject to the review witnessing and documentation process approved by the Engineer. Software testing shall be a prerequisite to higher level testing such as system level and vehicle level tests. Software validation test procedures must be approved by the Engineer prior to the execution of the tests.

After the initial version of software is installed on the cars, all software revisions shall be tested by the supplier in the supplier’s facilities (laboratory) in accordance with its testing processing and procedures. After successful completion of such tests, a test version of the software revision shall be placed on a limited number of cars and dynamically tested for a period of time as approved by the Engineer. After results of the dynamic tests on a limited number of cars have been approved by the Engineer a new software revision shall be applied to the fleet or any portion of the fleet. Application of any software revision to any portion of the fleet at any time shall be in conformity with the approved configuration control plan.

17.30.6 Software Documentation

17.30.6.1 General

For non-commercially available software, thorough and accurate software documentation including source code shall be submitted by the Contractor for Engineer’s approval. [CDRL 17-063] The Contractor shall provide sufficient documentation to permit the Engineer to fully comprehend and analyze the operation of the equipment in which the software is to be installed and to enable SEPTA to maintain and modify the software to correct problems, adapt it to changing requirements, add features, and port it to a new hardware platform.

The Contractor shall define a single software documentation methodology for the project and require all suppliers to comply with it. The methodology shall be submitted to the Engineer for approval. [CDRL 17-064] If CASE tools are used which automatically generate documentation, they shall be consistent with the Contractor’s documentation methodology. The Contractor shall provide descriptions to enable the Engineer to understand the documentation methodology. Software documentation training for specialized CASE tools shall be included within the formal training.

Documentation for non-commercially available software shall be divided into two (2) categories as follows:

  a. Category A: Application specific software developed or adapted specifically for this Contract
b. Category B: Application independent software that is fixed system software that is used in multiple applications (e.g., operating systems) or software that is encapsulated in a replaceable component (e.g., intelligent power modules) and in either case was not developed or adapted specifically for this Contract.

Documentation for software in Category A shall meet all requirements of this Specification. Documentation for software in Category B may be exempt from certain Specification requirements as approved by the Engineer.

Classification of software as Category A or B shall be subject to approval by the Engineer. [CDRL 17-065] In any case, Category B software must be of an existing service proven design. New software first developed or software adapted under this Contract that is intended for use on other applications as well shall be considered as Category A regardless of the supplier’s intended use of the software in the future.

17.30.6.2 Escrow

The placing of software design documentation details such as proprietary source code or compilers in an escrow account in lieu of submittal to the Engineer and SEPTA is permitted subject to approval by the Engineer provided that sufficient software information is provided (submitted and/or shown to an approved reviewer) to enable the Engineer to evaluate the overall system performance. In any case, delivered documentation shall be sufficient to allow SEPTA to operate and maintain the software including, but not limited to, parameter adjustment and troubleshooting of software issues.

The Contractor shall conduct a software escrow verification test for all escrowed software. These tests, at a minimum, shall verify that all software and developmental tools have been escrowed to compile, link, or otherwise generate the firmware, object code, P-Code, executable code, or whatever is required to run on the vehicle system or portable test equipment or other software based systems supplied by the Contractor or its suppliers.

The escrowed software design, documentation details, source code, etc., shall be made available to SEPTA for its own use for any of the below listed reasons:

a. If the Contractor or its supplier is no longer in business or no longer supports the product and has not transferred the rights to the design to another entity

b. If based on an independent third party assessment the Contractor or its supplier no longer supports the product at a reasonable cost

17.30.6.3 Configuration Control

The Contractor shall develop a configuration control plan (CCP) for tracking software changes to individual cars on SEPTA’s property until acceptance of the entire fleet. The CCP shall also control software on non-car equipment such as PIUs, PTUs, BTE, WMDS, and the like and shall include a mechanism to ensure continuing compatibility between car software and non-car software. This plan shall be submitted for approval by the Engineer. [CDRL 17-066] It shall be consistent with the Contractor’s approach to configuration control of hardware and require similar approvals and tests.
All software shall be identified by a name and a unique version number and date. The name shall identify the equipment into which the software is installed. Every change to software shall be reflected in an update to the version number and date.

The Contractor shall maintain a database of the software version of every software item on each car and in each piece of non-car equipment. The database shall be kept current by the Contractor at all times and made available upon request. The software version status of every software item on the car shall be provided by the Contractor at the time of approval for revenue service/acceptance of each car. The software version status of every software item on each piece of non-car equipment shall be provided by the Contractor at the time of approval for revenue service/acceptance of that piece of equipment.

A utility shall be provided with all PIUs, BTEs, and software workstations by which a unique version ID value can be calculated using CRC-32 on the executable file for each software configuration Item. The calculated version ID shall be included in the SVD of each software release.

17.30.7 Software Maintenance and Related Tools

SEPTA retains the right to perform software modifications. All software for this Project shall be delivered to SEPTA on CD-ROM.

The Contractor shall provide a total of two (2) software workstations including the same version of all of the software and software development tools used by the suppliers. The complement of equipment shall include all compilers, assemblers, linkers, in circuit emulators, and other such tools that are used for software development. All associated manuals shall be provided. [CDRL 17-067] The development system shall allow software modifications and tests of all rail application related software for this Project related to onboard diagnostic equipment and all off car support equipment including, but not limited to, the PTU and DTE. The complete complement of software development/modification tools shall be delivered such that software modifications can if desired be made on site during acceptance testing. Password protection shall be provided for modifications to all safety critical software such as for example doors, ATC, propulsion, and friction brakes. PROM reprogramming equipment shall allow reprogramming of PROMs at a rate adequate to support SEPTA’s maintenance needs.

The workstation and software documentation equipment is to be delivered, demonstrated, and proven to perform its function as part of the whole car first article inspection. The demonstration shall consist of SEPTA personnel using the workstation, source code files, and written instructions to create program files that then must match the programs stored within the system's equipment.
17.30.8 Portable Interface Unit (PIU) and Bench Test Equipment (BTE) Software

For custom software that is resident in test computers, SEPTA shall be given a no cost license for unlimited use and copying of the software for the approved purposes of this Contract for the life of the fleet. Licenses shall not be linked to specific hardware serial numbers. In addition, PIU and BTE equipment software documentation shall be furnished. [CDRL 17-068] PIU and BTE software shall be subject to the approved configuration control plan. The operating system employed for the PIU shall be the most-advanced user friendly system available at the time of the system design and development. While it is anticipated that the system will be Microsoft WindowsTM based, advances in technology may preclude this from being the best choice. Accordingly, identification of the system to be used will be made by SEPTA at the time of the preliminary design review.

17.30.9 Communication and Control System Security

Vehicle communication and control systems shall be secured against unauthorized access and attack both from the vehicle itself and from the wayside. Security requirements shall apply both when the vehicle is in revenue service and when the vehicle is out of service for maintenance or storage. Security measures shall be consistent with industry best practices at the time of design.

To demonstrate compliance, the Contractor shall prepare and submit for approval a vehicle communication and control system vulnerability assessment identifying all potential system vulnerabilities, associated risk (including exploit likelihood and consequences), countermeasures applied, and resulting mitigated risk. The report format shall be similar to that of a hazard analysis; a representative sample of the proposed report format shall be submitted for approval as part of the software documentation methodology. [CDRL 17-069]

17.30.10 Delivery of Software

Each software release shall be provided to SEPTA via official project correspondence and shall include executables, updated software documentation, updated user documentation, a software version description document, and an SVVR. If source code will not be placed into escrow, source code must be included. [CDRL 17-070]

With the exception of source code covered under an escrow agreement, an initial release of software executables for carborne systems shall be supplied to SEPTA within 180 days of the approval for revenue service of the first car. The initial release shall include portable interface unit (PIU) executables. [CDRL 17-071]

With the exception of source code covered under an escrow agreement, an initial release of non-carborne software shall be supplied to SEPTA within 180 days of conditional acceptance of the related system. [CDRL 17-072]

When half of the total number of cars has been delivered, the Contractor will deliver to SEPTA all software executables and source code for carborne systems with the exception of source code covered under an escrow agreement. [CDRL 17-073]
Within 180 after the delivery of the final car, the Contractor shall deliver final versions of all software with the exception of source code covered under an escrow agreement. [CDRL 17-074]

After the delivery of the final software versions through the end of the warranty period, software changes shall be accompanied by a delivery of the updated software, excluding source code covered by an escrow agreement. [CDRL 17-075]

17.30.11 Software and Microprocessor Based Systems Security

Onboard systems will have multiple access methods (i.e. train to wayside and wayside to train communication, passenger internet access over WiFi, portable test unit ports, USB ports, etc.) that could potentially allow unauthorized users to gain access to and/or attack these systems. All intelligent onboard systems shall be secured against unauthorized access and/or attack both from the vehicle itself and from the wayside. Security requirements shall apply both when the vehicle is in revenue service and when the vehicle is out of service for maintenance or storage. Security measures shall be consistent with industry best practices at the time of design.

To demonstrate compliance, the Contractor shall prepare and submit at the FDR for approval by the Engineer a System Vulnerability Assessment identifying all potential system vulnerabilities; associated risk (including exploit likelihood and consequences); countermeasures applied; and resulting mitigated risk for each intelligent subsystem. [CDRL 17-076] The report format shall be similar to that of a hazard analysis; a representative sample of the proposed report format shall be submitted to the Engineer for approval prior to the FDR. [CDRL 17-077] An intelligent subsystem shall mean any system which has a microprocessor, software, and any communications interfaces to external equipment (for example, connections to another system, to the vehicle network, or to test equipment).

Exploits to be considered shall include, but are not necessarily limited to, the following as appropriate:

a. Vandalism
b. Eavesdropping
c. Device/user impersonation
d. Dictionary attacks
e. Message modification
f. Session hijacking
g. Buffer overflow
h. Denial of service
   i. Jamming (physical layer denial of service)
j. Virus/worm infection
k. Unauthorized software installation
l. Unauthorized root/administrator access

Security measures shall include, but are not necessarily limited to, the following as appropriate:

a. Restricting physical access to communication and control system components to all but authorized personnel
b. Use of access control lists (ACL)
c. Use of device and/or user authentication  
d. Use of encryption  
e. Use of hardware keys in conjunction with passwords/pass-phrases  
f. Access logs  
g. Intrusion detection/prevention  
h. Antivirus  
i. Proper isolation of security critical system functions from other functions  
j. Application of secure coding practices  
k. Use of secure operating systems

Security measures shall be designed and implemented such that their effect on reliability, availability, and basic system operation is minimized.

The Contractor shall make available any security updates to SEPTA over the life of the Contract without charge. The Contractor shall notify and make available to SEPTA any recommended security upgrades over the service life of any network connected intelligent system.

### 17.31 CONTRACT DELIVERABLE REQUIREMENTS LIST

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18.1 TESTS AND ADJUSTMENTS

18.1.1 General

As part of the production of the cars under this Contract, the Contractor shall be responsible for a comprehensive series of tests to be performed to verify both the suitability of design and workmanship of each car. These tests are to be performed to ensure compliance with Specification requirements, confirm the elimination of deficiencies, and to provide data on car operating characteristics. The Contractor is also responsible to fulfill all requirements called for by the Federal Railroad Administration for testing passenger equipment which has not been used in revenue service, per the requirements of 49 CFR 238.111(b) for Tier I equipment, for submission by the Engineer to the FRA.

The required tests and adjustments shall be performed on the cars supplied under this Contract and are grouped into four (4) classifications:

a. Qualification
b. Production (routine)
c. Pre-delivery
d. Acceptance

The Contractor shall ensure that all test procedures and reports are formally reviewed and approved for validity and reliability by their engineering department prior to their submittal to the Engineer. Each procedure and report shall include a sign off block that includes the name and signature of its responsible engineer and the date the review was completed and approved. Whenever test requirements overlap, the more restrictive shall govern. Any components, subsystems, or systems not specifically listed in the following sections shall be completely tested by the Contractor. Test procedure and report requirements shall also apply to these tests.

The Contractor shall perform all required tests under Engineer observation, and the FRA may also observe such tests. The Contractor’s engineering department shall also be responsible for providing assistance and expertise during performance of tests and for preparation of related test reports. It shall be the responsibility of the Contractor's engineering department to develop procedures for the vehicle tests to be conducted. All contractual tests shall be conducted in accordance with Engineer approved test procedures. Testing activity scheduled and/or conducted before test procedure approval will be at the Contractor’s risk.

Qualification tests (see TS 18.2) encompass components, systems, and car tests to be performed at the manufacturer’s, Contractor’s, and SEPTA’s facilities to demonstrate conformance of the component, system, or car design with the Specification requirements including the performance and operational tests.
Production (routine) tests (see TS 18.3) encompass all components, systems, and car tests to be performed on an ongoing routine basis at the manufacturer's or Contractor's facility on a specified number of components, systems, and cars to demonstrate proper operation and conformance with Specification requirements.

Pre-delivery tests (see TS 18.4) encompass all components, systems, and car tests to be performed on an ongoing routine basis at the manufacturer's or Contractor's facility on each component, system, and car to demonstrate proper operation and conformance with Specification requirements prior to delivery.

Vehicle acceptance tests (see TS 18.5) encompass all car tests to be performed by the Contractor on each car at a SEPTA site to demonstrate the conformance of the car to the performance requirements of the Specification as a condition of acceptance of each car.

The pilot car test program shall consist of those tests outlined in TS 18.6 for those systems installed on two (2) cars delivered for the pilot test cars' program. At least one (1) car of each car type shall be included in the pilot test cars' program.

Each car and its associated equipment shall be subjected to a comprehensive test program to validate the design and performance to assure operational compatibility with existing systems and existing cars and to establish the service lives of systems and components for optimum reliability and maintainability. "Proof of design" tests (type tests, qualification tests) on the pilot cars or first articles, Specification compliance tests, and routine acceptance tests on all items shall be required. Components or systems not to the approved production configuration used to perform any test defined in this Section with the exception of car level testing shall not be used for production or spares unless approved by the Engineer.

A written procedure and report for all tests performed shall be submitted to the Engineer for approval. The report pertaining to routine acceptance tests on cars and equipment shall be included in the "Car History Book" (see TS 1.20) for that car. A separate procedure and report for each qualification test and group of car tests (production, pre-delivery, and vehicle acceptance) shall be submitted (five (5) copies of each). All procedures shall be submitted at least thirty (30) days prior to the scheduled test date, and such procedures shall be approved by the Engineer prior to conducting any test. The Contractor shall assign as part of this Contract one (1) or more engineers who shall make all necessary tests as delineated in TS 18 render the installed equipment fully operational and demonstrate that the equipment properly interfaces with other systems installed in the cars. No test will be considered completed until the test procedure is approved and the respective test report has been received and approved by the Engineer.

18.1.2 Requirements

The Contractor is required to perform all tests as specified herein. All tests shall be conducted by the Contractor at their expense. SEPTA shall provide test train operating crews and all other individuals required by SEPTA policies at their expense. These tests shall be conducted at such times and on such portions of rail lines as mutually determined by the Engineer and Contractor. Each car shall be subjected to all tests to show compliance with the specified performance.
SEPTA retains the right to attend any or all testing. The Contractor shall provide at least fifteen (15) working days’ notice to the Engineer prior to the start of any test referred to herein not counting SEPTA holidays. During the manufacturing sequence of the production cars if a field representative is already present at the Contractor’s facility, prior notice of testing must be given to the field representative at least 24 hours prior to the event at which time the inspection shall be scheduled at SEPTA's convenience.

The Contractor shall perform all tests specified herein. The Contractor and their subcontractors may at their option perform additional testing as they deem necessary as part of the quality assurance program. Unless indicated otherwise, all costs associated with any tests performed shall be borne by the Contractor.

Prior to shipment, each car shall be carefully inspected by the Contractor as required by TS 1.13.9.5. Any part, device, or equipment requiring adjustment, repair, or replacement shall be attended to by the Contractor. After receipt and prior to acceptance testing, SEPTA will completely inspect each car, and the Contractor shall correct all discrepancies at their expense to the satisfaction of the Engineer. This shall not relieve the Contractor of their obligation to correct defects exclusive of items relating to "appearance" that subsequently become apparent. Appearance items shall be inspected for verification prior to car acceptance.

All working and moving parts and all operating devices and controls of each car and its equipment shall be tested and put in operating condition by the Contractor before the cars are presented for acceptance. The Contractor shall perform all tests and make all adjustments specified herein.

The Contractor shall ensure the success of the test before sending actual test date notification. Any corrections necessary to ensure the success of the test shall be made prior to the final test to be performed on the date notified to SEPTA. In the event of a failure to meet the Specification requirements in any test, necessary corrections shall be made by the Contractor at their expense, and the failed test shall be rerun in its entirety at the Contractor's expense. If further corrections or modifications affecting the item under test are instituted, the Contractor shall perform a complete system retest at their expense to demonstrate compliance with the Specification requirements.

SEPTA reserves the right to perform at their own expense additional operating tests of each car separately or in trains of up to seven (7) cars to verify the acceptability of the cars. These additional tests will be conducted within 30 days after completion of Contractor acceptance testing. The Contractor may be required to participate and furnish technical assistance for such tests. If the result of the testing indicates that the vehicle was noncompliant with the Specification (in line with the stated purpose of the testing), the cars in question shall be returned to the Contractor for correction, and on resubmittal SEPTA will have an additional 30 days to retest.

All expenses and costs incurred in the removal of cars from the designated delivery point for correction of defects shall be borne by the Contractor.
18.1.3 Test Plans and Reports

18.1.3.1 Master Test Plan

The Contractor shall submit to the Engineer for approval a master test plan as described in TS 1.6.6.3.3 and elsewhere in the Specification covering all tests and adjustments listed in or otherwise required by this Specification and 49 CFR 213, 238, and 239. The master test plan shall be submitted to the Engineer for review and approval no later than 180 calendar days after the Notice to Proceed.

The frequency and proposed schedule for each test shall also be included. The master test plan shall be submitted to the FRA to comply with 49 CFR 238.111.

The master test plan shall cover all supplier and subcontractor tests to be completed at their plants, all Contractor tests to be completed at their plant prior to issuance by the Engineer of a release for shipment document, and all testing to be conducted on SEPTA’s property prior to the issuance by the Engineer of a certificate of acceptance.

The master test plan shall include and differentiate between, but is not limited to, all tests as required to be performed by the Contractor and suppliers:

- Qualification and material certification tests
- Proof of design tests including all required carshell, truck and suspension, and ride quality tests
- Production tests and pre-delivery tests
- Vehicle acceptance tests

It shall include a detailed schedule showing the sequence in which type test will be performed, and the time and place of each test to be performed.

This document shall be updated monthly and presented as an attachment to the program meeting minutes showing the status of each test procedure, test, and associated report summarized in a spreadsheet format. [CDRL 18-001]

The inspection plan and the master test plan shall be administered by the Contractor’s quality assurance department. It shall be the responsibility of the quality assurance department to ensure that all inspection and test requirements have been met, inspection and test data is complete and accurate, any follow up or corrective action that may be required has been completed, and all final reports are complete, accurate, and Specification compliant.

The Contractor’s quality assurance representatives shall perform inspections at subcontractor and supplier facilities to ensure compliance with all aspects of this Specification.

The Contractor shall test vehicle functions and performance to assure compliance with all technical requirements. Functional tests shall be performed to approved procedures. The results shall be documented and included in the car history book as defined in TS 1.20. Final vehicle inspection and release to commissioning site shall not be permitted until functional testing is completed and successful.
A test log shall be maintained during equipment assembly. All Contractor and Engineer in process inspection sheets and test data records for a car shall be contained in this test log. The log shall be submitted to SEPTA for review before each car shall be released for shipment to the commissioning site.

[CDRL 18-002]

18.1.3.2 Test Procedures

The Contractor shall prepare a detailed test procedure for each test described herein and for any other tests conducted by the Contractor in connection with their own quality assurance program. [CDRL 18-003] Each test shall be a separately controlled document and identified by its own number, title, and revision. All revisions shall be submitted to the Engineer for approval. A history of test revisions and changes shall be maintained and recorded within the test document. All tests must be written in an instructional form describing the full activity of each test step and written in duplex numerical form (similar numbering system as seen in this Specification). All special tools and/or equipment to be used must be specified within the test document. The test procedures shall identify all settings and calibrations.

Test procedures shall be delivered to SEPTA for approval at least 90 days prior to the test date allowing the Engineer at least thirty (30) working days for initial review with sufficient remaining time for the Contractor to modify a rejected procedure and resubmit for approval a minimum of five (5) working days prior to testing covered by the procedure.

The procedures for these tests shall be continually updated. The basis for changes to these procedures shall be the feedback from both the Contractor and the Engineer. The procedures may be expanded to include checkpoints in areas which have proven to be troublesome. All test procedure revisions shall be subject to the Engineer’s approval. For production tests, which are performed on all cars or all components, a separate volume shall be submitted to the Engineer containing all approved test procedures applicable to individual cars. In the event a test is revised, the Contractor shall supply a copy of the test reflecting approved changes, and the upgraded revision status to replace the existing test within this volume.

Each individual test shall be accompanied by a separate test results sheet. Each step of the test requiring a specified result or measurement shall be included and identified by the duplex numeric step number referenced in the test document. Areas shall be provided for recording actual values produced during the test where needed. In addition, pass/fail criteria and associated tolerances shall also be shown in parenthesis near the space available for recording the actual value. Each test sheet shall be identified by the associated test number and revision. Areas shall also be allocated for the date, car number, component serial numbers (as applicable), test equipment serial numbers, verification of test equipment calibration, test status (accept/reject), and signature areas for the test technician, Contractor QC, and SEPTA field representative.

Microprocessor software test procedures shall include test cases designed to uncover software errors as appropriate.
Test results shall not be accepted by the Engineer without an approved procedure. Supplier test reports and procedures shall be approved by the Contractor prior to submittal to the Engineer. No test will be considered completed until a test report has been received and approved by the Engineer and, as required, the FRA. [CDRL 18-004]

The test procedures shall include the following information:

a. Title/Approval Page: Includes the name of the test, test number, revision level, date, author, signature of engineer responsible for system, signature of personnel who reviewed and approved the test, etc.

b. Revision History: Provides the history of changes made to the document including description not merely date.

c. Table of Contents: Table of contents

1.0 Purpose Identifies what the test is to accomplish

2.0 Application Identifies which car types/equipment is tested with this procedure. Provisions for retest in case of test failure shall be identified.

3.0 References Identifies any documents used as guidance for the test such as APTA, FRA, ASTM, etc. Identifies applicable Sections of the Specification.

4.0 Definitions Provides definitions of terms used in the test

5.0 Prerequisites Provides requirements of car condition, personnel, and environment before the test can be conducted such as which tests must be successfully conducted before this test

6.0 Equipment Identifies test equipment and any other special requirements; lists instrument model numbers, calibration dates, and serial numbers

7.0 Initial Conditions Identifies positions and/or state of all devices, controls, and equipment

8.0 Procedure This is the actual test sequence. The test procedure shall identify pass/fail (or in some cases intentional overload) criteria for each step in the procedure. Test data may be recorded within this section or in a separate data section.

The test procedure shall identify the conditions required for the performance of the test including a sheet where test conditions can be recorded such as voltage, current, resistance, time, etc. Any adjustments permissible during the test shall be identified.
Each test performed shall be signed and dated by the technician performing the test.

9.0 Conclusion
Provides summary of the test findings including vehicle number, date, test conducted, overall pass/fail, test technician signature, Engineer witness, etc.

10.0 Data Sheets
This is a form in which data is recorded if it is not recorded within the body of the test. If data is recorded by instruments such as strip chart format, etc., those results shall be attached here.

18.1.3.3 Testing Notification
In the case of pre-revenue service tests per 49 CFR 238.111 (b) (2), 45 calendar days’ notice shall be given to the Engineer in order to assure timely notification of the FRA. Except where otherwise indicated, 15 working days’ notice shall be provided prior to any test. The Engineer will at their option witness all tests.

18.1.3.4 Test Documentation
Within seven (7) days of the completion of each test, the Contractor shall submit a written report of each test including copies of all test data to the Engineer for approval. [CDRL 18-005] The Contractor’s quality control department shall certify all test results prior to submission to SEPTA. In every case, the report shall include a description of the test, all raw data collected in the test, and a summary of the results in a form that can be directly compared to the Specification without further calculations.

Should the test procedure and/or report be inadequate and not meet the requirements of the Specification, the Engineer reserves the right to require additional plans, procedures, details, and schedules to assure that the test program or report is adequate and does meet the Specification requirements. The approval of the Engineer does not in any way relieve the Contractor of responsibility for the adequacy of the test program within the scope of this Specification.

As a minimum, every report shall include:

a. Description of the test
b. Date and location of the test
c. Identity of person(s) conducting, witnessing, and/or inspecting
d. Detailed physical description of test specimen (length, width, height, weight material, etc.)
e. Part and serial number(s) of equipment tested
f. All raw data collected in the test on DVD or other approved format
g. All data reduction forms

h. Pass/fail criteria

i. Calibration certificates of all test equipment

j. Photographs

k. Any other data necessary to support the test results

l. A summary of the results in a manner that can be directly compared to the Specification without further calculations

m. Any deviations from the test procedures, discrepancies in test results, and corrective actions

For tests which are performed on all cars or components, the reports of those tests shall be included in the appropriate car history book. At the front of the test section of the car history book there shall be a test log. This test log shall be maintained by the Contractor during the equipment assembly. The test log shall have a place for a technician’s signature and date and will be signed when each test procedure has been completed. Per TS 1.21.9, the test log and associated documentation shall be submitted to the Engineer for review before each car shall be released for shipment to the delivery site.

All material certification and proof of design test procedures and reports shall be supplied by the Contractor in a separate binder and submitted to the Engineer for review and approval prior to acceptance of the first car of each type. [CDRL 18-006] The master test plan shall be included in this binder. Reports on all certification and proof of design tests plus the acceptance tests for the first car of each type shall be submitted and approved by the Engineer prior to acceptance of the first car of each type. [CDRL 18-007]

Upon the completion of all required engineering tests associated with the pilot car program, all copies of all test procedures, reports, and approvals shall be copied and presented to the Engineer in a single volume. [CDRL 18-008]

The Contractor shall ensure that subcomponent test reports for tests completed prior to the shipping of equipment to the Contractor shall be available to SEPTA upon request at the Contractor’s facility prior to subcomponent shipment. Per TS 1.13.6, the Contractor may use certificates of compliance for certain materials and products in lieu of the specified sampling and testing procedures as approved by the Engineer.

18.1.3.5 Testing and Rework

Following failure of a test, equipment rework and retest shall be performed until compliance with the stated requirements is achieved.

Each individual retest must demonstrate that the entire set of prescribed criteria has been met following rework. SEPTA may at their discretion waive portions of the retest.
18.1.4 Car Acceptance Testing Facilities

The Contractor will be allowed by SEPTA to use a portion of the yard tracks and the automotive parking lot at SEPTA's Frazer Electric Locomotive Shop. The Contractor will be responsible for providing office trailers for their use and for arranging for electricity and telephone service at Contractor's expense. The Contractor shall use this site to prepare cars for acceptance testing and to perform modification or rework required on cars under their control prior to acceptance as well as warranty work. SEPTA will supply at no charge to the Contractor the catenary power, tracks, train crews, and supervisors as required for yard movement of cars. The Contractor shall provide 480 V power during static testing.

SEPTA will designate the hours (during off peak and late evening/overnight periods in general) that tracks will be available for testing and assign crews as requested by the Contractor who shall give a minimum of eight (8) days written notice of crew and track requirements to the Engineer and a minimum of 48 hours written notice when canceling or postponing a previously scheduled test. In all cases however, SEPTA’s requirements will have priority. No assurance is given to the Contractor that the requested number of hours per day, time of day, or number of days per week of track time will be available for testing. All car and train operations must take place under the regulations of the FRA, the Northeast Operating Rules Advisory Committee (NORAC) operating rules, and SEPTA’s Railroad Division’s rules.

18.2 QUALIFICATION TESTS

Qualification tests shall be organized into three (3) subcategories:

a. Component/subsystems
b. Static vehicle
c. Dynamic vehicle

Each component shall be wired, piped, and assembled with auxiliaries as necessary to allow for complete component conformance tests which shall be run in conjunction with the first article inspection. Components shall pass each test in acceptable condition. Tests shall be witnessed by the Engineer or an appointed representative at their option.

18.2.1 Component Qualification Testing

The following summary table is provided for convenience only and does not in any way reduce the Contractor's responsibility to ensure that all tests required by this Specification are performed in accordance with the requirements listed herein:

Testing required for specific materials or applications are listed in TS 17.
<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Performed By</th>
<th>TS Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbody Interior Materials</td>
<td>As required</td>
<td>Manufacturer</td>
<td>18.2.1.1</td>
</tr>
<tr>
<td>Window</td>
<td>Each window type</td>
<td>Manufacturer</td>
<td>18.2.1.2</td>
</tr>
<tr>
<td>Flammability, Smoke, and Toxicity Emission</td>
<td>All materials for items listed in TS 17.24</td>
<td>Manufacturer</td>
<td>18.2.1.3</td>
</tr>
<tr>
<td>Door</td>
<td>As required</td>
<td>Manufacturer</td>
<td>18.2.1.4</td>
</tr>
<tr>
<td>Dynamic Coupler and Intercar Connection</td>
<td>Pilot cars and as required</td>
<td>Manufacturer and Contractor</td>
<td>18.2.1.5</td>
</tr>
<tr>
<td>Motor</td>
<td>First motor and one (1) motor for every 100 produced</td>
<td>Manufacturer</td>
<td>18.2.1.6</td>
</tr>
<tr>
<td>Battery and Power Supply</td>
<td>As required</td>
<td>Manufacturer</td>
<td>18.2.1.7</td>
</tr>
<tr>
<td>Heating, Ventilation, and Air Conditioning</td>
<td>One (1) system and controls</td>
<td>Manufacturer</td>
<td>18.2.1.8</td>
</tr>
<tr>
<td>Friction Brake System</td>
<td>One (1) of first three (3) systems</td>
<td>Manufacturer</td>
<td>18.2.1.9</td>
</tr>
<tr>
<td>Truck Static and Fatigue Load</td>
<td>First truck of each type</td>
<td>Manufacturer</td>
<td>18.2.1.10</td>
</tr>
<tr>
<td>Truck Damper</td>
<td>One (1) damper of each type</td>
<td>Manufacturer</td>
<td>18.2.1.11</td>
</tr>
<tr>
<td>Truck Primary Suspension</td>
<td>One (1) system</td>
<td>Manufacturer</td>
<td>18.2.1.12</td>
</tr>
<tr>
<td>Electrical Interference</td>
<td>All systems</td>
<td>Manufacturers</td>
<td>18.2.1.13</td>
</tr>
<tr>
<td>Carbody Static Structural</td>
<td>One (1) of the first four (4) production cab car shells</td>
<td>Manufacturer</td>
<td>18.2.1.14</td>
</tr>
<tr>
<td>Microprocessor Control Unit</td>
<td>One (1) of each type</td>
<td>Manufacturer</td>
<td>18.2.1.15</td>
</tr>
<tr>
<td>Packaged Components</td>
<td>One (1) of each type</td>
<td>Manufacturer</td>
<td>18.2.1.16</td>
</tr>
<tr>
<td>Equipment Noise and Vibration</td>
<td>One (1) of each system and entire car</td>
<td>Manufacturer and Contractor</td>
<td>18.2.1.17</td>
</tr>
<tr>
<td>Communication System</td>
<td>One (1) complete system</td>
<td>Manufacturer and Contractor</td>
<td>18.2.1.18</td>
</tr>
<tr>
<td>Lighting Ballast</td>
<td>Two (2) of each type</td>
<td>Manufacturer</td>
<td>18.2.1.19</td>
</tr>
<tr>
<td>Door Panel</td>
<td>One (1) of each type</td>
<td>Manufacturer</td>
<td>18.2.1.20</td>
</tr>
<tr>
<td>Seat Frame and Cushions</td>
<td>One (1) of each type</td>
<td>Manufacturer</td>
<td>18.2.1.21</td>
</tr>
<tr>
<td>Truck Frame Weld</td>
<td>As required</td>
<td>Manufacturer</td>
<td>18.2.1.22</td>
</tr>
</tbody>
</table>
### Component Qualification Test Summary

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Performed By</th>
<th>TS Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination Sign and Interior Message Display</td>
<td>One (1) complete system</td>
<td>Manufacturer</td>
<td>18.2.1.23</td>
</tr>
<tr>
<td>Jumper</td>
<td>One (1) of each type</td>
<td>Contractor</td>
<td>18.2.1.24</td>
</tr>
<tr>
<td>Monitoring and Diagnostic System</td>
<td>One (1) complete system</td>
<td>Contractor</td>
<td>18.2.1.25</td>
</tr>
<tr>
<td>Cab Signal, ATC, and SEPTA PTC System</td>
<td>As required</td>
<td>Contractor</td>
<td>18.2.1.26</td>
</tr>
<tr>
<td>Composite Floor Panel</td>
<td>One (1) of each type</td>
<td>Contractor</td>
<td>18.2.1.27</td>
</tr>
<tr>
<td>Floor Covering Removal</td>
<td>Representative sample</td>
<td>Contractor</td>
<td>18.2.1.28</td>
</tr>
<tr>
<td>Floor Panel Fire Resistance</td>
<td>Representative sample</td>
<td>Contractor</td>
<td>18.2.1.29</td>
</tr>
<tr>
<td>Elastomer</td>
<td>One (1) of each type</td>
<td>Contractor</td>
<td>18.2.1.30</td>
</tr>
<tr>
<td>Bridge Plate</td>
<td>One (1) of each type</td>
<td>Contractor</td>
<td>18.2.1.31</td>
</tr>
<tr>
<td>Relays and Contactors</td>
<td>One (1) of each type</td>
<td>Contractor</td>
<td>18.2.1.32</td>
</tr>
<tr>
<td>Electrical and Electronic Panels</td>
<td>One (1) of each type</td>
<td>Contractor</td>
<td>18.2.1.33</td>
</tr>
<tr>
<td>Network Integration and Fault Tolerance Testing</td>
<td>One (1) complete system</td>
<td>Contractor</td>
<td>18.2.1.34</td>
</tr>
</tbody>
</table>

#### 18.2.1.1 Carbody Interior Materials Tests

The carbody interior materials and insulation materials shall be tested to confirm compliance with the requirements of TS 17.13, TS 17.14, and TS 17.24 and other Sections of the Specification as appropriate for each item. Seats shall be tested for compliance with TS 17.10 and TS 17.11 and other appropriate Sections of the Specification.

#### 18.2.1.2 Window Tests

Cab windshields, left side windshields, standard passenger side windows, emergency exit passenger side windows, cab sliding windows, cab partition door windows, end of car door windows, and passenger side door windows shall be tested in accordance with the requirements of 49 CFR 223 and 238. Each window test shall test the complete window system including all frames, moldings, rubber extrusions, etc. Each window system shall be tested in a fixture that represents and simulates the manner and method of the actual window installation on the car.
The exterior window assemblies shall be capable of withstanding with a safety factor of not less than 2.5 the pressure caused by the combination of maximum wind speeds and train speed considering their relative direction created by trains passing in the opposite direction on adjacent tracks.

### 18.2.1.3 Flammability, Smoke, and Toxicity Emission Tests

All combustible materials used in the construction of the cars shall be tested in accordance with TS 17.24 and 49 CFR 238. All materials shall be tested at a recognized Engineer approved independent testing laboratory. One (1) sample of the production structural floor shall be tested in accordance with ASTM E119 as stated in TS 17.24.

### 18.2.1.4 Door Tests

One (1) door panel of each type shall be tested to demonstrate proper strength and rigidity to sustain a concentrated load of 200 pounds applied perpendicular to either surface of the door leaf at the center of the span adjacent to its abutting (nosing side) edge with a maximum deflection of 1/4 inch without permanent set while the door is freely supported at both top and bottom edges. In the case of the end side doors, the maximum deflection must not exceed 0.30 inch.

A door qualification test shall include an accelerated life test of 1.5 million cycles for one (1) complete door set (corner post sliding, quarter point sliding, and sliding body ends). The life test shall include temperature variations, temperature extremes, and simulated dirt contamination. All parameters of the life test shall be approved by the Engineer. A physical door obstruction shall activate the obstruction-sensing device for a test of 200,000 door recycles.

These tests shall be completed before the first car is ready for final assembly. Failures recorded during testing must correlate within specified reliability values. Door speed and noise tests shall be performed at the beginning, mid-point, and end of the life test for comparative evaluation.

A qualification test of at least 100,000 cycles shall be conducted on the trapdoor assembly. As a minimum, the trapdoor springs and bushings shall survive the duration of the test without yielding, failing, chaffing, or wearing. Any applicable wear parameters must be submitted to the Engineer for review and approval prior to commencing the test. During the test, the Contractor shall periodically inspect the trapdoor assembly to identify any abnormalities. Failures encountered during the test shall be rectified and the test restarted from the beginning. All parameters of the test shall be approved by the Engineer.

A qualification test of at least 200,000 cycles shall be conducted on the sliding threshold heater assembly and cable assembly. As a minimum, the sliding threshold heater assembly and cable assembly shall survive the duration of the test without yielding, failing, chaffing, or wearing. Any applicable wear parameters must be submitted to the Engineer for review and approval prior to commencing the test. During the test, the Contractor shall periodically inspect the sliding threshold heater assembly and cable assembly to identify any abnormalities. Failures encountered during the test shall be rectified and the test restarted from the beginning. All parameters of the test shall be approved by the Engineer.
18.2.1.5 Dynamic Coupler and Intercar Connection Tests

The coupler at both ends of a car, the car to car electric jumper cables, and the car to car hoses shall be mocked up as they are installed and supported on the car. The couplers set up at the manufacturer's plant and on the pilot cars or other car as approved by the Engineer shall be tested to determine that they have a sufficient gathering range and rotation as defined in TS 5.2 to operate properly under the simulated worst case conditions of the specified vertical and horizontal curves, wheel wear, deflated and fully inflated air bags, and static and dynamic spring deflections as specified in TS 2.2.

All intercar trainline electric cables and hoses shall be given a 100,000 cycle flexing test equivalent to the motions the cables would experience with the cars negotiating the "worst case" conditions of vertical and horizontal curves and minimum turnouts. Pins shall be energized with maximum operating voltage during these tests. The pneumatic hoses shall be pressurized with the maximum normal pressure. After the application of the 100,000 cycles of flexing, the leads and cables shall exhibit no evidence of wear or failure. At the conclusion of the test, the cables shall exhibit no evidence of short circuits, open circuits, intermittent circuits, high resistance circuits, insulation wear or failure, or broken wire strands as verified by disassembly and inspection and dielectric tests. No insulation wear or rupture shall be permitted, and no wire strands may be broken. If an existing service proven jumper cable is provided, testing is not required, but test data must be submitted to the Engineer for approval.

Coupler and draft gear qualification tests shall include tests pertaining to the performance and capabilities of the equipment and shall, at a minimum, include the following:

a. Coupler draft and buff loading
b. Draft gear deflection and uncoupling mechanism
c. Anchor casting static loading
d. All applicable inspections and verifications defined in APTA-PR-M-RP-002-98
e. Vertical strength

18.2.1.6 Motor Tests

Each type of motor supplied shall be "type" tested by the manufacturer in accordance with IEEE-11 with electrical characteristics per IEEE-112, IEC-349-2, or NEMA MG-1, Part 12, as appropriate for the motor application and as approved by the Engineer. The first motor produced in each production lot and one (1) additional motor for every 100 motors produced in each production lot or portion thereof shall be tested. The additional motors to be tested shall be selected by the Engineer at random from the production run.

18.2.1.7 Battery and Power Supply Tests

A test of battery capacity per TS 10.3.1, the low voltage power supply per TS 10.3.2, and the PA, intercom, radio power supply per TS 13 shall be performed to show compliance with their specified requirements. Other power supplies listed in this Section and battery charger shall also be tested to show compliance with specified requirements.
18.2.1.7.1 Low Voltage Power Supply Qualification Test

The low voltage power supply qualification test shall include as a minimum:

a. A continuous heat run at rated input voltage and rated output voltage and current. The heat run shall be of sufficient duration to allow all critical elements to stabilize in temperature. Temperature rise over ambient shall be within the Contractor's limits as set forth in the test plan.

b. The unit under test shall be operated for one (1) hour at an input voltage just below the upper limit of the specified operating range and at rated output current and voltage.

c. The unit shall be operated for one (1) hour at an input voltage just above the lower limit of the specified input range for which rated output voltage and current are to be delivered.

d. The unit shall be cycled off and on into rated load by interruption of the source voltage supply external to the power supply. Rate of cycling shall be approximately one (1) second on, 1/2 second off and shall proceed for two (2) minutes.

e. The unit shall be started into an open circuit five (5) times in succession.

f. The unit shall be started into a short circuit (as nearly representative of a "bolted fault" as the test setup allows) five (5) times in succession.

g. The unit shall be started into an overload (approximately 120 percent of rating). The overload shall then be removed, and the unit shall automatically provide rated output voltage.

h. Noise measurements shall be taken sufficient to demonstrate compliance with the specified requirements.

i. At all operating points representing deliverance of rated output voltage or routine current limit operation, voltage wave forms shall be monitored by an oscilloscope to determine compliance with the specified levels of ripple. Similarly, output voltage during normal operation at various operation points shall be monitored for compliance with the voltage regulation requirement.

18.2.1.7.2 Cab Control Unit, PA, Intercom, and Radio Qualification Tests

The cab control unit, PA, intercom, and radio shall each receive power supply qualification tests to include as a minimum:

a. A continuous heat run at rated input voltage and rated output voltage and current. The heat run shall be of sufficient duration to allow all critical elements to stabilize in temperature. Temperature rise over ambient shall be within Contractor's limits as set forth in the test plan.

b. The unit under test shall be operated for one (1) hour at an input voltage just below the upper limit of the specified operating range and at rated output current and voltage.
c. The unit shall be operated for one (1) hour at an input voltage just above the lower limit of the specified input range for which rated output voltage and current are to be delivered.

d. Noise measurements shall be taken sufficient to demonstrate compliance with the specified requirements.

e. Compliant with emergency communications requirements of:

1) 49 CFR 238.121

2) APTA-PR-PS-S-001-98


18.2.1.8 Heating, Ventilation, and Air Conditioning

The HVAC unit used for qualification testing and the units on the vehicle climate room test car shall have the following test fittings:

a. Pressure tap fittings in each suction header adjacent to the expansion valve equalizer connections

b. Liquid line pressure tap fitting

One (1) air conditioning module and its controls shall be tested for capacity in a laboratory climate room by the air conditioning manufacturer to verify the functioning of the system at the design conditions specified in TS 8. Tests may be performed in an independent laboratory approved by the Engineer. The test shall be performed according to ASHRAE Standard 37, "Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment". The secondary applicable test method shall be selected by the Contractor for Table 1 of Standard 37. The instrumentation and required test data shall meet the requirements of the Standard. This test shall be successfully completed before conducting the pre-delivery tests. A demonstration of the pressure modulation capability and compressor unloading at design conditions with 115° F dry bulb (° F DB), 85° F wet bulb (° F WB) air delivered to the condenser shall be included in the test. A successful condenser high ambient test shall consist of continuous operation of the system for at least three (3) hours without shutdown due to high pressure, circuit breaker trip, compressor motor overload, or device failure. A shutdown, while operating at the high ambient temperature for any condition, shall constitute a failure of the test. At the end of the three (3) hour operation, the system shall be momentarily stopped and restarted. The system shall continue to function properly with all components safe from malfunction. All tests shall include the effects of dirty condenser coils, dirty filters, etc.
The system shall be installed in a suitable fixture to separate exterior and car’s interior conditions using appropriate equipment. Temperature and humidity controls shall be used to maintain the specified conditions in the exterior and interior sections of the air conditioning module for the duration of the test period. Pipe diameter, length, and bends shall be the same as those to be used on the car. All equipment normally mounted on the car roof or under floor exposed to ambient conditions shall be installed in the "exterior" area. Items normally present with the evaporator such as the inlet plenum, filters, fresh air ducts, blower, inlet grilles, condensate drain pan and tubing, and any fan housing to main duct transition shall be installed in the "interior" area. The resistance of the airflow circuit external to the evaporator blower heater unit and its associated ducting and filters similar to the actual car installation shall be simulated by an approved method during testing. The evaporator unit shall be installed so that the quantity of entering air can be measured and regulated to the design volume. Electrical data, motor RPM, and system static pressures shall be recorded. The evaporator air pressure drop measurements shall be compared with the manufacturer’s coil curves in terms of CFM, RPM, and static pressure.

All data except as otherwise indicated shall be continuously recorded by a digital data acquisition system using appropriate transducers and sensors. The instruments and transducers/sensors shall have been calibrated before the test, and calibration certificates for all instruments shall be available for inspection by the Engineer or approved by the Engineer on the day prior to the commencement of the test. Copies of these certificates shall be included in the test report. The Contractor may propose alternate methods of instrumentation for the Engineer’s approval.

Air side pressure drops and motor speeds may be recorded manually as required. Prior to the test, the air conditioning unit shall be evacuated and dehydrated to 50 microns or less; the system pressure shall not rise above 300 microns after one (1) hour when the vacuum pump is isolated.

The following data shall be taken during each test run:

a. Temperatures

1) Evaporator
   a) ≅ °F DB in and out of the unit
   b) ≅ °F WB in and out of the unit
   c) ≅ Blower motor winding temperature

2) Condenser
   a) ≅ °F DB in and out of coil(s)
   b) ≅ All fan motor winding temperatures

3) Exterior Area
   a) ≅ °F DB and °F WB

4) Interior Area
   a) ≅ °F DB and °F WB
5) Refrigerant
   a) ≅ Compressor suction
   b) ≅ Compressor discharge
   c) ≅ Condenser outlet
   d) ≅ Evaporator inlet
   e) ≅ Evaporator outlet

6) Compressor Motor
   a) ≅ Winding temperatures

b. Pressures
   1) Compressor suction
   2) Compressor discharge
   3) Condenser air pressure drop across the coil
   4) Evaporator suction
   5) Evaporator discharge
   6) Evaporator air pressure drop across the coil

c. Electrical
   1) Compressor voltage
   2) Compressor current
   3) Compressor RPM
   4) Blower voltage
   5) Blower current
   6) Blower RPM
   7) All condenser fans - voltage, current, RPM

d. Airflow
   1) Fresh air intake
   2) Evaporator discharge
   3) Return air

For each test, continuous readings shall be taken during the test period. The system capacity calculated from the change in enthalpy of the air stream through the evaporator coil. The following tests shall be conducted:

a. Capacity Test
   1) At design conditions listed in TS 8.1
   2) At design conditions listed above but with the condenser ambient at 115° F DB, 85° F WB
b. Pull Down Test

1) At design conditions listed in TS 8.1
2) At design conditions listed above but with the condenser ambient at 115° F DB, 85° F WB

c. Temperature Control Test

The temperature control components shall be exposed to the test environment by installation in their proper locations and energized during the capacity and pull down tests although they will not function to control the system during these demonstrations (the mixture temperatures used are higher than the thermostat set points).

Following the pull down test, the "interior" area load shall be reduced until the temperatures are low enough for the thermostats to control the system. The "exterior" area shall be maintained at design conditions during this procedure. The load shall be varied in the "interior" area in a manner such that the thermostats operate the system through the full control range on rising and falling "interior" temperature including heating and ventilating modes of the thermostatic control. The use of substitute switches shall not be permitted. During this demonstration, temperature, pressure, and electrical data as recorded for the other tests shall be recorded at each control step.

d. Control Stability Test

The "interior" area shall be held at the requirements specified in TS 8.1. The "exterior" area shall be held at design conditions specified in TS 8.1. The system shall be operated with the thermostat in control. Control voltage shall be held at 74 volts DC. When stable operation is reached, the control voltage shall be varied between the limits required by TS 2.2.7.2.3 to show the effect of such a change. The same data as that recorded for the temperature control operational test shall be recorded. Additionally, any changes noted in the mode of system operation shall be recorded as the control voltage is changed.

e. Abnormal Heating Condition with Restricted Air

Unit ambient temperature shall be maintained at approximately 70° F DB. Mixed inlet air shall be restricted slowly such that the heater unit temperature rises not faster than 2° F per minute until the high limit switch cycles off. The restriction shall then be backed off to the point where the high limit switch closes and remains closed. The heating test shall be continued simulating a dirty filter condition. The system shall be operated until a steady state is reached. Temperature readings shall be taken every five (5) minutes. Acceptance criteria shall be as follows:

1) The fusible link or shunt trip shall not open during these tests.
2) The temperature inside the unit shall not cause damage to the equipment and components.
3) The high limit switch shall open at design set point +/-10° F.
f. Abnormal Heating Conditions without Air Circulation

The unit ambient temperature shall be maintained at approximately 70° F DB. Power shall be applied to the heaters with no air blowing over them. The system shall be operated as the high limit switch cycles.

The acceptance criteria for the restricted airflow test shall apply to this test. The test shall be performed at the nominal voltage and at limits required by TS 2.2.7.2.3.

g. Fusible Link Backup Protection Test

The fusible link located in the overhead heater section shall be tested following the pull down demonstration to ensure that it did not open under those temperature conditions in addition to those listed below.

The air conditioning system shall be shut down and the "interior" area brought to an ambient temperature of approximately 70° F DB. With the evaporator fans shut down, the overhead heat shall be turned on using suitable jumpers. The high limit switch and duct temperature control thermostat shall be jumpered. During this testing, the following data shall be recorded continuously from the time of power “on” until thirty (30) minutes after the fusible link opens:

1) Temperature
   a) Air inside the evaporator unit measured as close to the thermal fuse as possible
   b) Ambient air at the intake to the evaporator coil

2) Electrical
   a) Voltage and current to the heater

3) Time
   a) From the time of power “on” until 30 minutes after the opening of the fusible link
   b) A visual and electrical observation (to be recorded on the test charts) shall be made of the thermal fuse opening.
   c) The melting temperature of the fusible link shall be high enough to allow it to open only in the event of a failure of the primary protective devices while still preventing damage to the equipment and any carbody components.
   d) The test shall be performed at nominal voltage and at limits specified in TS 2.2.7.2.3.
h. Condensate Carry Over Test

Under the design conditions of 80° F DB/75° F WB, the air conditioning system shall be operated for six (6) hours to verify that there is no carryover of condensate into the air ducts and that the condensate drain pan and drain piping operates properly. The evaporator assembly shall be elevated to simulate conditions of acceleration, deceleration, grade, and super elevation of the track as approved by the Engineer. During the test, no condensed water shall drop, run, or blow-off from the unit casing and drain pan. Coil surfaces shall be in the as manufactured condition without special wetting agents applied or any other surface coating that is not part of the production configuration approved by the Engineer.

i. Low Temperature Operation Test

At 50° F DB/40° F WB, return air and ambient temperature without people and solar load. After establishment of specified conditions, the unit shall be operated continuously for a period of four (4) hours. During the entire test, the air conditioner shall operate without damage to the equipment; evaporator air quantity shall not drop more than 25 percent from the manufacturer’s rating.

At 42° F DB, ambient temperature and a sufficient passenger and solar load to induce the cooling mode of operation.

Air conditioning equipment shall operate without damage or malfunction.

j. Refrigerant Charge Determination

The system shall be leak tested, evacuated, and dehydrated prior to the refrigerant charge determination test.

The climate room shall be programmed for 95° F DB, 78° F WB. All cooling loads as specified in TS 8.1 shall be applied. The system shall be charged initially to 1/4 full bottom receiver sight glass. Measure and record the refrigerant weight accurately. At stable conditions, record temperature and pressure conditions.

The following criteria shall constitute correct system refrigerant charge:

1) 10° F superheat at evaporator outlets

2) Minimum 10° F liquid subcooling at heat exchanger outlet

3) The oil level in the compressor sight glass should be observed immediately after the compressor shutdown as recommended by Carlyle. The system should be operating for at least 30 minutes in fully loaded conditions before shutdown to obtain the correct oil level.

4) Compressor sight glass approximately 1/2 full of oil

5) Compressor crankcase oil not foaming
6) Compressor fully loaded (all cylinders)

7) No bubbles in liquid lines at 115° F and 125° F ambient

The exact recorded refrigerant charge weight shall be applied to all remaining units.

18.2.1.9 Friction Brake System Tests

Friction brake system qualification tests shall include the following tests on one (1) of the first three (3) production units to determine the following characteristics:

a. Brake Unit Endurance Tests

A test setup shall be arranged such that one (1) tread brake unit and one (1) disc brake assembly are exposed to simulated conditions they shall encounter in service including shoe force and force developed by braking torque in each direction. The brake pad and shoe shall be loaded by applying air pressure equivalent to a maximum service brake (friction only) application to the disc brake assembly and the tread brake unit, and the forces developed by the brake reaction torque shall be applied through the mounting arrangement. The brake assemblies shall be placed in an environmental chamber capable of imposing the minimum and maximum specified operating temperatures and airborne dirt and moisture according to a cycling schedule approved by SEPTA throughout the duration of the test. The direction of the reaction torque shall be reversed every ten (10) brake applications. They shall be subjected to 1,000,000 cycles of the full friction working loads predicted. The load levels shall represent AW2 conditions.

The brake assemblies shall be considered acceptable if no component failure of any kind or any abnormal wear occurred during the 1,000,000 consecutive operating cycles. A complete teardown inspection shall be conducted following the test to verify full compliance.

b. Response

The friction brake system shall be tested to verify the response to all control inputs.

c. Linearity

Dynamometer test runs shall be made for simulated car weight AW0, AW2, and AW3 from each of the entry speeds of 110, 80, 70, 60, 45, 30, 20, and 15 mph. For each entry speed, input signals calling for 25 percent, 50 percent, 75 percent and 100 percent of full service braking effort and for emergency braking effort shall be applied. Results shall be plotted to show the relationship between input signal and output braking effort over the speed and weight range.
d. Brake System Capacity

A full scale dynamometer test shall be performed to demonstrate that the proposed foundation friction brake components shall perform as required and that thermal capacity requirements have been met with both hot and cold initial brake disc or wheel conditions. Tread brake actuators and disc brake calipers shall be the same model to be employed on the car. The test wheel shall match the proposed wheel but be machined away to simulate fully worn conditions. A brake pad wear in procedure is required.

Prior to the test, static shoe force and/or pad force measurements shall be made at all brake cylinder pressures in ten (10) psi increments. Dynamometer speeds shall be adjusted for worn wheel diameters. Brake cylinder pressure response times shall match the actual car build-up rate within ±0.25 seconds for both full service and emergency.

The brake disc and pad or wheel and shoe surface temperature shall be measured and recorded throughout the test. Speed, shoe force, wheel load, stop distance, and the average braking rate \((V/T)\) for each stop shall also be continuously recorded. The stop distance shall be calculated for each stop.

The following braking profiles are to be tested:

1) AW2 load in a service compatible with that from Suburban Station to Chestnut Hill East, Chestnut Hill West, Trenton, Newark, DE and Harrisburg through one (1) round trip on each route making all station stops and observing all speed restrictions. The speed profile will be provided by SEPTA.

2) A series of slowdowns from 110 mph to 90 mph using full service net shoe and pad force with two (2) minutes between brake applications shall be run. After each slowdown, brakes shall be released upon reaching 90 mph, and the dynamometer shall accelerate immediately at the specified performance rate up 110 mph. A test cycle consists of six (6) slowdowns, and a test series consists of two (2) test cycles. The wheel and disc are to be air cooled to a maximum of 60° F (above ambient) between cycles.

3) Two (2) emergency brake applications from 110 mph to 0 mph. Upon reaching 0 mph, the dynamometer shall remain stationary for one (1) minute and then accelerate at the specified performance rate up to 110 mph.

The maximum allowable measured temperatures permitted during any of the following tests are 600° F for wheel tread, and the maximum allowable temperature recommended by the brake disc manufacturer of the brake disc. At the completion of this test, the brake unit shall remain in an undamaged fully operable condition. The test procedure and report shall include calculations to demonstrate compliance with the performance requirements of TS 2.2.7.3.

e. Pressure

All pneumatic brake system components shall be tested at 180 psi or the compressor safety valve operating pressure whichever is greater. No component damage shall occur.
f. Brake System Endurance Test

A complete friction brake system including the electronic control unit but excluding the master controller shall be subjected to an endurance test of 1/2 million cycles of normal apply and release applications. Brake reaction forces shall be simulated on the actuators.

The first complete production friction brake system shall be assembled before mounting on a vehicle and shall be subjected to an endurance test of 250,000 cycles of normal applications and releases to demonstrate that the control apparatus has the endurance required for intended rail service. For each cycle, the Brake Control Unit shall 1) apply, 2) hold (with controlled leakage), and 3) release in response to reductions and increases in brake pipe pressure. The wheel slide control valves shall be tested for 1,000,000 cycles of modulating application and release according to an approved routine. The system shall be tested in an environmental chamber and subject to an approved cycling schedule of simulated conditions.

The system shall be considered acceptable if no component failure of any kind or any abnormal wear occurred during the specified consecutive operating cycles. A complete teardown inspection shall be conducted following the test to verify full compliance.

g. Brake System Environmental Test

A test setup in an approved environmental laboratory shall be prepared to simulate the climatic conditions to be encountered. The test setup shall include conditions of high humidity with rapid temperature fluctuation cycles between 110° F and -20° F. If it is impractical to test a complete braking system, parts of the system may be simulated. During environmental tests, system function ambient temperature and humidity shall be recorded.

The test schedule shall start with overnight (eight (8) hours minimum) soak at the high temperature limit with the power on. The equipment shall then be tested. After which the equipment shall be subject to eight (8) temperature and humidity cycles between high and low temperature limits with each cycle lasting 12 hours including holding at the high and low temperature limits for a minimum of one (1) hour during each cycle.

During the one (1) hour hold period, the brake system shall be operated to apply and release the brakes at least once every five (5) minutes. The brake operation shall be cycled between full application and full release with the brake application held on for one (1) minute. There shall be at least two (2) emergency applications. All applications shall simulate full passenger load conditions. The wheel slide correction control shall also be cycled during each application.

The system will be considered acceptable if no system component or part fails or malfunctions. A complete disassemble and parts inspection shall be conducted following completion of the test to verify compliance.

h. Wet Braking Rate Test

A series of brake dynamometer tests shall be conducted to compare the braking rates achievable with wet wheels and shoes or wet brake discs and pads.
A series of stops with dry wheels and shoes or dry brake discs and pads shall be simulated at 25 percent, 50 percent, 75 percent, and 100 percent of AW3 full service brake pressure and AW3 emergency brake pressure with entry at each pressure under both hot wheel or disc and cold wheel or disc conditions. Speed vs. time, stop distance, and average braking rate (V/T) for each stop shall be recorded.

The same series of stops shall be simulated with wet brake conditions. Water shall be sprayed onto the wheel or disc at the wheel shoe or disc pad interface. The water spray apparatus, pattern, and flow rate shall conform to UIC 541-4, Appendix 4, if tread brakes are used and UIC 541-3, Appendix 4, if disc brakes are used. The spray apparatus shall be oriented to spray the disc/pad interface if disc brakes are used, and the wheel/shoe interface if tread brakes are used.

The average braking rate under wet conditions shall not decrease by more than 15 percent nor increase by more than 10 percent from the dry stop conditions.

i. Glazing Tests

A series of brake dynamometer tests equivalent to a snow brake application shall be performed. Each application shall be held for two (2) minutes followed by release for one (1) minute. A series of 12 applications shall be made. At the end of this test, the pads and shoes shall be removed from the dynamometer and inspected. No evidence of glazing is permitted. If small amounts of glazing are found, then the pad and shoe shall be reapplied and the test repeated. No additional glazing is permitted.

18.2.1.10 Truck Static and Fatigue Load Tests

Each truck frame and bolster type shall be tested to verify that the maximum allowable stresses specified in TS 11.4 under an AW3 load are not exceeded. The first production unit of each type shall be used unless otherwise specifically approved by the Engineer. The load test shall be performed with the suspension elements replaced by solid blocking. The truck shall be tested as an assembly as approved by the Engineer.

Prior to and after the static load tests, a magnetic particle or dye penetrant inspection of the truck for cracks shall be performed in the presence of the Engineer. A stiff elastomeric pad shall be placed between the solid blocking and the truck frame or bolster to allow deflection without altering the normal load path. If critical cracks as defined in TS 18.2.1.10.3 are detected, the design shall be corrected and reinspected before testing.
Not less than 75 strain gauges shall be applied to the truck at locations as agreed to by the Contractor and the Engineer with the Engineer having the power of decision in the event of a disagreement. The locations to be strain gauged shall be determined by analysis and by a preliminary static test to determine the location and direction of stresses using brittle lacquer or other indicators. If the Contractor elects to use analytical methods in lieu of brittle lacquer, photoelastic, or other indicators, then the Contractor shall apply not less than 100 rosette strain gauges to the truck at locations of expected high stress and areas of interest as agreed to by the Contractor and the Engineer. The Engineer shall determine the locations in the event of a disagreement. There shall be no less than two (2) locations where there are a sufficient number of gauges to encircle the side frames, and two (2) locations that encircle the bolster to appraise the stress distribution at these cross sections. Dial indicators or equivalent will be applied to monitor the truck dimensional behavior during the static tests.

Unit stresses and dimensional measurements at all instrumented locations shall be taken before, during, and after the static normal and overload tests as approved by the Engineer. Unit stresses at agreed locations will be taken continuously throughout the fatigue test.

18.2.1.10.1 Test 1 – Nominal Loads

All nominal loads shall be applied and released in a series of not less than four (4) steps to demonstrate a linear stress response and performed twice. One (1) of the steps shall be the fatigue test value for each load. Load cases will be applied for each load individually and all loads simultaneously up to the maximum values indicated. Sufficient load cases will be performed with load directions varied to ensure that all unique truck quadrants are subjected to the maximum combined load.

The vertical load shall be 55 percent of the AW3 loaded carbody weight. The lateral load shall be 15 percent of the vertical load, and the longitudinal load shall be 15 percent of the vertical load. The lateral and longitudinal loads shall act as if applied at the center of gravity of the AW3 loaded carbody. Accessory loads such as those from the brake units shall represent maximum steady state conditions; i.e., maximum brake unit reactions and brake unit weights but shall not be less than:

a. Tread Brake Unit (TBU)

   1) Horizontal       Max outward reaction
   2) Vertical         Max vertical reaction plus six (6) times the TBU weight

b. Disc Brake Unit (DBU)

   1) Horizontal       Max horizontal reaction
   2) Vertical         Max vertical reaction plus six (6) times the DBU weight

Manual calculations may be required in areas of high stress gradient or near welds to extrapolate the test results and determine the critical stresses.
The stress results of the two (2) load applications shall be compared with the calculated stresses, and
the higher shall be less than the allowable stresses as specified in TS 11.4. If the stress exceeds the
allowable stresses, the truck design shall be corrected to bring the test stress to less than the allowable
stress. The redesigned truck shall be retested at the expense of the Contractor, and all trucks previously
installed in the cars shall be modified to be in accordance with the corrected design.

18.2.1.10.2 Test 2 – Overload

To demonstrate that the truck has adequate strength to sustain a maximum load in the presence of a
combination of minor manufacturing defects, it shall be overloaded statically once as follows with the
direction of loads chosen to apply the highest stress to the most critical section(s) of the truck:

a. Overload Test Loads

1) Truck

   a) Vertical       100 percent x (carbody + 50,000 pounds)
   b) Lateral        15 percent x vertical
   c) Longitudinal   15 percent x vertical

2) Tread Brake Unit

   a) Horizontal – the greater of two (2) times the maximum normal outboard
      reaction or the reaction resulting from maximum MR pressure in the brake
cylinder and sufficient adhesion between wheel and rail to prevent wheel slide.

   b) Vertical – the greater of two (2) times the maximum normal vertical reaction or
      the reaction resulting from maximum MR pressure in the brake cylinder and
      sufficient adhesion between wheel and rail to prevent wheel slide.

3) Disc Brake Unit

   a) Horizontal – the greater of two (2) times the maximum normal horizontal
      reaction or the reaction resulting from maximum MR pressure in the brake
cylinder and sufficient adhesion between wheel and rail to prevent wheel slide.

   b) Vertical – the greater of two (2) times the maximum normal vertical reaction or
      the reaction resulting from maximum MR pressure in the brake cylinder with
      maximum shoe wheel friction and sufficient adhesion between wheel and rail to
      prevent wheel slide.

In addition to not exceeding the maximum allowable stresses specified in TS 11.4, there shall be no
permanent deformation as determined from strain gauge or dial indicator readings.
18.2.1.10.3 Test 3 – Truck Frame and Bolster Fatigue Test

To demonstrate that each truck type has adequate fatigue strength under dynamic loading, each tested truck frame and bolster type shall be subjected to a combined cycle loading fatigue test. Each tested unit shall be the unit previously tested in TS 18.2.1.10.1 and TS 18.2.1.10.2. The loads specified are minimum values. Each test truck frame and bolster shall be tested as a unit with the suspension elements replaced by approved solid blocking. A stiff elastomeric pad shall be placed between the solid blocking and the truck frame or bolster to allow deflection without altering the normal load path.

The vertical load shall vary either between 50 percent of the carbody weight and 55 percent of the combined carbody and crushload weight, or +/-15 percent of the combined per truck carbody and crushload weight for the heaviest vehicle whichever is greater. The lateral load shall be applied first in one (1) lateral direction and then in the opposite lateral direction. The longitudinal load as indicated below shall be applied first forward and then rearward. Both lateral and longitudinal loads shall act as if applied at the center of gravity of the carbody at maximum crushload with resulting vertical loading due to transferring the loads from the center of gravity to the truck bolster applied to the bolster. Accessory loads shall vary between plus and minus 100 percent of their maximum steady state values; brake unit under full cylinder pressure with sufficient adhesion to prevent wheel slide.

a. Fatigue Test Loads - Range

1) Truck

   a) Vertical
      50 percent x carbody to
      55 percent x (carbody + crushload) or
      30 percent of the combined per truck
      carbody and crushload weight for
      the heaviest vehicle whichever is
      greater

   b) Lateral
      ±15 percent x (carbody + crushload)

   c) Longitudinal
      ±15 percent x (carbody + crushload)

2) Tread Brake Unit

   a) Horizontal
      0 to max horizontal reaction

   b) Vertical
      (max vert. react.+ 6 x TBU wt)

3) Disc Brake Unit

   a) Horizontal
      max horizontal reaction

   b) Vertical
      max vertical reaction plus 6 x DBU weight

Note: The "±" symbol means that the load is first applied in the direction indicated and then 180° from that direction.
The phasing of loads shall result in maximum combined stresses at the critical locations. Lateral load phasing may be reversed relative to the longitudinal load midway through the fatigue test to acknowledge that the truck will experience half of the lateral loads in each lateral direction. Longitudinal load phasing will not be reversed. All tests shall result in maximum combined stresses at the critical locations that do not exceed those required in TS 11.4. Critical locations shall be presented by the Contractor and approved by the Engineer. [CDRL 18-009] The frequency of the load cycling shall not exceed three (3) Hz, and load phasing shall remain within five (5) degrees of theoretical or as otherwise agreed to by the Engineer. Test frequency shall be such so as to not cause deterioration of rubber components.

During the fatigue test, the truck shall be inspected regularly using a magnetic particle or dye penetrant to detect any crack initiation and progression. At the conclusion of the fatigue test, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer. If evidence of critical cracking or failure is found, the cause shall be assessed by the Engineer and the Contractor after which an appropriate correction shall be established and the test repeated at the expense of the Contractor, and all trucks installed under the cars shall be modified to be in accordance with the corrected design. The correction shall be approved by the Engineer. Cracks will be considered critical, if they have a definite direction and a minimum length of 1/4 inch. A crack will be considered as a cause of failure for the fatigue test once it has progressed 1/4 inch after initial recognition. The correction and test shall be repeated until successful.

Cast trucks will be submitted to a 6,000,000 cycle fatigue test using the above specified fatigue test load ranges for the first 2,000,000 cycles. At the conclusion of the first 2,000,000 cycles, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer.

Upon completion of the first 2,000,000 cycle test, the frame and bolster used in that test shall be subject to an extended fatigue test, as tabulated below:

- 2,000,000 cycles with loads increased by 10 percent over fatigue test loads, then
- 2,000,000 cycles with loads increased by 20 percent over fatigue test loads

At the conclusion of each 2,000,000 cycles, the extended fatigue test or by failure a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer. If a crack is found, the condition shall be assessed by the Engineer and the Contractor to determine if a design change is required.

Fabricated trucks or combination cast/fabricated trucks will be submitted to a minimum 10,000,000 cycle fatigue test using the above specified fatigue test load ranges. The number of cycles will be increased beyond 10,000,000, if required, to ensure that the most severe fatigue strength weld detail has been exposed to the full endurance limit as defined by the American Welding Society Structural Welding Code D1.1, 2008, Figure 2.11, as detailed in APTA-PR-M-RP-009-98. No less than every 2,000,000 cycles and at the conclusion of the fatigue test, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer. Cracks will be considered as a cause for failure as detailed above.
18.2.1.10.4 Anti-Roll Bar Life Test

If a secondary suspension anti-roll bar is proposed, the roll bar, roll bar lever, and connecting components will be life tested to demonstrate that they meet the requirements of TS 11.8.2.3. The anti-roll bar load will be no less than the load developed due to +/-15 percent of the AW3 carbody weight. The relative stiffness of the air springs to the anti-roll bar stiffness may be considered to determine the amount of load being carried in the anti-roll bar, but in no case will the anti-roll bar be assumed to carry less than 75 percent of the vehicle roll moment. The anti-roll bar attachments to the truck will be life tested as part of the truck fatigue test.

18.2.1.11 Truck Damper Tests

18.2.1.11.1 Functional and Dimensional Testing

a. General functional and dimensional testing will be done to EN13802:2004 with the addition of cycling at the low and high operational temperatures to determine the actual damping rate. The operating and extreme temperatures per Section 4.2.2.1 of 4.2.2.2 of EN13802 shall be -30° C and +70° C (-22° F and 158° F). The dampening rates at these extremes will be measured per Table 3, Section 5.2.2.2, of EN 13802:2004 and will be reported to SEPTA. The Contractor will certify that the rates obtained including expected manufacturing tolerances will provide for the safe operation of the truck.

b. A constant force of 3,000 pounds shall be applied once against the piston stops at each end of the stroke. The load shall be applied and then maintained for a period of not less than 30 seconds. The structure of the damper shall not exhibit any permanent deformation or leakage of oil as a result of the test.

18.2.1.11.2 Durability Testing

a. A minimum of one (1) damper of each type will be tested as follows: a new damper may be used for each of the durability tests noted below. All tests will be done at between 17 and 23° C (63 and 73° F). The damper will be supported in the expected operating position and nominal length. The dampening rates will be measured before and after each test, and no more than a 10 percent change in dampening energy per cycle is allowed from the pretest value. No visible evidence of accumulated fluid in the form of drips on the body of the damper which originated from within the damper is allowed.
b. Life cycle and vibration testing will be per the following matrix:

<table>
<thead>
<tr>
<th>Life Cycle Test</th>
<th>Primary Suspension</th>
<th>Secondary Suspension</th>
<th>Yaw Damper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycles</td>
<td>5 million</td>
<td>1 million</td>
<td>3 million</td>
</tr>
<tr>
<td>Frequency</td>
<td>5 Hz</td>
<td>1 Hz</td>
<td>3 Hz</td>
</tr>
<tr>
<td>Peak Velocity</td>
<td>0.3 m/sec (11.8 in/sec)</td>
<td>0.15 m/sec (5.9 in/sec) if vertically mounted</td>
<td>0.1 m/sec (3.9 in/sec)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.10 m/sec (3.9 in/sec) if horizontally mounted</td>
<td></td>
</tr>
<tr>
<td>Vibration Test to IEC 61373</td>
<td>Category 3</td>
<td>Category 2</td>
<td>Category 2</td>
</tr>
</tbody>
</table>

1) Life cycle test will be simple harmonic (sinusoidal) motion, and the testing machine will have measurement errors no greater than stated in EN13802:2004, Section 5.1.2.

2) Vibration testing per IEC 61373 will include the damper mounts.

3) The vibration test acceleration levels may be reduced with a commensurate increase in test time per IEC 61373, Appendix A, to prevent non-representative deterioration of rubber components with the approval of the Engineer.

4) For the vibration test, dampers will have one (1) end attached to the actuator, and the other end fixed relative to the actuator. Both ends of the damper must be tested, e.g. two (2) tests in each axis are required, but two (2) dampers may be used, one (1) for tests with the body attached to the actuator, and the other with the rod or lever attached to the actuator.

5) Damper may be air cooled during testing to prevent excessive temperature rise.

6) Rotary dampers will have the peak velocity applied to the attachment end of lever.

### 18.2.1.12 Truck Primary Suspension Tests

A load deflection test shall be performed to demonstrate that the spring rates of the primary suspension system in all axes are within the design limits of the car. This test shall demonstrate that the primary suspension system responds as predicted and will not result in excessive deflection or decrease in truck clearance above top of rail to less than the minimum prescribed in TS 2.2.

If a primary suspension articulation is proposed, the articulation will be subjected to a life test sufficient to show that it will survive for 8 1/2 years in the SEPTA environment per TS 11.8.1. The specific loads and/or deflections developed for the life test will be developed from the mathematical vehicle model and validated through pilot car testing in SEPTA’s operating territory. This test may be waived by SEPTA if the specific articulation to be used has a successful application history on similar high speed North American passenger services.
### 18.2.1.13 Electrical Interference Tests

Tests shall be conducted to ensure compliance with TS 2.6 including those tests which shall be conducted following pilot car delivery.

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### 18.2.1.14 Carbody Static Structural Tests

#### 18.2.1.14.1 General

One (1) of the first four (4) production cab carshells shall be tested by the Contractor to confirm that the FEA is sufficiently accurate to assure that the carbody structure complies with this Specification. If there are no major structural differences between the carshell types and the test results are comparable with the FEA, one (1) cab carshell shall be tested. The tests shall be performed at an Engineer-approved facility. The tests shall not begin until the carbody stress and energy absorption analyses have been submitted and approved by the Engineer.

The test specimen shall be completely inspected and all non-conformances corrected. All inspection, test, and corrective action reports shall be available for review. Particular attention shall be given to recording flatness and straightness.

The test shell shall be structurally complete including all carshell structural parts and fiberglass ends (if part of the design) but excluding such items as exterior and interior trim, windows, doors, seats, lights, interior lining, or other parts that would obscure any structural member from view or that would interfere with the performance of the test. The test shell shall have no paint, primer, sound damping coating, or insulation. The weight of the underfloor and above floor compartment mounted equipment and heavy roof mounted equipment shall be simulated by equivalent weights at their respective locations. All structural tests shall be conducted on the same specimen. In the judgment of the Engineer, results of structural tests previously conducted on an identical carbody may be submitted in lieu of a second structural test provided there has been no design or material change since the previous test.

The carshell shall be weighed and the weight recorded prior to installation of any test equipment. For the tests, the car shall be supported on the trucks or equivalent supports to allow longitudinal movement.

All gauges and instruments shall be in current calibration and remain so for the duration of the test. The methods of calibration and time periods for recalibration shall be in accordance with the test laboratory's national standard or ISO standards. The laboratory shall have on file a current certification of calibration traceable to the laboratory's national standard.

The Contractor may conduct preliminary tests, but all critical dimensions and flatness shall be verified after the Contractor tests and before the official test begins. The official test (test of record) shall be witnessed by the Engineer. A copy of all recorded data shall be given to the Engineer at the conclusion of each test.
Where practical, all gauges shall have an electric output suitable for recording on electronic (magnetic) media. A data acquisition system shall be provided to permanently record all gauge outputs at each load step. At the end of each load step, a printout of all strain gauge readings in proper engineering units (microstrains) and a plot of load vs. gauge reading for critical gauge locations shall be given to the Engineer or the Engineer’s representative for review. The Contractor shall obtain approval of the Engineer or the Engineer’s representative after every load step before proceeding with the next step. The Contractor shall not break down the test fixtures until the Engineer or the Engineer’s representative has reviewed all data.

The Contractor shall prepare a color photographic record of the test. This record shall include photographs of the car in the several test fixtures, installation of critical strain gauges, repairs or modifications, deviations from the drawings, and any areas found to be non-compliant.

The entire procedure shall be videotaped by the Contractor with a sound equipped digital color video camera. The camera shall rove to view and record key areas. All video tapes taken during this test shall become the property of SEPTA.

SEPTA reserves the right to test a second car of each type during the construction period. Should such a test be ordered, it shall be at the expense of SEPTA unless such tests prove the design is non-compliant in any structural area in which case the Contractor shall be responsible for the test expense and for all of SEPTA’s costs and the cost of modifications necessary for the car and all other cars to be made compliant with the Specification. The Contractor (at their expense) shall also perform a complete set of structural tests to qualify the modified car.

### 18.2.1.14.2 Test Procedure

The procedure shall include a description of the test, its purpose, how and with what equipment the specimen is to be loaded and the load increments, the type and location of strain gauges, the location of deflection gauges, a complete description of all fixtures, instruments, and gauges, and a detailed description of the data acquisition system. Annotated copies of catalogue cuts may be used to provide parts of the description. An explanation of the accuracy of the instrumentation shall be provided. Drawings and sketches shall be included to clarify the text. The test procedure shall provide a step by step instruction describing how the load is to be applied, the load at each step, when data is to be recorded, a space for the signature of the test supervisor, and a space for recording the authorization to proceed obtained from the Engineer or the Engineer’s representative. Test procedures shall be submitted not less than sixty (60) days in advance of the proposed test date; approvals of the test procedure and stress analysis are prerequisites for the start of testing.

The test procedure shall include a copy of the current calibration certification for each instrument and gauge to be used for the test. Typical logging sheets, print outs, plotting forms, and examples of any other data sheets for the test or in the final report shall also be submitted as part of the test procedure.

Tables shall be included to give the maximum allowable reading for each gauge and loading condition. Other tables shall be included to provide the requirements for all other test criteria. The test procedure shall include the tables required by TS 3.8.5 for the validation of the stress analysis.
Each test procedure shall contain a table of the predicted strain (or stress) and deflection at selected gauge locations. This table shall list the strain or deflection gauge number, the location of the gauge, the predicted strain (or stress) or deflection from the stress analysis, a space to enter the actual gauge readings, and a space to enter the calculated percent difference defined as:

\[
\% \text{ difference} = \frac{\text{Actual} - \text{Predicted}}{\text{Actual}} \times 100
\]

18.2.1.14.3 Strain Gauges

A minimum of 240 strain gauges shall be applied to the car structure for each of the compression, vertical load, and diagonal jacking tests. Some gauges may be used for more than one (1) test if their location on the structure is appropriate for other tests, but readings from at least 240 strain gauges in locations shall be obtained for each test. The location of the strain gauges shall be based on the Contractor’s experience, the stress analysis, and the Engineer’s recommendations.

In order to appraise the stress distribution in the carbody at these cross sections, there shall be no less than three (3) locations where there are a sufficient number of gauges to encircle the carbody. One (1) location shall be outboard of the bolster, one (1) shall be between the bolster and the transition to the upper and lower levels, and one (1) shall be at the center of the car. Gauges shall be placed for example on all four (4) sides of the side sill and body sills, on the side framing, along the cantrail, on the cross members, and at the center line of the car.

For each post load test, there shall be a minimum of 100 strain gauges applied to the post and car structure in the vicinity of the post. Some of the gauges may be for more than one (1) test if their location on the structure is appropriate for other tests, but readings from at least 100 strain gauges in locations where the stress may be critical shall be obtained for each test.

Drawings and sketches showing the location of each strain gauge shall be prepared by the Contractor and submitted for approval as part of the test procedure. These drawings shall dimension the location of each gauge showing their distances from edges, connections, and bends. Their locations on the upper or lower, inner, or outer surface shall be noted on these drawings.

The strain gauges shall be bonded resistance (SR-4) type or other approved gauges suitable for the application. The gauges shall be calibrated in accordance with the manufacturer’s instructions for the material being measured. The gauges shall be compensated for temperature.

18.2.1.14.4 Deflection Gauges

Vertical deflection of the carbody shall be measured along both side sills at each load step during all tests. At least 11 gauges per side shall be used. Gauges shall be located at the end sills, at the bolsters, and at the midpoint between the bolsters. The remaining gauges shall be evenly spaced between the five (5) locations. Measurements shall be taken to the nearest 0.01 inch (0.25 mm), and the deflections shall be considered as the average of the readings recorded on both sides of the car.

To measure the longitudinal deflection of the car during compression testing, additional deflection gauges shall be applied at the end sill, near the ram, and at the opposite end sill near the reaction.
For the diagonal jacking test, an additional deflection gauge shall be applied at the jack which is lowered or raised to measure the vertical movement at that point.

During the vertical load test, the change in carbody width due to bending shall be measured and recorded at the belt rail in the center of the car. Two (2) additional deflection gauges shall be applied in one (1) of the side door openings closest to the center of the car to measure the change in the diagonal dimensions of the opening during the tests.

To measure the bending of the collision and corner posts during the post tests, deflection gauges shall be applied at a minimum of seven (7) locations on each post being tested: top, bottom, middle, load application point, between the load application point and the bottom, between the load application point and the center, and between the center and the top. These gauges shall be mounted to measure the deflection of the post in the direction of the applied force.

Deflection gauges shall be mounted on rigid stands separate from the carbody and its fixtures. The contact surface on the car shall have a smooth polished low friction surface plate mounted perpendicular to the axis of the deflection gauge. If during a test the deflection gauge moves off of this surface plate or contacts the test specimen or the fixtures, the test shall be terminated. The gauges shall be readjusted and the test repeated from the beginning.

Deflection gauges shall have electrical outputs compatible with the data logging apparatus used with the strain gauges. All deflections shall be recorded simultaneously with the strain gauge recordings.

In addition to the above electronic recordings, dial indicators (mechanical) of sufficient stroke shall be employed. Two (2) shall measure the vertical deflection at the center of both side sills during all tests. During the compression tests, dial indicators shall be employed to measure the longitudinal deflection at the end sill next to the ram and next to the reaction at the opposite end of the car. An indicator shall be located next to the lowering jack during the diagonal jacking test. A dial indicator shall be mounted at the center of the post during each post test. These dial indicators shall be read and manually recorded at each load step.

All deflection gauges shall have sufficient stroke capacity to measure the maximum deflection expected in the test without the need for resetting any gauge during a test.

18.2.1.14.5 Load Cells

In order to verify the accuracy of the applied loads and reactions, load cells shall be provided at the appropriate locations for each test. Each load cell shall be calibrated to 1.0 percent accuracy and certified within two (2) months before commencement of the tests over the full range of 1.5 times the maximum load to which the load cell will be subjected during these tests. The load cells shall have electrical outputs compatible with the data logging apparatus used with the strain gauges. All loads shall be recorded simultaneously with the strain gauge recordings.
Load cells shall be placed at the end of the ram and at the reaction point for the compression test. A load cell shall be placed at each secondary spring location for the vertical test and at each ram if the load is applied hydraulically. A load cell shall be placed at each jack location for the diagonal jacking test. A load cell shall be placed at the end of the ram for each post test. Load cell readings shall be taken and recorded at each step of the load application and removal process.

18.2.1.14.6 Vertical Load Test

a. Test Description

The carbody specimen supported on trucks or simulation thereof shall be subjected to a vertical load test. A test load equal to the static vertical operating load specified in TS 3.3 shall be applied to the specimen. The load shall be applied in four (4) approximately equal increments resulting in a total of five (5) vertical load increments. One (1) of these increments shall be equivalent to a ready to run carbody weight plus a passenger load of AW3. The test load may be applied by means of weights or jacks but shall be distributed in proportion to the distribution of weight in the finished car. The specimen shall be unloaded in the increments in which it was loaded. Strain gauge, deflection, and load cell readings shall be taken at each load increment.

b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Stresses are in accordance with the requirements of TS 3.3.

2) Vertical deflection readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at that point which represents the measured deflection for maximum vertical load.

3) Strain readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

4) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

5) Recorded residual vertical deflection between bolsters following removal of the maximum vertical test loading does not exceed 0.01 inch (0.25 mm).

6) Recorded residual car transverse width and/or opening diagonal dimensions following removal of the maximum vertical test load do not exceed 0.01 inch (0.25 mm).

7) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
8) Carbody deflection as measured during the vertical load tests under a load equal to the passenger load of AW3 is not more than the design camber in the side sill at any point between the carbody bolsters.

9) There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

10) The flatness and straightness of structural members meet the requirements of TS 3.2.

18.2.1.14.7 End Sill Compression Load Test

a. Test Description

A compression test load as defined in TS 3.3.2.1.1 shall be applied to the end sill assembly in the underframe of the test specimen by means of a ram. This load shall be applied horizontally at the horizontal centerline of the carbody.

During the compression test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded car. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of those producing the force. The force shall be measured at the ram and at the reaction at the opposite end of the car. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.

b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Stresses are in accordance with the requirements of TS 3.3.2.1.1.

2) The vertical deflection of each side of the test structure is within +/-10 percent of the value determined by the analysis.

3) The force measured at the reaction load cell is within 1.0 percent of the force applied at the ram.

4) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
5) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

6) There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

18.2.1.14.8 Compression Load Test at the Draft Stop

a. Test Description

A compression test load as defined in TS 3.3.2.1.2 (a test load of 800,000 lbs.) shall be applied to the rear draft stop in the draft gear housing. This load shall be applied at the car transverse centerline and vertically at centerline of the draft. No allowance shall be made for the camber of the carbody.

A fixture, which simulates the regular draft gear and carrier, shall be installed.

During the compression test, the carshell shall be supported on trucks or a simulation thereof to allow free longitudinal movement. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded car. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of those producing the force. The force shall be measured at the ram and at the reaction at the opposite end of the car. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. After each load increment is applied, the load shall be reduced to not more than two (2) percent of full load. Strain gauge, deflection, and load readings shall be taken at each load increment and at each relaxation of the load. The ram may be supported at the car end but shall remain free to rotate at its contact with the car end.

b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Stresses are in accordance with the requirements of TS 3.3.2.

2) The vertical deflection of each side of the test structure is within +/-10 percent of the value determined by the analysis.

3) The force measured at the reaction load cell is within 1.0 percent of the force applied at the ram.
4) Vertical deflection readings plotted against the load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

5) Strain readings plotted against the load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point, which represents the measured deflection, at maximum load.

6) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

7) Recorded residual vertical deflection between bolsters following removal of the maximum vertical test load does not exceed 0.01 inch (0.25 mm).

8) The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 inch (1.0 mm).

9) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

10) There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

11) The flatness and straightness of structural members meet the requirements of TS 3.2.

18.2.1.14.9 Diagonal Jacking Test

a. Test Description

The carshell shall be loaded to its AW0 weight with trucks or equivalent weight hanging from the body bolsters. The carshell shall be supported symmetrically at the jack pads at the four (4) corners of the car. One (1) of the jacks shall be lowered in five (5) equal increments until the load on the jack is ten (10) percent of its original load. All gauges shall be recorded at each increment of jack position. The procedure shall be reversed until the load on the jack is returned to its original level.

b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to the start of the test program as part of the stress analysis.
2) Strain readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.

3) Indicated residual strains at strain gauges following return to original level do not exceed the maximum error resulting from the accuracy of the instrumentation.

4) There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

5) The flatness and straightness of structural members do not exceed the requirements of TS 3.2.

18.2.1.14.10 Collision Post Elastic Test

a. Test Description

The ability of the carbody structure to resist the collision post longitudinal loads specified in TS 3.3 shall be tested. Loads shall be applied to both posts simultaneously.

During the collision post test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The post applied loads shall be reacted at the coupler. The carshell shall be loaded with sufficient dead weight to bring the total carbody weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The specimen shall be instrumented as required for the car and each collision post per TS 18.2.1.14.3, TS 18.2.1.14.4, and TS 18.2.1.14.5. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

A longitudinal test load as specified in TS 3.3.6.1 shall be applied to and centered on each collision post at an elevation 18 inches (457 mm) above the top of the underframe. This load shall be distributed over an area not to exceed the width of the collision post by six (6) inches (152 mm) in height.

The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning such as lead sheets shall be provided to assure uniform bearing and to prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. The load shall be reduced to not more than two (2) percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.
b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Deflection readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.

2) Strain readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

3) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

4) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

5) There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

18.2.1.14.11 Corner Post Longitudinal Load Test

a. Test Description

The ability of the carbody structure to resist the corner post longitudinal compressive loads specified in TS 3.3 shall be tested. Loads shall be applied to both posts simultaneously.

During the corner post longitudinal test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The post applied loads shall be reacted at the coupler. The carshell shall be loaded with sufficient dead weight to bring the total carbody weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The specimen shall be instrumented as required for the car and each corner post in TS 18.2.1.14.3, TS 18.2.1.14.4, and TS 18.2.1.14.5. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.
Longitudinal test loads shall be applied to and centered on the corner post at an elevation of 18 and 30 inches above the top of the underframe as specified in TS 3.3.6.1. The magnitudes of the loads shall be limited to values which approach the yield strength of the post as predicted by the approved FEA. These loads shall be distributed over an area not to exceed the width of the collision post and not to exceed six (6) inches in height.

The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning such as lead sheets shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car’s longitudinal centerline. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. The load shall be reduced to not more than two (2) percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.

b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Deflection readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

2) Strain readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

3) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

4) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

5) There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

18.2.14.12 Corner Post Transverse Load Test

a. Test Description

The ability of the carbody structure to resist the corner post transverse load specified in TS 3.3 shall be tested. Loads shall be applied to both posts simultaneously.
During the corner post test, the carshell shall be supported on trucks or simulations thereof. Transverse restraint if required shall be at the lateral stops between the carbody bolsters and truck frame. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The specimen shall be instrumented as required for the car and corner post in TS 18.2.1.14.3, TS 18.2.1.14.4, and TS 18.2.1.14.5. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

Longitudinal test loads as specified in TS 3.3 shall be applied to and centered on the corner post at an elevation of 18 inches (457 mm) above the top of the underframe. This load shall be distributed over an area not to exceed the width of the corner post and not to exceed six (6) inches (152 mm) in height.

The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning such as lead sheets shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally perpendicular to the car longitudinal centerline. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. The load shall be reduced to not more than two (2) percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move transversely with respect to the car end.

b. Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

1) Deflection readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

2) Strain readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

3) Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

4) Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
5) There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and SEPTA to determine if the failure is the result of weld quality or stress.

18.2.1.14.13 Collision Post Elastic-Plastic Test

a. Test Description

The ability of the connections between the collision posts and the carbody structure to withstand a longitudinal load equal to the ultimate load carrying capacity of the post as specified in TS 3.3.6.1 shall be tested.

The test specimen shall be a full scale structural model of the cab end of a car. The structural model shall include all structural elements required to support the collision posts including the end underframe and roof between the forward end of the end frame and the bolster. All connections shall be identical to those of production cars. The bolster end of the model shall be attached to a rigid fixture so that the stresses in the post and its supporting structure shall be the same as those in a car subjected to the same load.

The specimen shall be instrumented in the same manner in which it was instrumented in the collision post elastic test TS 18.2.1 except that instruments of greater capacity may be needed for this test. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the specimen to the carbody can be determined.

Longitudinal test loads shall be applied to and centered on the collision post at an elevation of 30 inches (457 mm) above the top of the underframe. This load shall be distributed over an area not to exceed the width of the post and not to exceed by six (6) inches (152 mm) in height.

The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning such as lead sheets shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The initial load shall be applied in increments of the same magnitude as those used during the collision post elastic load test, TS 18.2.1.14.10. The load shall be reduced to not more than two (2) percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load.

The strain gauge readings and deflections measured during this test shall be within 5.0 percent of the gauge readings for the same load and location measured during the collision post elastic test. If difference between the two (2) test results, the fixture and/or the model shall be corrected until agreement within 5.0 percent between the two (2) tests is obtained.
After agreement between the two (2) tests is demonstrated, the collision post shall continue to be loaded in stroke increments of 20 percent of the full depth of the collision post until the load carrying capacity of the collision post is obtained. At each 20 percent load increment, all load cell(s), strain gauges, and deflection gauges shall be recorded. The load need not be relaxed after each step.

The ultimate load carrying capacity of the post shall be defined as the condition where the post cannot support an increased load or the center of the post has deflected more than its full depth. This deflection shall be measured at the middle of the post from a string connected between the top and bottom of the post.

b. Test Criteria

The collision post shall be compliant with this Specification if all of the following conditions are met:

1) All strain gauges and deflection gauges have the same readings within +/-5 percent for the same loads at the same locations as the collision post elastic load test for 0 to 100 percent as tested in TS 18.1.14.10.

2) The connections between the collision post and all other structural members are not broken.

18.2.1.14.14 Structural Changes

Any structural changes or modifications performed during any test or during construction and assembly shall be subjected to the entire test series. All cars constructed prior to and subsequent to these tests shall incorporate the same structural changes or modifications. These tests and modifications shall be at the expense of the Contractor.

18.2.1.14.15 Test Report

In addition to the requirements of TS 3 as a minimum, the test report shall include:

a. A table of contents

b. All pages numbered including the appendices and data sheets

c. A narrative describing the performance of the test

d. Tables showing stresses and deflections that were 80 percent or more of the allowable

e. Description and explanation of any value that exceeded the test criteria

f. Appendices containing all data, i.e., output from each gauge for each load step. These data shall be clearly identified and include the date that they were recorded.
g. Record photographs mounted on pages the same size as the report pages

h. Digital video record of the tests

i. Side sill deflection curve for each load step

j. Stress (or strain) vs. load curves for the ten (10) locations of greatest tensile stress and the ten (10) locations of greatest compressive stress for each series

k. Tables comparing the stresses computed in the analyses with stresses computed from the strain gauge readings for each test. The tables shall be annotated to explain differences between the predicted and test values.

18.2.1.15 Microprocessor Control Unit Tests

One (1) of each type of microprocessor based control unit shall receive a functional test that simulates all normal and abnormal inputs and verifies all outputs. These tests units shall include, but not be limited to, the car control and the propulsion inverter control logic units. All microprocessor based control units shall receive a burn in test in accordance with TS 17.27.2 while cycling the temperature over the specified temperature range.

18.2.1.16 Packaged Components

Packaged components and assemblies that do not receive testing as parts of a system shall be tested at the point of manufacture as part of the quality assurance program. Test results shall be available for the Engineer’s inspection.

18.2.1.17 Equipment Noise and Vibration

The Contractor shall conduct a noise and vibration analysis of the car which shall include the predicted contribution of individual equipment and the effect of vibration dampening and sound deadening provided by the subassemblies. Equipment and subassembly noise and vibration tests shall be conducted prior to installation to demonstrate the accuracy of the Contractor's noise and vibration model. The subassemblies (i.e., roof, side, floor) shall be tested as defined in ASTM E90-85 for measurement of sound transmission losses.

Noise produced by the individual operation of all undercar and overhead ceiling mounted equipment and equipment mounted in lockers which normally operates (except equipment that only operates occasionally such as a circuit breaker or pneumatic venting device) shall not exceed eighty (80) dBA at 15 feet (4.6 m) from the center of the equipment while operating under normal conditions and loads. This equipment includes motors, generators, blowers, brakes, compressors, valves, and other noise generating components.

Equipment and subassemblies shall be tested in accordance with the requirements of IEC-61373 Railway Applications Rolling Stock Equipment Shock and Vibration Tests. The equipment and subassemblies when installed on the cars shall comply with the requirements of TS 2.3.
The Contractor shall perform noise and vibration tests on the completed car in accordance with the requirements of TS 2.3.

### 18.2.1.18 Communication System Tests

The complete communication system shall be tested on a one (1) time basis to demonstrate compliance with the requirements of TS 13 and TS 15 and all applicable IEEE, FCC, and AAR requirements. It is emphasized that the entire system shall be tested in a laboratory bench setting in which each and every device shall be connected and functional. It shall be possible to exercise, use, and visually confirm any and all devices including indicators, buttons, microphones, speakers, and switches of the communication system. All components shall be of the production configuration. Prior to the test, a complete test procedure shall be provided which shall include a concise step by step process of systematically verifying all requirements of the system.

### 18.2.1.19 Lighting Ballast Tests

Two (2) lighting ballasts of each type used in the car shall be tested to verify conformance to the specified requirements.

### 18.2.1.20 Door Panel

One (1) door panel of each type as described in TS 4.6 shall be tested to confirm compliance with the requirements of that section.

### 18.2.1.21 Seat Frame and Cushions

One (1) seat frame of each type, one (1) seat cushion of each type, one (1) seat back of each type, and one (1) seat set of upholstery shall be tested to confirm compliance with the requirements of TS 4.2.4, TS 17.10, and TS 17.11. This test result must be approved by the Engineer before additional seats can be ordered and assembled into the pilot cars for pre-delivery testing.

The cab seat shall be tested to demonstrate compliance with the static load tests, dynamic load tests, cushion durability tests, and life cycle tests as defined in APTA-PR-CS-S-011-99, Sections 6 and 9.

### 18.2.1.22 Truck Frame Weld Inspection

Critical welds shall be as identified by the truck manufacturer and approved by SEPTA and shall include as a minimum all assembly welds and welds or portions of welds which based on the results of the stress analysis and/or truck tests are expected to be critical in fatigue. Critical areas of castings shall be identified in a similar fashion.
Qualification shall require 100 percent radiographic inspection for all welds used for either construction or repair, and all critical areas of all castings in those areas where radiographic inspection is possible. If not possible, ultrasonic inspection methods shall be used. Radiographs shall be made in accordance with American Welding Society (AWS) D1.1. Inspection quality level shall be selected by the truck manufacturer consistent with the truck design but shall not be of lesser quality than that required by AWS D1.1. If the first truck fails the radiographic inspection then the second shall be inspected, and this process shall continue until a truck passes the inspection. Production variables for the succeeding trucks shall duplicate those for the truck that passes the radiographic inspection. Critical welds shall continue to be inspected by radiography on ten (10) percent of the trucks chosen at random. Critical areas of castings will be subject to radiographic inspection per TS 17.5. A means shall be provided by the truck manufacturer to positively identify the work of each welder.

All exposed welds and entire castings of any steel castings used for succeeding trucks shall be subjected to magnetic particle or dye penetrant inspection. Magnetic particle inspection shall be in accordance with ASTM E 709 or approved equal.

18.2.1.23 Destination Sign and Interior Message Display Testing

One (1) complete destination sign system shall be tested to demonstrate conformance to all Specification requirements including TS 5 and TS 13. This test shall organize all displays, signs, operating knobs, and equipment as designed for actual car installation. The test shall include trainline capability for software download and upload verification, diagnostics verification, and verification that all other car and trainline system tests are compatible with the destination sign system.

One (1) complete interior message display system shall be tested to demonstrate conformance to all Specification requirements. This test shall include the actual display of Engineer approved messages and demonstrate provisions for changing messages.

18.2.1.24 Jumper Testing

The intercar jumper cables shall be tested at the manufacturer’s facility to verify correct pin to pin continuity and to ensure that the wiring insulation requirements of TS 5.5 are met.

18.2.1.25 Monitoring and Diagnostic System

The complete monitoring and diagnostic system shall be tested to demonstrate compliance with the Specification prior to incorporation into the vehicles. The entire system shall be tested in a laboratory bench setting in which the operation of each vehicle subsystem shall be functional. All components and interfaces shall be of the production configuration. Prior to the test, a complete test procedure shall be provided which shall include details described in TS 18.1.3.
18.2.1.26 Cab Signal, ATC, and SEPTA PTC System

The Cab Signal, ATC, and SEPTA PTC equipment supplier shall conduct a test at their facility on a complete Cab Signal, ATC, and SEPTA PTC system to demonstrate compliance with the requirements of TS 14. These tests shall include complete functional tests while the equipment is subjected to the environmental and input variations specified. Equipment so tested shall conform to the manufacturing drawings. A cab signal EMI test to establish the immunity of the system to EMI shall be performed to demonstrate compliance with TS 2.6.3.

18.2.1.27 Composite Floor Panel Tests

The following tests shall be conducted on a representative composite flooring panel which shall be supported on beams that are equal to the longest distance between support spans found within the carbody floor structure. Production configuration leveling tape and fasteners shall be used to simulate the actual floor installation, but no rubber floor covering shall be applied. For all test conditions, there shall be no visible or audible indications of delamination of the panel skin from the core, no puncture or damage to fibers of the panel surfaces, no separation of any internal web from the top or bottom skin, and no degradation, cracking, or fracture of the foam core except where so identified. Test panels shall be sectioned to verify internal conditions.

18.2.1.27.1 Floor Deflection Test

The test panel shall successfully withstand a uniformly distributed load of 60 pounds/square foot. The maximum surface deflection under load shall be less than 1/250th of a 32 inch span. Permanent deformation of the top surface shall be less than 0.010 inch.

18.2.1.27.2 Indentation Resistance Test

The test panel shall successfully withstand a concentrated load of 300 pounds applied to a 0.375 inch diameter area having a 0.0625 inch radius on the bottom edge. Permanent deformation of the top surface shall be less than 0.010 inch.

18.2.1.27.3 Maximum Load Test

The test panel shall successfully withstand a distributed load of 200 pounds per square foot, covering an area approximately three (3) feet six (6) inches wide, applied so that the load is evenly distributed starting in the unsupported area adjacent to the panel’s end connection, then extending over a single supporting member and the next adjacent unsupported section of the panel. Permanent deformation of the top surface shall be less than 0.010 inch.

18.2.1.27.4 Rolling Load Test

The test panel shall successfully withstand the loading of a two (2) wheeled or four (4) wheeled cart with a load of 200 pounds per wheel which shall be rolled on the panels laterally, longitudinally, and in a circular path with a two (2) foot radius. The wheels shall be three (3) inches in diameter, one (1) inch wide with a 0.125 inch radius on each edge, and a Shore A80 durometer hardness. Permanent deformation of the top surface shall be less than 0.010 inch.
18.2.1.27.5 Small Object Impact Test

The test panel shall successfully withstand a 16 pound spherical weight 8.5 inches in diameter being dropped from a height of 60 inches. Two (2) drops shall be performed, the first in the midsection of the long span sample and the second in the midsection of the shorter span sample each 12 inches from the edge of the panel. For both tests, the permanent deformation of the top surface shall be less than 0.095 inch. While localized separation of internal webs from the top or bottom skins is allowable, this damage shall not exceed ten (10) inches in diameter and shall not propagate beyond the outermost adjacent web or parallel to the damaged webs when subjected to passenger loading. Localized fracture of the foam core shall be permitted.

18.2.1.27.6 Large Object Impact Test

The test panel shall successfully withstand a 150 pound weight having a three (3) inch by eight (8) inch contact area being dropped from a height of 12 inches. The contact area shall have a minimum hardness of Shore D70, a thickness of 0.25 inch, and shall be machined flat within 0.060 inch. Two (2) drops shall be performed, the first in the midsection of the long span sample and the second in the midsection of the shorter span sample each 12 inches from the edge of the panel. The long axis of the contact area shall be parallel with the support beams. For both tests, the permanent deformation of the top surface shall be less than 0.125 inch. While localized separation of internal webs from the top or bottom skins is allowable, this damage shall not exceed 18 inches in diameter and shall not propagate beyond the outermost adjacent web or parallel to the damaged webs when subjected to passenger loading. Localized fracture of the foam core shall be permitted.

18.2.1.27.7 Dynamic Load Life Cycle Test

The test panel shall successfully withstand 1,000,000 load and release cycles of a 200 pound weight having a three (3) inch by eight (8) inch contact area applied directly over the mid span six (6) inches from the edge. The contact area shall have a minimum hardness of Shore D70, a thickness of 0.25 inch, and shall be machined flat within 0.060 inch. Following the test, permanent deformation of the top surface shall be less than 0.010 inch. The panel shall have less than 0.188 inch deflection when a uniformly distributed load of 60 pounds per square foot is applied when the panel is supported on beams spaced 22 inches apart.

18.2.1.27.8 Insert Testing

The following insert tests shall be performed on a representative composite flooring panel sample consisting of the installation of two (2) 1/4 inch 20 UNC threaded inserts and two (2) 5/8 inch 11 UNC threaded inserts applied to the solid core resinous syntactic material:

a. Torque Test

Both 1/4 inch 20 UNC threaded inserts shall withstand a torque load of 75 lb.-in. and both 5/8 inch 11 UNC threaded inserts shall withstand a torque load of 100 lb.-ft. without rotation of the inserts or damage to the panel.
b. Tensile Test

Both 1/4 inch 20 UNC threaded inserts shall withstand a tensile load applied perpendicularly to the panel surface of not less than 250 pounds, and both 5/8 inch 11 UNC threaded inserts shall withstand a tensile load applied perpendicularly to the panel surface of not less than 500 pounds. No cracking or structural failure shall occur.

c. Shear Strength Test

Both 1/4 inch 20 threaded inserts shall withstand a shear load applied parallel to the panel surface of not less than 450 pounds. No cracking or structural failure shall occur.

18.2.1.28 Floor Covering Removal Testing

The following test shall be conducted on a representative composite flooring panel which shall have the approved rubber floor covering applied using the approved adhesive. During the installation process, all bubbles shall be rolled out and the exposed ends clamped to the panel to assure the highest bond possible. To verify the panel strength, after the adhesive has been totally cured, a tool shall be used to lift a corner edge and separate the floor covering from the panel surface for a minimum depth of three (3) inches for a distance of two (2) feet along both side edges of the panel. This test shall be repeated at an adjacent corner of the panel. In both cases, the top skin of the panel must not delaminate from the panel's edge when being rolled back from the edge in a "cold roll" fashion.

To verify the proposed rubber floor covering removal technique, the floor covering shall be removed at the opposite end of the test panel using the recommended technique. No delamination shall occur. Continue removing any remaining adhesive to simulate preparing the composite panel for new floor covering. No damage shall occur to the panel finish during the adhesive removal process.

18.2.1.29 Floor Panel Fire Resistance

A sample of materials representing structural flooring, floor panels, and floor covering along with a representative section of cab structure shall be tested to verify the ability to withstand the requirements of ASTM E119-07 when exposed for 15 minutes at up to 1400° F on the material underside. The Contractor shall provide the test procedure, test report, and a DVD with video of the actual testing.

18.2.1.30 Elastomer Tests

Test specimens shall be cut from the extruded material and at least one (1) tensile strength and elongation test and one (1) accelerated aging test shall be made on the material used for each car order. If the compound or cure or both are changed during the production of material for one (1) car order, at least one (1) test of each type shall be made for each different batch. When testing the six (6) inch by 0.5 inch ASTM dumbbell type test specimen (or smaller size if the size of the part necessitates) by the methods specified in ASTM Specifications D 318, D 318b, D 3188, D 3190, D 3192, and D 412 for neoprene door edges, the tensile strength shall not be less than 1,700 pounds/square inch and elongation shall not be less than 350 percent. The tensile strength of the neoprene shall not be reduced more than 25 percent when subjected to accelerated aging by the methods specified in ASTM Specification D 573.
18.2.1.31 Bridge Plate

Roll a 600 pound axle load with 32 inches between wheels across the bridge plate extended over a five (5) inch drop. Severe deflection shall not occur. No permanent deflection or damage to the assembly shall occur.

18.2.1.32 Relays and Contactors

Test data for one (1) type of each relay and contactor shall be provided by the manufacturer to verify compliance with the design requirements for that specific device and the Specification requirements defined in TS 17.29.2. Contactors shall be tested for proper functioning in orientations up to 30 degrees from the orientation in which they are mounted in the car in each of the three (3) possible rotations: pitch, yaw, and roll.

18.2.1.33 Electrical and Electronic Panels

One (1) type of each electric and electronic panel shall be tested by the manufacturer to verify compliance with the design requirements for that specific panel and the Specification requirements defined in TS 15.

18.2.1.34 Network Integration and Fault Tolerance Testing

The Contractor shall perform a complete network integration test of all train subsystems as required by TS 15.5.4.

18.2.2 Vehicle Level Qualification Testing

The following summary table is provided for convenience only and does not in any way alleviate the Contractor's responsibility to ensure that all tests required by this Specification are performed in accordance with the requirements listed herein:

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Vehicle Level Qualification Test Summary

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18.2.2.1 Clearance Tests

The Contractor shall perform complete dimensional and clearance measurements of the car and car mounted equipment on the pilot cars.

The pilot cars shall be measured by the Contractor for proper truck, coupler and cable, and hose clearance on the minimum radius horizontal and vertical curves, reverse curves, crossovers on minimum track centers, vehicle outline, and combination thereof as specified in TS 2.2.3. The trucks shall be measured for proper swing and for clearance from carbody and undercar components. All cables and hoses shall be measured for clearance, stretching, and chafing. These tests shall be performed at both AW0 and AW3 car weight. Tests shall also be carried out with one (1) AW3 weight car with deflated air springs and simulated minimum uncompensated wheel diameters coupled to another car at an AW0 weight with new wheels at simulated maximum upwards dynamic air spring extension. A test shall be made with air bags at one (1) end fully deflated and air bags at the other end of the car inflated to maximum pressure (each end to be tested at both full and deflated pressures).

Truck clearances, coupler/drawbar clearances, and operation shall be measured by moving a train of the consist listed in TS 18.2.3 over a curve and a crossover duplicating the most restricting track work and car condition specified in TS 2.2. These tests shall be repeated two (2) additional times on production cars selected at random by the Engineer. This test shall demonstrate that no interference occurs under all conditions.
The carbody clearances including trucks and couplers shall be measured by moving a train comprised of the pilot cars with temporary templates and cameras installed at all locations representing the worst case dynamic clearance envelope of the car over the entire right of way including yards and the North River Tunnels into Penn Station New York. The test cars shall be configured to simulate AW3 passenger loads. Template design, template locations, and test methodology shall be subject to approval by the Engineer.

18.2.2.2 Roll Angle and Stability Tests

In accordance with 49 CFR 213.329 (d) (1), the pilot cars at AW0 and AW3 weight shall be placed on a superelevation of three (3) inches, six (6) inches, and seven (7) inches and measured to determine compliance with the clearance requirements of TS 2.2 despite carbody roll and lateral shifting of the body. Additionally in accordance with 49 CFR 213.329 (d)(2) when tested at seven (7) inches, no wheel may unload to less than 60 percent of its static value on perfectly level track, and the angle measured about the roll axis between the floor of the vehicle and the horizontal does not exceed 8.6 degrees. To comply with 49 CFR 213.329(e)(1), the center of gravity above top of rail for each car type will be determined and reported.

To verify the car stability provided by the truck design, the first pilot car of each type with simulated crushload shall be run up on a rail or blocking on one (1) side to simulate seven (7) inches of superelevation. Lateral displacement and roll angle of the carbody shall be measured. In the event that the degree of motion restriction required is not attained as indicated by the test, the truck design shall be altered and the car retested.

18.2.2.3 Fresh Air Duct Tests

All car fresh air intake ducts with blowers connected and operating at maximum speed shall be tested once on one (1) pilot car to determine the effectiveness of the water excluding features. This shall be done by simulating heavy rain at car speeds of 100 miles/hour, by operating through a simulated car washer, and by operating through a simulated snowstorm as a test of snow plugging resistance.

18.2.2.4 Trainline and Intercar Tests

The pilot cars shall be tested using suitable apparatus to demonstrate that all trainline functions including HEP trainlines perform satisfactorily under the control of the multi-level cab car and under control of the new electric locomotive. All cab and interface functions shall be tested. This test shall be performed at the Contractor's facility prior to delivery. Any modifications required as a result of these tests shall be incorporated into all cars.

One (1) car of each type shall be tested with another car of each type furnished under this Contract to demonstrate that all trainline functions perform satisfactorily from control cabs of each car when cars are coupled together. These tests shall include dynamic as well as static tests.

These tests shall be performed at the Contractor's facility prior to delivery of the first car except for those trainline tests requiring the use of non-multi-level equipment which shall be performed on SEPTA property. The Contractor shall demonstrate consistent and acceptable method of interoperability with the following vehicles from other contracts:
a. One (1) multi-level trailer car with five (5) existing Bombardier coaches, one (1) cab car and AEM-7 locomotive

b. One (1) multi-level cab car with six (6) existing Bombardier trailers and AEM-7 locomotive

c. One (1) multi-level trailer car with five (5) existing Bombardier coach cars, cab car and SEPTA’s High speed electric locomotive

d. One (1) multi-level cab car with one (1) multi-level trailer car and five (5) Bombardier coach cars and SEPTA’s high speed electric locomotive

e. One (1) multi-level cab car with six (6) existing Bombardier coach cars and ALP-44 locomotive

f. Other consists as required to demonstrate compliance

Any modifications required as a result of these tests shall be incorporated into all cars prior to delivery.

These trainline tests shall include all signals that may be transmitted to and from the cab car, the locomotive, the car level processing unit, the cab message display, and all data loggers. This shall include all normal and abnormal conditions such as faults which may be simulated as approved by the Engineer. Proper cab message display, storage (including data loggers), and transmission (including radio) of data shall be demonstrated.

### 18.2.2.5 Door Operation Tests

Before delivery, all of the passenger doors and controls of one (1) of the pilot cars shall be operated for 25,000 continuous trouble free cycles each. All doors on one (1) side of the car shall operate at high station platform mode, and all doors on the other side of the car shall operate at low station platform mode. After 12,500 continuous trouble free cycles each, each doorway will be reconfigured to the other station platform height configuration for the remainder of the test. Monitoring apparatus shall verify the true fully open and fully closed and locked position of each door leaf during the test. No adjustments or maintenance shall be allowed during the test. Any door or door control failure occurring prior to completion of the test shall nullify the test, and the test will be resumed at the beginning for all car doors.

### 18.2.2.6 Climate Room – Air Conditioning Tests

#### 18.2.2.6.1 Purpose

The purpose of the air conditioning climate room test is to demonstrate that the performance of the ventilating and air conditioning system of a completely assembled car is in compliance with all of the Specification requirements. The climate room test car shall not be removed from the climate room chamber until all tests and results are approved by the Engineer. The climate room test car shall be the fully assembled and completed pilot cab car.
18.2.2.6.2 Facilities

The tests described in the following Sections and in TS 18.2.2.7 shall be conducted in an approved climate room in North America capable of heating and cooling to maintain specific ambient temperatures between -10° F and 125° F and relative humidity levels between 25 percent and 90 percent.

The temperature in the climate room shall not vary by more than five (5)° F from two (2) feet above top of rail to two (2) feet above the car roof and from end to end of the car.

If the car is equipped with a rooftop package HVAC unit, care shall be taken to assure that the localized heat rejection from the condenser section and the condenser cooling airflow does not unduly influence the test results. In no case shall the distance from the highest point of the car to the ceiling of the climate room be less than the minimum clearance existing on any SEPTA line.

Engineer approved equipment shall be provided inside the car to simulate the latent and sensible heat loads required by the Specification. Fans may be used to circulate air within the climate room to maintain uniform conditions.

The climate room shall be equipped to supply sufficient wayside electrical power at the nominal car voltage defined in TS 2.2. All vehicle equipment shall be powered from the carborne power conditioning and distribution equipment.

18.2.2.6.3 Recording and Instrumentation

a. Instrument Calibration

All test data shall be recorded by a computer based data acquisition system with sufficient input channels to record the required data. Multiplexing of data shall not be allowed. If multiple recorders are necessary to obtain the required number of channels, they shall be time synchronized. The data sampling rate shall be adjustable with the minimum time being not more than one (1) sample per second. Each sample shall be time and date-stamped. Real time display of test data and trending shall be possible. Real time calculation and display of information such as the average of several channels, difference between selected channels, or minimum and maximum of a group shall be possible. All real time display data and recorded data shall be in engineering units and if possible selectable between I-P and SI units. Recorded data shall be capable of export to normally available spreadsheet programs such as MS Excel.

The data acquisition system shall be capable of recording both analog data streams and digital (on/off) events. It is preferred that digital events be recorded on an interrupt basis.

For temperature measurements, the range shall be adequate as required by the environmental conditions listed in the Specification. Temperature measurements shall be at a resolution of 0.1° F and with the total accuracy (including thermocouples, thermocouple wires, signal processing, and conversion) not to exceed 1.0° F.

The climate room shall be equipped with the following instrumentation:
1) Thermocouples (temperature sensors) with 0.5° F accuracy. Thermocouples shall be in accordance with ASHRAE Standard 41.1

2) Psychrometers in accordance with ASHRAE Standard 41.6

3) Ammeter

4) Recording ammeters

5) Voltmeter

6) Recording voltmeters

7) Manometers

8) Thermometers

9) Hand held hygrometer

10) Flow hood as manufactured by Shortridge Instruments, Inc., or approved equal

11) Vane anemometer with the ability to calculate and display average velocity recorded over a selected period of time

12) Electronic manometer

13) Refrigerant cylinder

14) Refrigerant recovery unit

15) Refrigerant scale

Additional instruments shall be provided to perform specific tests as described herein. All instruments shall demonstrate satisfactory compliance with approved calibration standards and the requirements of this Specification. All instruments and measurements shall meet the requirements of the latest edition of the ASHRAE Standards 41.1 and 41.6.

b. Test Data

Equipment shall be available for acquiring the following data as necessary for the individual tests:

1) Names and affiliations of observers

2) Dates and times

3) Barometric pressure in inches of Hg
4) Nameplate data of all test equipment

5) Instrumentation calibration records

6) Input power to all equipment

7) Applied voltage

8) Frequency, Hz

9) Fan speeds, RPM

10) Ambient air dry-bulb temperature, °F

11) Ambient air wet bulb temperature, °F

12) Dry bulb temperature of conditioned air leaving car ceiling diffusers, °F

13) Wet bulb temperature of conditioned air leaving car ceiling diffusers, °F

14) Car interior temperatures, °F, in locations approved by the Engineer in cab, upper, lower, and intermediate areas

15) Each evaporator fan motor winding temperature, °F

16) Each condenser fan motor winding temperature, °F

17) Each compressor motor parameters

18) Each condenser fan motor operation

19) Each evaporator blower motor operation

20) Each liquid line solenoid valve operation

21) Each modulation solenoid valve operation

22) Overhead heat operation

23) Floor heat operation

24) Each high pressure limit switch operation

25) Each compressor crankcase heater operation

26) Time delay relay operation

27) Overload relay operation
28) Line and control voltage and current demand of all equipment

Additional data shall be recorded for certain other tests as described herein. All instruments and transducers used for the climate room tests shall have been calibrated within one (1) year of the test or as otherwise required by the Specification. Calibration certificates for all the instruments and transducers shall be available for inspection by the Engineer on the day prior to the commencement of the test. Copies of these certificates shall be included in the test reports.

18.2.2.6.4 Air Balance Test

a. Purpose

The purpose of the air balance test is to demonstrate conformance with interior ventilation, air flow, and pressurization requirements.

b. System Conditions

This test shall be performed with only the evaporator blowers operating at an ambient temperature of approximately 70° F.

c. Miscellaneous Parameters

During the air balance test, the Contractor shall measure and record the following:

1) Line voltage

2) Blower motor voltage (at each blower motor)

3) Blower motor current (at each blower motor)

4) Passenger compartment temperature (an average of not less than 18 locations approved by the Engineer throughout the length and width of the car at the cab, upper, lower, and intermediate areas)

d. Air Volumes

Air volumes shall be measured using the following steps modified as necessary for the car subject to approval by the Engineer:

1) Select hood size appropriate to the duct openings to be monitored

2) Assemble the hood with a flow meter

To provide a leak free seal, additional ducting or adapters may be required between the flow hood and the carbody grilles and/or louvers depending on their configuration.
1) Measure fresh air volume:
   a) Set the flow hood with adaptor (if required) on the outside of the car’s fresh air intake (a pitot or anemometer traverse shall be used if the unit configuration does not allow a suitable adapter for the flow hood to be constructed). Select appropriate scale for the flow hood meter.
   b) Measure fresh air volume using flow hood meter using backpressure correction
   c) Repeat the above steps for each fresh air intake grille. Calculate total fresh air supply by adding measurements obtained from each intake grille.

2) Measure conditioned airflow into the car interior at the diffusers:
   a) Attach the flow hood to a section of one (1) of the diffusers. Make certain that seal is tight. Select appropriate scale for the flow hood meter.
   b) Measure airflow
   c) Repeat the above steps to cover the entire area and length of all diffusers throughout the car. Calculate total diffuser airflow by adding each measurement obtained from the total area and length of diffusers. Total conditioned airflow shall comply with the requirements of TS 8.1.

3) Measure recirculated air volume:
   a) Place the flow hood (with appropriate adaptor if required) under the recirculated air grille. Select appropriate range for the flow hood meter.
   b) Measure and record recirculated air volume using back pressure correction
   c) Repeat the above steps for each recirculated air grille. Calculate total recirculated air volume by adding measurements obtained from all recirculated air grilles.

e. Car Pressurization

A car pressurization test shall be performed to measure the difference in pressure between the inside of the car with all doors closed and the ambient pressure outside of the car. Measurement shall be taken with a differential manometer using the following procedure:

1) Connect the “high” side port of the manometer to the car interior and the “low” side port to the exterior

2) Read the differential pressure. Interior pressure shall meet the requirements of TS 8.1.

f. Diffuser Discharge Velocity
Diffuser discharge velocity (TS 8.7) shall be measured to verify conformance with the applicable Specification requirements. Measurements shall be made using the following procedure:

1) Establish a grid using strings at the specified distance below the diffusers. Each grid square shall be no more than eight (8) inches per side.

2) Measure and record the velocity at the center of each grid square using a four (4) inch diameter vane anemometer. Velocity at any point must not exceed the Specification allowed maximum.

3) Auxiliary diffusers shall be measured with the same instrumentation with measurement points appropriate to the configuration.

g. Refrigerant Charge Determination/Verification

1) Purpose

The purpose of this test is to determine or verify the proper quantity of refrigerant required by the air conditioning system (unitized or split) to satisfy the design requirement under all applicable conditions.

This test shall be a verification of the HVAC unit refrigerant charge determined by the HVAC supplier at the unit qualification testing. During the car climate room test, the correct charge shall be verified by comparing system pressures, subcooling and superheat at operating conditions identical to those of the unit qualification test.

2) Procedure

The HVAC systems shall be leak tested, evacuated, and charged at the manufacturer’s factory per a procedure approved by the Engineer.

All refrigeration system work shall be performed according to the EPA (or other governmental agency) rules currently in effect. The refrigerant charge shall be determined by the following:

a) Establish interior and ambient conditions identical to those used for the unit cooling capacity qualification test TS 18.2.1.8.

b) Observe the refrigerant level in the unit in accordance with the manufacturer’s specifications; add or remove refrigerant as necessary.

c) Operate the system for one (1) hour at stabilized conditions as described above in TS 18.2.1.8.

d) Record the following data at two (2) minute intervals:

   (1) Ambient climate room temperature
(2) Car interior temperatures at locations approved by the Engineer

(3) Internal sensible and latent load applied

(4) Suction and discharge pressures

(5) Compressor motor voltage, current, and RPM

(6) Condenser motor voltage, current, and RPM

(7) Refrigerant level

(8) Compressor oil level

(9) Degrees of superheat of vapor at evaporator outlet

(10) Degrees of subcooling of liquid at condenser or subcooler outlet.

If the refrigerant level is incorrect, adjust the amount of refrigerant in the unit and repeat the test. Record the correct total refrigerant weight for the unit.

h. Scan Test

1) Purpose

The purpose of this test is to demonstrate that the HVAC control performs in accordance with the specified sequence and parameters. The data acquisition system shall record data parameters for the following system elements:

   a) Each compressor motor
   b) Each condenser motor
   c) Each evaporator blower motor
   d) Each liquid line solenoid valve
   e) Each modulation solenoid valve
   f) Overhead heat
   g) Each compressor crankcase heater
   h) Time
   i) Climate room ambient temperature and humidity
j) Each return air temperature in car (independent from the HVAC unit’s return air sensors)

k) HVAC unit return air sensor readings

l) Average interior temperature and humidity for upper, lower, and intermediate areas.

2) Procedure

The sequence of the scan test shall be arranged to ensure that all control points for rising and falling temperatures are included and tested. The test sequence shall be such that all temperatures which affect system control are tested individually. Results of the test shall conform to the temperature requirements of TS 8.1. The scan test shall be satisfactorily completed before proceeding to further climate room testing.

In the event of any control failure, appropriate adjustments shall be made and the entire scan test shall be repeated until all system controls perform in accordance with the specified requirements.

i. Vehicle Heat Transfer (UA)

1) Purpose

The purpose of this test is to demonstrate that the overall carbody heat transmission does not exceed the specified limits.

2) Test Conditions

The following conditions shall be maintained during this test:

a) Floor heat Operable
b) Ventilation blowers Inoperable
c) Overhead heat Inoperable
d) Cab heat Inoperable
e) Lights Inoperable
f) All auxiliary equipment Inoperable
g) Doors (side and end) Closed
h) Fresh air intakes Sealed

3) Procedure

The heat transfer test shall be performed in accordance with the following steps:

a) The fresh air intakes shall be sealed to eliminate the “chimney” effect. Door seals shall be maintained in their normal closed condition.
b) Lower the climate room ambient temperature to zero (0)° F DB and maintain this temperature throughout the test.

c) Turn ON the floor heat. Allow the car interior temperature to stabilize.

d) Record the interior temperature throughout the car at locations approved by the Engineer and the ambient temperature throughout the climate room at locations approved by the Engineer at three (3) minute intervals for a period of one (1) hour (producing 20 sets of data).

e) Calculate the average car interior and climate room ambient temperatures for each of the 20 sets of data.

f) At the conclusion of the test, calculate the average car interior and climate room ambient temperatures for the entire test period.

g) Calculate the "UA" value using the following formula:

\[
UA = \frac{3.413 \times W}{(T_2 - T_1)}
\]

Units = Btu/(hour EF)

where

W = total heat applied to the car in watts
T2 = average car interior temperature
T1 = average climate room ambient temperature

The heat transfer test shall be satisfactorily completed before proceeding to further testing in the climate room.

In the event the heat transfer test failed, appropriate changes to the carbody insulation system shall be made, the test shall be repeated, and this process shall continue until the referenced Specification requirements are met.

j. Cooling Equipment

1) Purpose

The purpose of this test is to demonstrate the performance of the air conditioning system in cooling the car and maintaining the specified car interior temperatures at various designated ambient conditions.

2) Instrumentation

In addition to the instrumentation requirements of this Section, the instrumentation described in TS 18.2.2.6.3 shall also be provided for all cooling equipment testing.
The event recorder shall be used to record the same parameters recorded for the scan test described in TS 18.2.2.6.4.h.

The temperature recorder shall be used to record temperatures in predetermined locations throughout the car and the climate room as proposed by the Contractor and approved by the Engineer. A minimum of 50 thermocouples (channels) shall be located in the car (including the cab) and a minimum of five (5) thermocouples (channels) in the climate room.

The voltage recorder shall record all voltages applied to the car.

The electric current recorder shall be used to record the current drawn by the following equipment:

   a) Each compressor motor
   b) Each condenser fan motor
   c) Each evaporator blower motor
   d) Each overhead heater

3) Pull Down

The objective of this test is to determine the temperature pull down time after the air conditioning system is energized and to measure cycling periods and air temperature stratification after stabilization. The pull down test shall be performed in accordance with the following:

   a) Prior to this test, the car shall be "soaked" in the climate room for at least six (6) hours at 100° F DB with the car doors and windows closed with the maximum solar load applied. Climate room conditions shall be maintained constant during the entire test.

   b) After completing the "soak" period, all electrical circuits including car lights shall be energized, and the air conditioning system shall be turned ON with all car doors and windows closed. Fresh air intakes shall be open.

   Record the time required for the system to reduce the interior air temperature to the Specification required value.

   c) Determine the time required to stabilize the car interior temperature. The car interior temperature shall be considered stabilized when the average interior temperature swing is less than 3° F in any five (5) minute period. All temperature and pressure measurements shall be taken at one (1) minute intervals.

   d) After initial temperature stabilization is attained, the test operation shall be continued for 30 minutes with temperatures and pressures recorded at one (1) minute intervals in order to evaluate temperature variations as the controls and equipment cycle.
4) Steady State Operation at Design Conditions

The pull down test shall have been satisfactorily completed prior to this test. The steady state operation test shall be performed in accordance with the following steps:

a) The following conditions shall be established and maintained during the steady state operation test:

   (1) Simulated load of passengers per TS 8.1
   (2) Simulated solar load per TS 8.1
   (3) All lights and electrical components ON
   (4) Fresh air inlets open
   (5) Climate room ambient temperature maintained at 95° F DB, 78° F WB

b) Energize the air conditioning system and operate until stabilized. Stabilization shall be considered the condition at which the average interior temperature changes no more than 2° F during three (3) consecutive recordings at five (5) minute intervals.

c) After stabilization is attained, all temperatures and pressures shall be recorded at one (1) minute intervals for a period of 30 minutes. The interior conditions of TS 8.1 shall be met.

5) Door Cycling Test – Cooling

The purpose of this test is to verify that the system capacity is sufficient to recover from temperature variations caused by door openings at station stops within the specified time.

With the same conditions as the steady state operation test, cycle the doors on one (1) side of the car as defined in below:

a) The average car temperature (within the intermediate, lower, or upper areas evaluated individually) shall recover within 2° F of the required interior car conditions within two (2) minutes maximum following a 30 second door opening. It shall be demonstrated that this requirement can be met during one (1) hour of continuous door cycling of 30 seconds open and 2.5 minutes closed at design conditions in both air conditioning and heating modes at the climate room test conditions specified in this Section.

Temperature measurements shall be sampled at a rate approved by the Engineer and shall in no case be at such a rate that allows “aliasing” of data. The doors on the opposite side of the car shall remain closed during the test.

6) Condensate Carry Over
The objective of this test is to demonstrate that no water (condensate) is carried from the evaporator into the supply air discharge plenum. The condensate carry over test shall be performed in accordance with the following steps:

a) Operate the air conditioning system continuously for a period of four (4) hours with the climate room ambient air temperature $80^\circ \text{F DB}/75^\circ \text{F WB}$.

b) Interior loads shall be adjusted during the test to maintain system operation in cooling mode. The system shall not enter ventilation mode during the test period. Any adjustments to internal loads must hold the interior sensible heat ratio constant at the design value.

c) At the end of the test, all heater coils, evaporator blower compartments (in draw through units), supply air discharge plenums, air ducts, and diffusers shall be examined for the presence of condensed water.

d) The test shall be considered successful if during the test no condensed water drops, runs, or is blown from any evaporator unit casing and/or its drain pan and is carried in the air stream to any heater coil, evaporator blower, supply air discharge plenum, air duct, or diffuser. All overhead heater elements shall remain dry.

7) Maximum Operating Conditions

The objective of this test is to demonstrate the air conditioning system operation at the maximum specified interior and exterior load conditions. The steady state operation test shall have been satisfactorily completed prior to this test. The following conditions shall be maintained for the duration of the test:

a) Climate room ambient temperature $125^\circ \text{F DB}, 84^\circ \text{F WB}$
b) Simulated passenger load as defined in TS 8.1
c) Solar load as defined in TS 8.1
d) All lights turned ON
e) Fresh air intakes OPEN

The maximum operating conditions test shall be performed in accordance with the following steps:

a) Operate the system continuously for a period of one (1) hour. During the entire test, the system shall not shut down due to high pressure, circuit breaker trip, compressor motor overload, or failure of any device. There are no capacity requirements to be met.
b) After one (1) hour of operation, the power input to the system shall be removed for two (2) seconds and then reapplied. The system shall recover from the power interruption and restart. After restart, the system shall function properly with all components free from malfunction. The removal of power simulates a power gap or phase break. The exact method of power removal and duration may be modified as agreed to and approved by the Engineer.

8) High Ambient Temperature Operation

The objective of this test is to demonstrate the air conditioning system operation and control function at extremely high ambient temperature conditions. The high ambient test shall be performed in accordance with the following steps:

a) All load requirements described for the maximum operating conditions test shall apply for this test except that the climate room ambient temperature shall be between 105° F DB to 110° F DB; the exact temperature to be approved by the Engineer. A temperature of 115° F DB shall be present at the condenser.

b) Operate the system continuously for a period of one (1) hour. As the condenser pressure changes, the proper operation of the modulation switch and compressor unloader (or other capacity reduction method as approved by the Engineer) shall be demonstrated. The system shall not shut down due to high pressure, circuit breaker trip, compressor motor overload, or failure of any device. There are no capacity requirements to be met.

The event recorder shall be used to monitor the modulation solenoid valve operation.

9) High Pressure Switch Test

After successful completion of the high ambient test, increase the climate room temperature until the high pressure switch is actuated. After actuation, the system must restart as dictated by the control system.

10) Low Ambient Temperature Operation

The objective of this test is to demonstrate the successful air conditioning system operation and control function at low ambient temperatures with minimum passenger load, with adequate oil return to the compressor, and without the freezing of the evaporator coils. The following conditions shall be maintained for the duration of the test:

a) Climate room ambient temperature 50° F DB, 40° F WB
b) All lights ON
c) Fresh air intakes OPEN
The low ambient test shall be performed by operating the system continuously for a period of four (4) hours. Internal loads shall be adjusted such that the system operates at its minimum cooling capacity for the entire four (4) hour period. Latent loads shall be sufficient to ensure that condensation forms on the cooling coil. During the entire test, the system shall operate without damage to the equipment, and the evaporator airflow shall not drop more than 15 percent from the manufacturer's design point. The interior car temperature shall not fall below 65° F.

18.2.2.7 Climate Room – Heating Tests

18.2.2.7.1 Purpose

The purpose of the climate room heating test is to demonstrate the heating system's ability to heat the cab and car interior and maintain specified interior car temperatures at various designated ambient conditions. The climate room facility shall comply with the requirements defined in TS 18.2.2.6.2. The climate room test car shall be the same car as used for the tests required in TS 18.2.2.6. The climate room test car shall not be removed from the climate room chamber until all tests and results are approved by the Engineer.

18.2.2.7.2 Instrumentation

Instrumentation shall be in accordance with the requirements of TS 18.2.2.6.3. The temperature recorder shall be used for the same purposes and in the same manner as in the cooling tests defined in TS 18.2.2.6. A minimum of 50 thermocouples (channels) shall be located in the car (including the cab) and a minimum of five (5) thermocouples (channels) in the climate room. The event recorder shall be used to record the same parameters recorded for the scan test (TS 18.2.2.6.4.h). The voltage recorder shall record all voltages applied to the car. The current recorder shall be used to record the current drawn by the following equipment:

- Each compressor motor
- Each evaporator blower motor
- Each overhead heater
- Each floor heat heater
- Each cab heater
- Each cab windshield defroster/demister

18.2.2.7.3 Layover

The purpose of this test is to demonstrate that the temperature control system can maintain the interior and cab temperature within the specified layover temperature range during changing ambient conditions and at the minimum ambient temperature. The summary of the test conditions is:

- Climate room temperature: 10° F DB with 50 percent humidity
- Car voltage supply: Nominal
- Internal loads: None
The layover test shall be performed in accordance with the following steps:

a. Begin the test after the car has reached a stabilized automatic heating condition and an ambient temperature of 60° F.

b. Place the car in its layover state.

c. Reduce the ambient temperature to the specified minimum temperature at a rate of change not to exceed 20° F/hour.

d. Maintain the ambient at the specified minimum for eight (8) hours. The average interior temperature must remain within the allowed layover temperature range for the entire eight (8) hour period.

18.2.2.7.4 Pull Up from Stable Layover Condition

The purpose of this test is to demonstrate that the heating system can raise the interior temperature of the car and cab from a stabilized layover condition to the specified design interior temperature within the specified time. During this test, the surface temperatures of the heater guards shall be verified and must not exceed the specified maximum. The summary of the test conditions is:

- Climate room temperature: 10° F DB with 50 percent humidity
- Car voltage supply: Nominal
- Internal loads: None

The pull up layover test shall be performed in accordance with the following steps:

a. At the conclusion of the eight (8) hour layover test defined in TS 18.2.2.7.3, energize the car and turn on the lights and all auxiliary circuits.

b. Record the time required to raise the average interior temperature to the specified level without the benefit of solar or passenger loads.

c. Record the time required to reach a stable interior temperature within the specified range of 67° F DB and 70° F DB. This time shall not exceed 30 minutes.

d. Record the temperature of the heater guards in the passenger area and in the cab. The surface temperature must not exceed 125° F at any time during the test.

18.2.2.7.5 Pull Up from Dead Cold Condition

The purpose of this test is to demonstrate that the heating system can raise the interior temperature of the car and cab from a cold soaked condition to the design interior temperature within the specified time. The summary of the test conditions is:

- Climate room temperature: 10° F DB with 50 percent humidity
- Car voltage supply: Nominal
c. Internal loads: None

The pull up layover test shall be performed in accordance with the following steps:

a. Prior to this test, the car shall be "soaked" in the climate room for at least eight (8) hours at the specified minimum dry and wet bulb temperature with all doors open, lights and electrical circuits OFF, and with no passenger or solar load.

b. Climate room conditions shall be maintained constant at the minimum specified dry and wet bulb temperature during the entire test.

c. After the complete "soak" period, the heating system shall be turned ON. All other electrical circuits including car lights shall be deenergized. All car doors and windows shall be closed and fresh air intakes shall be open.

d. Determine the time required for the average interior temperature to reach the minimum specified design dry bulb temperature.

e. Determine the time required to stabilize the car’s interior temperature. The car’s interior temperature shall be considered to be stabilized when the average interior temperature swing is less than 2° F over any five (5) minute period.

f. During the entire pull up period, monitor the surface temperature of the heater guards. The heater guard surface temperature must not exceed the specified maximum.

g. At the conclusion of this test, transition directly into the steady state at design conditions test described in TS 18.2.2.7.6.

18.2.2.7.6 Steady State at Design Conditions (Minimum Ambient, No Passengers)

The purpose of this test is to demonstrate that the heating system capacity is sufficient to maintain the car and cab interior conditions at the specified design temperature with the ambient temperature at the specified minimum. The test also shall demonstrate the ability of the temperature control system to maintain interior temperature control within the specified limits and that the required interior temperature uniformity can be met. Heater guard temperatures shall also be monitored. The summary of the test conditions is:

a. Climate room temperature: 10° F DB with 50 percent humidity
b. Car voltage supply: Nominal
c. Internal loads: None
After the average interior temperature has stabilized following the pull up test defined in TS 18.2.2.7.5, continue to record all data at one (1) minute intervals for a minimum of 30 minutes. The average interior temperature shall remain within the specified design conditions. The specified temperature uniformity conditions shall be established. The system’s return air sensors shall not exhibit undue influence from the incoming fresh air. Heater guard temperatures shall not exceed the specified maximum.

18.2.2.7.7 Door Cycling – Heating

The purpose of this test is to demonstrate that the heating system has sufficient capacity to restore the average interior temperature to the specified design conditions within the specified time with periodic door operation simulating station stops. The summary of the test conditions is:

a. Climate room temperature: 10° F DB with 50 percent humidity
b. Car voltage supply: Nominal
c. Internal loads: None

After successful completion of the steady state test defined in TS 18.2.2.7.7, reduce the voltage supplied to the car to the specified minimum. Open the doors and allow the interior temperature to drop to at least 10° F below the required interior temperature then close the doors. Allow the interior temperature to stabilize. After stabilization has been reached, record all data at one (1) minute intervals for a minimum of 30 minutes. It shall not be necessary for the average interior temperature to meet the specified conditions; however, the interior temperature uniformity requirements of TS 8.1 shall be met.

18.2.2.7.8 Steady State (Minimum Ambient, No Passengers, and Minimum Voltage)

The purpose of this test is to document the stabilized interior temperature that the system can maintain at the specified minimum car supply voltage. Control stability and temperature uniformity must also be demonstrated. The summary of the test conditions is:

a. Climate room temperature: 10° F DB with 50 percent humidity
b. Car voltage supply: Specified minimum
c. Internal loads: None

After successful completion of the steady state test defined in TS 18.2.2.7.8, begin operating the doors on only one (1) side of the car at the open closed cycle defined in TS 18.2.2.6.4.j.22) for a period of one (1) hour. Temperature measurements shall be sampled at a rate approved by the Engineer and shall in no case be at such a rate that allows “aliasing” of data. The doors on the opposite side of the car shall remain closed during the test. The average interior temperature shall recover as defined in TS 18.2.6.4.j.

18.2.2.7.9 Steady State (Design Passenger Load and Minimum Ambient)

The purpose of this test is to demonstrate control stability and temperature uniformity at the given test conditions. The summary of the test conditions is:
18.2.2.7.10 Steady State (Design Passenger Load, Minimum Ambient, and High Voltage)

The purpose of this test is to demonstrate that the average interior temperature is maintained within the specified limits, temperature control is maintained without excessive cycling of the system components, and temperature uniformity is maintained within the specified limits. The summary of the test conditions is:

- a. Climate room temperature: 10° F DB with 50 percent humidity
- b. Car voltage supply: Specified high limit
- c. Internal loads: Design passenger load, no solar load

After successful completion of the steady state test defined in TS 18.2.2.7.9, increase the supply voltage to the car to the specified maximum value and allow the car’s interior conditions to stabilize. After stabilization, record all data at one (1) minute intervals for a minimum of 30 minutes.

The average interior temperature shall remain within the specified limits. The interior temperature uniformity requirements of TS 8.1 shall be met.

18.2.2.7.11 Steady State (Design Passenger Load with Solar Load and Ambient Temperature Just Below Cooling Lock Out Point)

The purpose of this test is to demonstrate that average interior temperature is maintained within the specified limits, temperature control is maintained without the excessive cycling of the system components, and temperature uniformity is maintained within the specified limits. The summary of the test conditions is:

- a. Climate room temperature: Dry bulb temperature not more than 5° F lower than the cooling lock out temperature. Wet bulb temperature may be uncontrolled.
- b. Car voltage supply: Nominal
- c. Internal loads: Design passenger load, maximum solar load

After successful completion of the steady state test defined in TS 18.2.2.7.8, restore the supply voltage to the nominal value and introduce the design passenger sensible and latent internal loads and allow the interior condition to stabilize. After stabilization, record all data at one (1) minute intervals for a minimum of 30 minutes.

The average interior temperature shall remain within the specified limits. The interior temperature uniformity requirements of TS 8.1 shall be met.
Set the climate room ambient temperature to a value of 1°F to 5°F below the cooling lock out control temperature and apply the design passenger sensible and latent internal loads and maximum solar load to the car. Operate the HVAC system in automatic mode and allow the interior temperature to stabilize. After stabilization, record all data every minute for a minimum of 30 minutes.

The average interior temperature shall remain within the specified limits. The interior temperature uniformity requirements of TS 8.1 shall be met.

### 18.2.2.7.12 Overhead Heat Capacity – Temper

The purpose of this test is to demonstrate that the overhead heat capacity is sufficient to temper the specified quantity of fresh air from the minimum specified ambient dry bulb temperature to the required interior temperature. The summary of the test conditions is:

- a. Climate room temperature: 10°F DB with 50 percent humidity
- b. Car voltage supply: Nominal
- c. Internal loads: As required

Set the climate room ambient temperature to the specified minimum dry and wet bulb values and force the overhead heat to operate at the design power level. Adjust the internal heat load as required so that the average interior temperature stabilizes within the specified temperature range. Verify that the temperature of the air discharged from the HVAC unit is not more than 5°F below the return air temperature.

Calculate the energy input to the mixed air stream using the airflow values measured earlier and the enthalpy of the mixed air and delivered air. Verify that the energy input is equal to or greater than that required to increase the fresh airflow to the average interior condition.

### 18.2.2.7.13 Floor Heat Capacity

The objective of this test is to verify the capacity of the floor heaters (without overhead heat) and their ability to maintain the required interior temperature conditions. The summary of the test conditions is:

- a. Climate room temperature: 10°F DB with 50 percent humidity
- b. Car voltage supply: Nominal
- c. Internal loads: None

Set the climate room ambient temperature at the specified minimum dry and wet bulb temperature, disable the overhead heat, seal the fresh air intakes, close all doors and windows, and energize only the floor heaters. The test shall be concluded when the average interior temperature reaches and maintains the specified design temperature.
18.2.2.7.14 Abnormal Heating Conditions with Airflow Restricted

The objective of this test is to demonstrate that the first stage overheat protection device operates properly, the set point of the first stage overheat protection device is appropriate, the first and second stage overheat protection devices are properly coordinated, and that variations in overhead heat power caused by variations in the wayside supply voltage do not adversely affect the satisfactory operation of the first stage overhead protection device. The summary of the test conditions is:

a. Climate room temperature: Approximately 40° F dry bulb
b. Car voltage supply: Nominal, specified minimum and maximum
c. Internal loads: None

The abnormal heating test shall be performed in accordance with the following steps:

a. Bypass or disable any devices that would prevent the overhead heaters from operating under the abnormal circumstances of this test.

b. Slowly restrict evaporator unit mixed air inlet at a rate such that heater unit temperature rise is less than 2° F per minute. Stop when the first stage overheat protection devices trips. Back off the restriction to the point where the device resets.

c. Take temperature readings at five (5) minute intervals.

d. Continue to operate the heating system until a steady state is attained. A steady state shall be the condition at which three (3) consecutive temperature readings indicate no temperature rise.

e. The test shall be considered satisfactorily completed if the following conditions are met:
   1) Backup overheat protection device does not actuate
   2) Temperature inside the unit does not cause damage to any equipment or components
   3) No smoke or odors are detected
   4) High limit switch opens at design set point 10°F

Repeat the procedure at the specified maximum and minimum supply voltages.

18.2.2.7.15 Abnormal Heating Conditions with No Airflow

The objective of this test is to demonstrate the safe operation of the heating system with no airflow through the evaporator unit. This test shall be performed only after satisfactory completion of the restricted airflow test described in TS18.2.7.14. The summary of the test conditions is:

a. Climate room temperature: Approximately 40° F dry bulb
b. Car voltage supply: Nominal, specified minimum and maximum
c. Internal loads: None

The abnormal heating test shall be performed in accordance with the following steps:
a. Bypass or disable any devices that would prevent the overhead heaters from operating under the abnormal circumstances of this test.

b. Stop the airflow area completely. Heating system shall cycle on and off safely under the control of the high limit switch.

c. Force the overhead heat to operate at full power.

d. Take temperature readings at a rate approved by the Engineer.

e. Operate the system under these conditions until the peak temperature seen during the cycle does not increase for three (3) consecutive cycles.

f. The test will be considered satisfactorily completed if the following conditions are met:

   1) Backup overheat protection device does not actuate
   2) Temperature inside the unit does not cause damage to any equipment or components
   3) No smoke or odors are detected
   4) High limit switch opens at design set point 10° F

Repeat the test with the wayside power supply at the specified minimum and maximum values.

18.2.2.7.16 Back Up Overhead Heat Overheat Protection

The purpose of this test is to demonstrate that the backup overheat protective device functions correctly and that the set point of the backup overheat protective device is satisfactory. The summary of the test conditions is:

a. Climate room temperature: Approximately 40° F dry bulb
b. Car voltage supply: Nominal, specified minimum and maximum
c. Internal loads: None

The backup heating test shall be performed in accordance with the following steps:

a. Bypass or disable any devices that would prevent the overhead heaters from operating under the abnormal circumstances of this test. Bypass the first stage of the overheat protective device.

b. Stop the airflow area completely.

c. Force the overhead heat to operate at full power.

d. Take temperature readings at a rate approved by the Engineer.

e. The test will be considered satisfactorily completed if the following conditions are met:

   1) Temperature inside the unit does not cause damage to any equipment or components
   2) No smoke or odors are detected
3) Back up overheat device actuates at a temperature high enough to allow it to activate only in the event of failure of the primary protective devices

f. After the functioning of the device, temperature measurement records shall be continued at not greater than ten (10) second intervals until steady temperature fall is observed.

Repeat the test with the wayside power at the specified minimum and maximum values.

18.2.2.7.17 Cab Heater Test

The objective of this test is to demonstrate proper operation of the cab heater under the conditions detailed in TS 8. The cab heater shall be instrumented to measure the data as required below. The cab heater supply and return air temperatures shall be measured as the average of nine (9) point thermocouple U.L. type grid for each. The temperature measurements shall be taken at the cab heater's air inlet and outlet as close as possible to the unit but with no thermocouple in contact with the metal housing. The following measurements shall be recorded at the heater:

a. Blower motor voltage, current, and power
b. Blower motor speed
c. Heater element voltage, current, and power
d. Airflow (CFM) with and without heater element energized
e. Inlet and outlet air temperature
f. Surface temperature of exposed side of heater housing
g. Temperature at high limit switch
h. Temperature at fusible link
i. Temperature at blower motor
j. Climate room ambient temperature

Prior to testing, demonstrate the operation of the heater at all switch positions. The Operator's cab heater test shall be performed in accordance with the following steps:

a. Turn the Operator’s cab heater on HIGH HEAT and determine the time necessary to reach 65°F DB. Take measurements every minute during that period.

b. Measure the temperature of the heater enclosure at various locations to determine the maximum temperature. The temperature shall not exceed 125°F.

c. Conduct a test of the high temperature limit switch by very slowly restricting the heater's air inlet until the switch opens. Slowly back off the air restriction until the switch closes again. Cycle the high temperature limit switch at least three (3) times. The fusible link (if used) shall not open during this test.

d. Repeat the test as described in c above with no airflow through the unit. The high temperature limit switch shall cycle without permitting unacceptable temperature rise inside the unit and without damage to the motor, wiring, and other components of the unit or the carbody. The fusible link shall not open during this test.
e. Jumper the high temperature limit switch to perform the over temperature protection test. Blower motor power shall be disconnected and a suitable fire extinguisher shall be provided nearby. Apply power to the heater and monitor the temperature inside the unit and at the fusible link. Record the temperature at which the fusible link opens. The fusible link melting temperature shall not cause scorching or smoking inside the unit or any damage to the unit, wiring, or any component of the carbody. The unit must function normally and safely after fusible link replacement.

f. Repeat the last three (3) steps above with the Operator’s heater set to low heat and medium heat.

**18.2.2.7.18 Windshield Defrosting and Demisting Test**

The objective of this test is to demonstrate operation of the Operator’s cab windshield defroster/demister. The following measurements shall be recorded:

a. Heater element voltage, current, and power  
b. Climate room ambient temperature  
c. Cab temperature at locations approved by the Engineer

Obtain stable climate room conditions as specified in TS 8.5 with sufficient buildup of ice on the windshield such that objects cannot be seen when viewed through the windshield. Turn the defroster on and determine the time necessary to clear the windshield as required by TS 8.5. Take measurements every minute during that period. Take a photograph of the windshield every minute or outline the clear area(s) of the windshield until the entire windshield is clear. Measure the temperature of the windshield to determine the maximum temperature. The temperature shall not exceed 125° F. The time required to clear the windshield shall not exceed 15 minutes.

Obtain stable climate room conditions of F DB and 70° F dew point inside the cab. The time required to create dripping condensation on the windshield shall not exceed 15 minutes.

**18.2.2.8 Lighting Tests**

The intensity of the lighting shall be measured in one (1) of the pilot cars to verify the levels specified in TS 9.

**18.2.2.9 Brake Shoe Force Car Tests**

Tests shall be conducted on one (1) truck of a pilot car to determine the actual force produced at each brake location with brake cylinder pneumatic pressures in five (5) psi increments from zero (0) psi to the maximum and from application of the parking brake.

**18.2.2.10 Parking Brake Tests**

On a pilot car, parking brake interlocking circuitry including the applied indicator described in TS 12.22 shall be tested.
Testing of the parking brake shall demonstrate that under worst case load the application of force will hold an AW3 loaded cab car or AW3 trailer car indefinitely on a 3 percent grade. Testing to verify this requirement shall be conducted using new brake shoes and pads.

### 18.2.2.11 Truck Equalization Tests

To verify the equalization provided by the truck design, the lowest weight pilot car shall be tested per APTA-PR-M-S-014-06, Class G, requirements. The test will be conducted for both raising and lowering wheels of each truck type. The load at all other wheels on the test truck shall be monitored for all wheel displacements regardless of the previous truck service history.

To verify the equalization provided by the truck design, the first car shall be operated at track speed through a curve. At no point shall any wheel tread lose contact with the running surface of the rail.

In the event that suitable equalization is not attained as indicated by the tests, the truck design shall be corrected, the truck retested at the expense of the Contractor, and all trucks installed under the cars shall be modified to be in accordance with the corrected design.

### 18.2.2.12 Electromagnetic Compatibility Tests

The Contractor shall demonstrate through specified inductive and radiated emissions tests that the train worst case emissions are electromagnetically compatible with all SEPTA and host railroad systems.

The Contractor shall consider that meeting the emission limits herein does not guarantee elimination of interference; it is the first level of defining the interface between the vehicles and their intended environment. The Contractor shall be responsible for reducing emissions if necessary to prevent interference and for supplying equipment that is completely compatible with the SEPTA operating environment. These limits may be refined as necessary to ensure compatibility.

#### 18.2.2.12.1 Field Inductive EMI Test

The Contractor shall perform a field inductive EMI test as defined in UMTA-MA-06-0153-85-8 to demonstrate compliance with TS 2.6.3.2. The draft procedure shall be available at the CDP.

At other frequencies, train emissions shall be limited to acceptable values as approved. The Contractor shall document the inductive test results in a report that shall be submitted to the Engineer for approval. The report shall identify the source of all narrow band emissions from 20 Hz to 25 kHz.

#### 18.2.2.12.2 Field Radiated EMI Test

The Contractor shall perform a field radiated EMI test as defined in UMTA-MA-06-0153-85-11 to demonstrate compliance with TS 2.6.3.1. The draft procedure shall be available at the PDR. The test report shall identify the source of all narrow band emissions from 14 kHz to 3000 MHz.
18.2.2.12.3  Immunity Testing Using Handheld Radio (Car Level)

The Contractor shall test all car systems for RF immunity from car mounted and handheld two-way radios. This includes all types of VHF and UHF radios used by SEPTA. The intent of this Section is to ensure that the use of these radios, while on board the car, does not adversely affect the operation of any car system. All car systems containing electronics shall be tested. The Contractor shall submit a test procedure and report to the Engineer for approval.

18.2.2.12.4  Required EMI/EMC Testing for Subsystems

All car subsystems regardless of power level must be subjected to laboratory EMI/EMC tests to ensure that the subsystem meets the requirements of TS 2.6. The Contractor shall develop a test procedure for each of these tests.

18.2.2.13  Communication System Tests

The public address, intercommunication, and radio equipment on each car shall be tested and adjusted as necessary for proper functioning as specified in TS 13. The vehicle and trainline network shall be tested on the pilot cars for proper functioning and operation as specified in TS 15. Comprehensive tests shall be performed on the complete communication system installed in the pilot cars to ensure that all specified design parameters have been met.

The PA system (from the input of the microphone to the output of the interior speakers) shall have a 90 percent intelligibility rating when tested according to ANSI S3.2-1989 (R1999), Method for Measuring the Intelligibility of Speech over Communications System. Included with the communication system test shall be a complete verification of the assisted listening system.

18.2.2.14  Destination Sign and Interior Message Display Tests

The destination sign and interior message display systems shall be tested to demonstrate Specification compliance. These tests shall include all possible combinations of variables of sign, control, and message configurations including wayside inputs.

18.2.2.15  Automatic Passenger Counting System

As a minimum, the factory tests shall include all technical parameters delineated in TS 13 and TS 15. A copy of the test sheets with serial numbers of all equipment tested shall be furnished to the Engineer certifying that the standards listed in TS 13 and TS 17 have been met and that the method of measurement specified in the standards was followed in conducting the tests. [CDRL 18-010]

18.2.2.16  Monitoring System

The monitoring and diagnostic system shall be tested on the pilot cars for proper function and operation as specified in TS 16. Each level of system monitoring and diagnostics shall be tested.
18.2.2.17 LVPS/BCS

The operation of the low voltage power supply and battery charger shall be tested to demonstrate compliance with the requirements specified in this Specification.

18.2.2.18 Weight Distribution

A weight distribution test shall be performed on the pilot car of each car configuration to verify compliance with the requirements of TS 2.2.2.4.

18.2.3 Road Test Qualifications

The following summary table is provided for convenience only and does not in any way alleviate the Contractor’s responsibility to ensure that all tests as required by this Specification are performed in accordance with the requirements listed herein. The test procedures for all road tests shall include an Engineer approved listing of what parameters are to be verified and the pass/fail criteria of each.

Right of way and shop availability will be limited by the need to provide service for SEPTA’s customers and by the need to provide access for SEPTA’s personnel to perform maintenance activities. Because of these restrictions, the Contractor shall be required to conduct road tests at SEPTA’s designated locations. The test train shall consist of the two (2) pilot cars. The Contractor may propose a different test train make up for review and approval by the Engineer.

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18.2.4 Noise and Vibration Tests

The interior and exterior noise and vibration levels of the pilot cars shall be measured to assure compliance with the requirements of TS 2.3, 40 CFR Part 201, 49 CFR Part 210, and 49 CFR 229.121. Vibration tests and interior noise measurements shall be performed with all car systems in operation while operating the car on level tangent track in an open area from standstill to 110 mph and back to stand still using full service braking. The sound level meter shall conform, at a minimum, to the requirements of ANSI S1.4, Type 2, set to the A-weighted slow response or an audio dosimeter of equivalent accuracy and precision may be used. Vibration and shock tests shall conform to requirements of IEC-61373, Railway Applications Rolling Stock Equipment Shock and Vibration Tests.

In conducting sound level measurements in the interior of the cabs and passenger compartments with a sound level meter, the microphone shall be oriented vertically and positioned approximately 15 centimeters from and on the axis of a seated passenger’s or the Operator's ear. Measurements with an audio dosimeter shall be conducted in accordance with the manufacturer's procedures as to microphone placement and orientation.

Measurement of the sound levels of the horns shall be made using a sound level meter conforming, at a minimum, to the requirements of ANSI S1.4, Type 2, and set to the A-weighted slow response. With the cars on level tangent track, the microphone shall be positioned four (4) feet above the ground at the center line of the track 100 feet from the end of each car and shall be oriented with respect to the sound source in accordance with the manufacturer's recommendations. Sound level measurements shall be tape recorded in the event further analysis is required.

For the preceding tests, completed test reports shall include the following:

a. Description of noise or vibration source being measured including pertinent statistical information

b. Description of the environment where noise or vibration source is measured including a sketch showing source position

c. Operating conditions of noise or vibration source during measurements

d. Pertinent meteorological data if applicable

e. Locations and orientations of microphones with respect to noise source

f. Equipment used for making measurements

g. Description and measurement of ambient noises

h. Data obtained including range of variation

i. Instrumentation, settings, corrections, and calibration results

j. Summary of results and conclusions
18.2.5 Braking Performance Tests

All of the following tests shall be performed by all pilot cars. SEPTA shall specify a location for the test runs. All pilot cars shall have these tests performed with no load (AW0), loaded to AW1, and loaded to AW2. All other cars may be tested with no load (AW0).

Prior to the start of the test program, a series of "shake down" tests as approved by the Engineer shall be conducted to determine the equipment settings and calibrations to be used.

Using the data from the shake down tests, characteristic car performance parameters and curves shall be generated for the evaluation of the test results of the production cars. These parameters shall include all air pressures, voltages, and currents.

A group of plots (at various speeds and wheel temperatures) of brake cylinder pressure versus braking effort (derived from deceleration recordings and known loadings) shall be developed. All pertinent data from each test at each loading shall be represented on a single graph.

If the pilot cars or any of their equipment fails to satisfy the specified performance and design criteria, the cars shall have the necessary adjustments made and be retested at the Contractor's expense.

The friction brake system shall be tested on the pilot cars to demonstrate that it meets the requirements of TS 12. The brake disc and brake pad or wheel and brake shoe temperatures shall not exceed the limits specified by the manufacturer(s). These limits shall be included in the test procedure for this test. Brake disc or wheel temperatures shall be measured and recorded in a manner approved by the Engineer such that the measurements can be compared directly to the manufacturer's specified limits during the testing without need for additional calculation. The brake disc or wheel manufacturer shall also approve the brake disc or wheel temperature measurement method employed by the Contractor for these tests. Successful completion of all of the preceding tests and acceptance of the test results by the Engineer shall be required for final approval of the friction brake system. Prior to testing, pads or shoes shall be fully seated.

Conformance or proof of design tests shall be performed on the pilot cars on a SEPTA line prior to acceptance. These tests shall be more inclusive than the performance and acceptance tests of the balance of the cars so as to demonstrate not only that the cars are properly adjusted but also that the design of the cars is correct in all respects and in compliance with the performance standards specified. The Contractor shall develop a list of tests to be performed and shall submit the same to the Engineer for approval. [CDRL 18-011]

The Contractor shall conduct proof of design tests to demonstrate compliance with the performance standards specified in TS 12.2 and TS 12.3. To ensure compatibility with the existing cars, static and road tests shall be performed.

All static tests shall be performed on a cab car, and all of the road tests shall be performed on SEPTA’s property and Amtrak’s NEC and Harrisburg routes.

As a minimum, two (2) runs in each direction shall be made for each road test condition listed in TS 18.2 (c) (3). These series of tests shall be used to determine the brake equipment settings and calibrations to be used for the car acceptance program.
After the successful completion of the test program, each car used in the test train shall be restored to its original configuration.

All recorded data shall be corrected for grade as part of the Contractor's test report. Test reports shall be forwarded to the Engineer and become the property of SEPTA.

If any car or any equipment fails to satisfy the specified performance and design criteria, the cars with the necessary adjustments shall be retested at the Contractor's expense.

Any modifications deemed necessary shall be submitted to the Engineer for review and approval. Modifications shall be verified by appropriate test(s) approved by the Engineer and effected on a fleet wide basis.

These tests shall be performed using automated digital data acquisition equipment such as National Instruments Lab View or equivalent. Built in software at the central diagnostic terminal may also be used if all of the required parameters are recorded. The test software shall display speed vs. time in real time. The data record shall be convertible to a chart recorder type display format that can be displayed and saved to a USB by the test train personnel. The Contractor shall electronically supply a permanent test record for each car.

The Contractor shall supply all recorders, sensors, pickups, and wiring. Internal combustion engine driven generators shall not be permitted. The equipment shall not be damaged by the conditions specified in TS 2. Isolation amplifiers and voltage dividers shall be provided as part of the instrumentation package to isolate the inside car instrumentation wiring and equipment from high voltages; no exposed terminals with potential differences greater than 50 volts shall be permitted. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the Specification and design data. Any reference clocks shall not depend upon the frequency accuracy of the power supply for their timing accuracy. The Engineer shall approve all test instrumentation prior to any testing.

For these tests, the following channel assignments shall be permanently recorded simultaneously:

**18.2.5.1 Static Tests**

a. Time
b. Brake valve handle movement
c. Load weigh pressure
d. Equalizing reservoir pressure
e. Brake pipe pressure
f. Brake cylinder control pressure
g. Brake cylinder pressure

**18.2.5.2 Road Tests**

a. Time
b. Brake valve handle movement
c. Load weigh pressure of cab car
d. Accelerometer of cab car
e. Brake pipe pressure of cab car
f. Brake cylinder pressure of locomotive
g. Brake cylinder pressure of each truck of each car
h. Speed of each axle on each car
i. Independent speed measurement such as radar or GPS
j. Wheel surface and brake disc temperature on one (1) axle
k. Distance (intervals in feet)
l. Event marker
m. Slide detection activity of each truck of each car
n. Slide correction activity of each truck of each car
o. Wheel slide enable trainline
p. Sander operation
q. Propulsion trainlines
r. Two (2) spare analog channels for additional tests as requested by the Engineer

As a minimum, the following tests shall be performed on a train consisting of six (6) multi-level cars with at least one (1) multi-level cab car and a locomotive except as otherwise required:

18.2.5.3 Braking Kinematic Tests

18.2.5.3.1 Static Tests

The static tests’ simulated passenger load shall be zero (0). The test shall be performed on one (1) multi-level cab car and shall include the following response time tests from time of brake valve handle movement:

a. Full Service

1) Brake pipe reduction time to full service
2) Brake cylinder build up time to 95 percent of maximum
3) Brake cylinder release time to five (5) psi

b. Emergency

1) Brake pipe reduction time to zero (0) psi
2) Brake cylinder build up time to 95 percent of maximum

The static test shall also include a pressure development test in which brake pipe reductions in various increments are recorded with the corresponding brake cylinder pressures.
18.2.5.3.2 Road Tests

The simulated passenger load in each car shall be zero (0). For each run, the wheel temperature shall not exceed 200° F before initiation of any test. The test procedure shall contain calculations to compensate for consist makeup and demonstrate compliance with the performance requirements in TS 2.2.7.3 and include:

a. Full service stops from 110, 80, 70, 60, 45, 30, and 20 mph with the braking provided by the multi-level cars only with locomotive brakes bailed off

b. Emergency stops from 110, 80, 70, 60, 45, 30, and 20 mph. For safety, the locomotive brakes shall not be bailed off for these tests.

c. Additional tests as needed to verify compliance with the parameters that cannot be evaluated by the tests listed above

18.2.5.4 Wheel Slide Tests

During the braking road tests, axle speed and brake cylinder pressure of each test car shall be monitored and recorded to indicate the wheel slide system operation and the ability of the car to withstand numerous wheel slide corrections without emergency application. The cars will be outfitted with a track sprayer system that will spray the rails in front of each truck of the test train. The sprayer will use a mixture of water, windshield washer solution, and soap in order to achieve reduced adhesion levels. The cars shall be tested on a designated dry section of track that is reasonably straight and within one (1) percent of level. Test stops shall be repeated with the mixture composition being varied as necessary until the test train begins to experience wheel slippage during the maximum speed. This mixture blend shall become the test mixture. Slippery rail stops from the maximum speed shall be conducted using the test mixture. The wheel slide protection system shall effectively protect against wheel flats during the test.

Two (2) series of tests shall be conducted, the first with the sanders not functioning and then the test series repeated with the sanders fully functional. For each test series, the train shall make four (4) full service braking stops from 110, 80, 70, 60, 45, 30, and 20 mph. These tests will be repeated under emergency braking conditions.

18.2.5.5 Dynamic Wet Braking

The pilot cars shall be dynamically tested under wet braking conditions to confirm the performance requirements defined in TS 18.2.1.9.

The Contractor shall provide water spray equipment capable of spraying water at each and every wheel to shoe interface or disc to pad interface of the pilot cars. All water spray equipment, spray pattern, and spray flow shall be in accordance with UIC 541-3, Appendix 4, if tread brakes are used or UIC 541-4, Appendix 4, if disc brakes are used. Water spray equipment and the method of directing water to the brake system shall be approved by the Engineer.
18.2.5.6 Additional Tests

Additional tests as needed to verify compliance with the parameters that cannot be evaluated by the tests listed above.

18.2.6 Air Conditioning Test

The pilot cars shall be tested at speeds up to 110 mph to demonstrate compliance with the interior pressurization and temperature requirements of TS 8. This test shall be conducted at ambient temperatures above 80° F with the test car as the lead unit of the train. The temperature at no less than 14 representative locations approved by the Engineer including the front cab shall be recorded every minute for ten (10) consecutive minutes. Interior car temperature variations shall comply with the requirements of TS 8.1.2.

18.2.7 Heating Test

The pilot cars shall be tested at speeds up to 110 mph to demonstrate compliance with the interior pressurization and temperature requirements of TS 8.1. This test shall be conducted at ambient temperatures below 40°F. The temperature at no less than 14 representative locations approved by the Engineer including the operating compartment shall be recorded every minute for ten (10) consecutive minutes. Interior car temperature variations shall comply with the requirements of TS 8.1.

18.2.8 Ride Quality Tests

Prior to conducting any ride quality tests, a completed car ready for service shall be “characterized” to determine the vehicle’s bounce, pitch, and upper and lower roll modes for comparison with those predicted by the dynamics model. If predicted Eigen frequencies vary by more than ten (10) percent from those measured, the model shall be adjusted to be in conformance and all prior analyses re-run.

To verify conformance with the ride quality requirements of TS 2.2.14.1, TS 11.2, 49 CFR 213.333, 49 CFR 213.345, and 49 CFR 238.227, ride quality tests shall be conducted on each pilot car type. The test track on SEPTA’s track shall be as selected by SEPTA, and tests shall be conducted at the same speed and in the same direction for all cars. The ballast used in simulating the seated load as well as the labor for loading and unloading shall be provided by the Contractor at their expense.

Ride quality shall be evaluated according to ISO 2631-1:1997(E). With inflated air bags at AW0 and AW3, the rms acceleration values for each measurement direction or rotation at a point shall not exceed 0.315 m/sec2 for seated and standing passengers. Also, the vibration total value (root sum of squares summation) for each measurement point shall be calculated and shall not exceed 0.5 m/sec2. The cars shall also be tested with deflated air springs to confirm safe train operation under those conditions at AW0 and AW3. With deflated air springs, ride quality shall not exceed 0.62 m/sec2 for each measurement direction or rotation at a point of seated and standing passengers, and total value (root sum of squares summation) for each measurement point shall not exceed 1.0 m/sec2.
Where appropriate, frequency weighting \( W_b \) shall be used instead of \( W_k \). Acceleration data shall be evaluated over the range of 0.5 Hz to 80 Hz. For seated passengers, the evaluation shall be made over three (3) axes on the seat pan and seat back and no rotational axes at the seat back and seat pan. For standing passengers, the acceleration data shall be evaluated in the three (3) translational axes of the floor and rotation motion about the x-axis as specified in the International Standard ISO 2631-4 (2001). Upper floor roll at frequencies between 0.1 and 4 Hz will be measured, weighted using the \( W_f \) factor, and assessed with the overall weighted acceleration in the z-axis per ISO 2630-1:1997, Section 9.2.2, and also added to the three (3) vehicle axes to produce the total vibration value per ISO 2630-1:1997, Section 6.5.

Representative seat and floor positions shall be proposed by the Contractor and approved by the Engineer. Ride quality shall also be calculated from the same data per ISO 2631-1:1985 for vertical and horizontal directions and submitted to the Engineer for information only. [CDRL 18-012]

Ride quality shall be evaluated for AW0 and AW1 load conditions and at all normal vehicle acceleration, deceleration, and speed conditions. As a minimum, the ride quality tests shall consist of operating the cars at speeds of 50, 70, and 110 miles per hour. The tests shall be conducted on class track appropriate for the test speeds. The vehicle shall be evaluated with new wheels on tie and ballast track, welded and jointed rail and turnouts with non-corrugated welded rail. There shall be no dangerous buildup of oscillations or excessive lean, sway, or yaw which could cause the car to violate the dynamic clearance limits.

Instrumentation capable of measuring and charting (for permanent record) the magnitude and frequency of the vertical, longitudinal, and lateral shocks expected up to 2.0 g and 150 Hertz shall be provided and operated by the Contractor who shall reduce the raw data for presentation to the Engineer. Sensing units shall be located on the car floor above the intersection of the car’s longitudinal center line and each truck’s transverse center line or other locations as approved by the Engineer. Provision shall be made for recording vertical, lateral, and longitudinal shocks (vibrations) concurrently, speed and distance in 100 feet increments, GPS location, and to allow entry of event markers on recorded data for these tests.

The Contractor shall demonstrate compliance with the requirements of 49 CFR 213.333, 49 CFR 213.345, and 49 CFR 238.227 for the truck and carbody as part of the ride quality tests. Hunting shall be evaluated by recording data from lateral sensing accelerometers mounted on the truck frame adjacent to the journal bearing housings. The measurements shall be processed through a filter having a pass band of 0.5 to 10 Hz. There shall be no sustained cyclic oscillations in excess of 0.4 g root mean square (mean removed) for two (2) seconds.
In the event that the dynamic behavior of the trucks or cars is inferior in any respect to the Specification requirements, the Contractor shall submit to the Engineer within ten (10) working days a program containing mathematical analysis of the problem and a course of action for its correction. If in the opinion of the Engineer the program and/or schedule are inadequate or unsatisfactory, an acceptable program and schedule shall be resubmitted within five (5) working days. If the revised program and schedule are not submitted in time or are still unacceptable, SEPTA will return the cars to the Contractor's plant at the Contractor's expense. If the Engineer approves the analysis and corrective measures, those corrective measures shall be made effective on the pilot cars within 90 calendar days at the expense of the Contractor, and the cars shall be retested. If the measures are successful, they shall be applied to all of the cars. If not, the analysis and correction steps shall be repeated, submitted, and retested until successful.

18.2.9 Electrical Interference Tests (EMI)

An electromagnetic compatibility test shall be performed on the pilot cars by methods referenced in TS 2.6 and TS 18.2 for compliance with those requirements and for compatibility with signal and communication systems. During these tests, confirmation of the appropriate emissions limits as previously developed shall be conducted by monitoring the signal and communication systems’ function.

18.2.10 Miscellaneous Tests

Other equipment not listed in the previous subsections shall also be tested to ensure compliance with this Specification and the manufacturer’s standards.

18.2.11 Pilot Train Road Tests

18.2.11.1 General

The pilot train will be made up of the first two (2) cars delivered to SEPTA and approved for road testing or as determined by the Engineer. The pilot cab and trailer cars shall be given shakedown and operational tests following the completion of all other testing required as practical for the time of year and as described below. Approved Contractor personnel shall be present on the cars for the testing. The testing period may include operation in snow and ice storms in the winter season and shall fully test all car components and subsystems in the rigor of simulated or actual revenue operation. The Contractor shall document and report to the Engineer all car defects, operational problems or failures encountered and their remedy, the type and kind of all maintenance performed, and any parts used. This documentation shall include all SEPTA as well as Contractor activities. The purpose of this test shall be to perform an intensive analysis of the suitability of the design, assembly, and materials used on the pilot cars with the intent that any changes or modifications found necessary shall be incorporated into the design of the remaining production cars to reduce the need for field modifications after delivery. The pilot cars shall be field modified by the Contractor to completely incorporate all changes found necessary for the production cars.
18.2.11.2 Coupler Test

The pilot cars shall be coupled to an HEP equipped electric locomotive, and all trainline functions shall be tested for proper response prior to operation. The cars shall first be coupled into a train of existing Bombardier cars, and all trainline functions shall be tested. This shall be done with the cab car functioning as a trailer in the middle of a train and as a cab car at the end of the train. The trainline functions shall be checked with the cab car as the last car in the train and also as the lead car in control of the train. After the trainline functions have been tested in all configurations, the cab car shall be placed in a train consisting of a locomotive, the pilot trailer car, an existing Bombardier coach, and an existing Bombardier cab car for the operational, braking, wheel slide, ride quality, air conditioning, and pressurization tests.

18.2.11.3 Brake System Interface Test

A complete series of brake system tests shall be performed to verify brake system response under all combinations of train compositions of the Pilot Cars and Bombardier coaches, Bombardier cab cars, locomotives and other railroad equipment, in accordance with TS 2.1.8. These tests shall be run with a Pilot Car instrumented to monitor all parameters.

18.2.11.4 Simulated Revenue Service Test

The operational test shall be conducted following the other tests listed and consist of a 40 hour simulated revenue test in which no failures of any equipment shall be permitted. (Cab cars shall be operated for 20 hours as a trailer and 20 hours in the lead position.) Station stops shall be made outside of station platforms, and the doors shall be cycled. SEPTA may wish to use this period to qualify transportation department staff. The cars shall first be fully instrumented. This test period shall be utilized to assure that all elements of the car are in proper working order and ready for the following tests. Failures or other incidents requiring attention that occur near the end of this period may be considered cause to extend the test period until the Engineer is confident that the cars are sufficiently "burned in" and trouble free.

18.2.11.5 Revenue Service Preparation

The pilot train shall then have instrumentation arranged so that it can be carried securely in the non-active cabs of the train and not interfere with passengers or staff during revenue operation. The intent will be to collect meaningful data as to the performance of the cars during revenue operation with parameters to be measured that are jointly agreed upon by the Engineer and the Contractor.
18.2.11.6 Actual Revenue Service

The pilot train shall then be operated in revenue test service for a minimum of 4,000 miles. During this period of operation, there shall occur a period of no less than 1,000 miles in duration without the occurrence of any failures or incidents that prevent the train from completing all of its scheduled trips or that require reset of protective devices unaccompanied by failure. Failures or incidents relating to a component or to a subsystem shall result in extension of the test period until the requisite mileage has been accumulated without failure or incident on that component or subsystem. This additional operation shall not be a burden on other components or subsystems which successfully completed the first 4,000 miles. The pilot train shall then be placed in unaccompanied and unrestricted revenue service with the Contractor continuing to closely monitor the car’s service record. The Contractor shall present a complete report documenting the operational tests and accompanied by such charts or other recordings as felt useful by the Engineer. This presentation shall include a detailed listing of all defects in the car design, materials, workmanship, or performance with specific recommendations by the Contractor for their resolution.

18.2.12 Signal System Tests

The cars shall be tested as a coupled consist over track designated by the Engineer to demonstrate that all systems installed on the cars are completely compatible with wayside equipment. This test shall include all possible wayside to car and car to wayside system possibilities and configurations.

The cab signal and PTC system and all major components shall be subjected to qualification tests to assure that they comply with the requirements of this Specification. As a minimum, these tests shall include complete functional tests while the equipment is subjected to the environmental and input variations specified. Equipment so tested shall conform to the manufacturing drawings.

18.2.13 Maximum Safe Operating Speed Tests

The Contractor shall conduct tests to determine the maximum safe operating speed of the vehicles along with permissible levels of cant deficiency as defined by 49 CFR 213.345. These limits will not be less than 110 mph and six (6) inches of cant deficiency. When this speed is determined, the Contractor shall conduct tests of the equipment over proposed routes for service. Additional test runs shall be performed at a speed of five (5) mph above the maximum operating speed and up to six (6) inches of cant deficiency. The test results shall demonstrate compliance with the requirements of 49 CFR 213.345. The Contractor shall prepare and submit test procedures and reports to SEPTA and the FRA for approval. [CDRL 18-013] The Contractor shall be responsible to comply with requests for changes or clarifications to the test procedures, reports, and for conducting additional tests as may be required by SEPTA and the FRA for approval.
# 18.3 PRODUCTION (ROUTINE) TESTS

The following summary table is provided for convenience only and does not in any way alleviate the Contractor’s responsibility to ensure that all tests as required by this Specification are performed in accordance with the requirements listed herein:

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Performed By</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Apparatus</td>
<td>All Equipment</td>
<td>Manufacturer</td>
<td>18.3.1</td>
</tr>
<tr>
<td>Intermediate and Low Voltage Power Supply</td>
<td>All Equipment</td>
<td>Manufacturer</td>
<td>18.3.2</td>
</tr>
<tr>
<td>Battery</td>
<td>All Batteries</td>
<td>Manufacturer</td>
<td>18.3.3</td>
</tr>
<tr>
<td>Motor</td>
<td>All Motors</td>
<td>Manufacturer</td>
<td>18.3.4</td>
</tr>
<tr>
<td>Heater Element</td>
<td>All Elements</td>
<td>Manufacturer</td>
<td>18.3.5</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.6</td>
</tr>
<tr>
<td>Friction Brake Equipment</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.7</td>
</tr>
<tr>
<td>Truck</td>
<td>All Trucks</td>
<td>Manufacturer</td>
<td>18.3.8</td>
</tr>
<tr>
<td>Wheel Slide System</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.9</td>
</tr>
<tr>
<td>Master Controller</td>
<td>All Cab Cars</td>
<td>Manufacturer</td>
<td>18.3.10</td>
</tr>
<tr>
<td>Air Brake Valves</td>
<td>All Valves</td>
<td>Manufacturer</td>
<td>18.3.11</td>
</tr>
<tr>
<td>Air Reservoirs</td>
<td>All Reservoirs</td>
<td>Manufacturer</td>
<td>18.3.12</td>
</tr>
<tr>
<td>Cab Signal and PTC Equipment</td>
<td>All Cab Cars</td>
<td>Manufacturer</td>
<td>18.3.13</td>
</tr>
<tr>
<td>Compressor, Condenser, and Evaporator</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.14</td>
</tr>
<tr>
<td>Destination Sign and Communication</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.15</td>
</tr>
<tr>
<td>Automatic Passenger Counting System</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.16</td>
</tr>
<tr>
<td>Monitoring Screens</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.17</td>
</tr>
<tr>
<td>Side Door Operator</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.18</td>
</tr>
<tr>
<td>End-of-Car Door Operator</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.19</td>
</tr>
<tr>
<td>Seat</td>
<td>All Systems</td>
<td>Manufacturer</td>
<td>18.3.20</td>
</tr>
</tbody>
</table>
All equipment on each car including the pilot cars shall be given a functional test (production test) to assure proper operation at the manufacturer's facility prior to shipment. Test procedures shall be provided for approval to the Engineer and test reports shall be made available for approval at the Contractor’s plant.

All equipment shall also be given a functional test (pre-delivery) on the completed car to test for proper operation by the Contractor prior to issuance of a release for shipment document by the Engineer. Test procedures and test reports shall be submitted to the Engineer for approval and shall become the property of SEPTA. Test reports shall be included in each car history book as specified in TS 1.20.

The test to be performed by each manufacturer and the Contractor on each car component or subsystem shall be in accordance with the applicable industry standards listed in this Specification and the approved test plan. The following tests in this Section list some but not all of the tests to be performed.

This shall be in addition to and shall not replace the Contractor's and supplier's quality assurance plans:

### 18.3.1 Electrical Apparatus Tests

Each component that is separately assembled, housed, and wired into a package unit prior to installation shall be tested at its point of manufacture and a certified test report signed by the responsible quality assurance representative of the manufacturer shall be furnished to the Contractor and made available to SEPTA. Tests shall be in accordance with IEEE Standard Number 11 for DC rotating machinery. AC rotating machinery shall be tested in accordance with IEEE Standard Number 112A for the electrical characteristics and IEEE Standard Number 11 for the mechanical characteristics. Control apparatus shall be tested in accordance with IEEE Standard Number 16 as appropriate.

### 18.3.2 Intermediate and Low Voltage Power Supply Tests

Each intermediate and low voltage power supply shall be given a "routine" test by the manufacturer as defined in IEEE standards and approved by the Engineer.

### 18.3.3 Battery Tests

Each battery shall be given a capacity test at the point of manufacture in accordance with the requirements included in APTA-PR-E-RP-007-98. Batteries shall be reconditioned as recommended by the manufacturer prior to testing.

### 18.3.4 Motor Tests

Every motor of all types shall be given a routine test by the manufacturer. The routine test shall be as specified in IEC Publication 60349-2, IEEE Std 11-2000, or other Engineer approved equivalent.

### 18.3.5 Heater Element Tests

Each heater assembly shall be high potential tested in accordance with IEEE Standard Number 16.
18.3.6 Air Conditioning Tests

Each air conditioning unit shall be subjected to a routine production test which shall include the following:

a. Nitrogen pressure test with a refrigerant backer for leak detection. The pressure shall be maintained for a minimum period of one (1) hour.

b. Evacuation Test

c. If completed or partially completed units are to be stored without refrigerant then the units shall be charged with a minimum of five (5) psig of nitrogen.

d. Each unit shall be functional at the manufacturer’s facility prior to shipment. The functional test shall include a minimum of four (4) hours of run time.

e. The requirements of TS 8.3.4 shall be included in the test.

18.3.7 Friction Brake Equipment Tests

All pneumatic valves shall be test rack tested and/or certified according to its manufacturer’s instructions.

18.3.8 Truck Tests

Critical areas of the welds of each truck frame and truck bolster shall be inspected as required by TS 17.5 and TS 17.22. The completely assembled truck shall not exceed the clearance limits specified between the truck and the rail as specified in TS 2.2. Trucks will be leveled and tested for the tram to be compliant with TS 11.4.1.

18.3.9 Wheel Slide System Tests

The wheel slide system shall receive a routine test as defined by the manufacturer and approved by the Engineer.

18.3.10 Master Controller

Each master controller and reverser shall be tested for correct sequences of operation in both power and braking positions by observing the functioning at the output terminals.

18.3.11 Air Brake Valves

All valves shall be test rack tested and certified to the latest COT&S per Federal Regulation 49 CFR 229 and 49 CFR 238.
18.3.12 Air Reservoirs

All reservoirs shall be tested and certified to 49 CFR 229 and conform to TS 12.20 as required.

18.3.13 Cab Signal and PTC Equipment

The Contractor shall develop a factory test plan and factory test procedures in accordance with the requirements of TS 14 and TS 18. The term "replaceable unit" as used below means a device or assembly of devices which is normally removed from the car as a unit for replacement or repair in the event of failure within the unit.

18.3.13.1 Plan

The factory test plan shall be submitted to the Engineer for approval a minimum of 180 days prior to the scheduled commencement of the testing of cab signal and PTC equipment. The plan shall identify the in process testing and inspections to be performed, the final factory tests and inspections, the anticipated schedule for the tests and inspections, and the schedule for submittal of detailed procedures. The plan shall describe the scope, method, result, documentation, and facility location of each test and inspection. The plan shall also describe the management control method by which the Contractor proposes to implement and enforce the plan. [CDRL 18-014]

18.3.13.2 Procedures

Detailed procedures shall be developed by the Contractor for the inspection and test of all replaceable units and major assemblies. The procedures shall be submitted to the Engineer for approval a minimum of 60 days prior to the scheduled performance of the test or inspection. The procedure shall identify the configuration of the unit, assembly, or system to be tested or inspected; the prerequisites; test equipment required; test setup; step by step instructions with pass/fail criteria; data to be recorded; and all special conditions or facilities required. If special or non-standard test equipment or fixtures are required, a description of such equipment and instructions for their use shall be included in the procedure or attached thereto. [CDRL 18-015]

18.3.13.3 Minimum Test and Inspection Requirements

The following tests and inspections shall be performed:

a. Each replaceable unit shall be 100 percent mechanically and electrically inspected and functionally tested.

b. Each major assembly shall be 100 percent mechanically and electrically inspected and functionally tested.

c. All wiring shall be thoroughly tested to ensure exact compliance with the approved circuits. The test shall be designed to detect all wiring faults including low insulation values, errors, extra wires, opens, shorts, and crossed connections.
18.3.13.4  Test Reports

Test reports shall be submitted for each test required by the approved test plan. The test reports shall comply with TS 18.1.3 and contain as a minimum:

a. Part number of equipment tested
b. Serial number(s) of equipment tested
c. Identify of test conducted
d. Date of test
e. Identity of person(s) conducting test
f. Identity of witnesses and/or inspector
g. Summary of test results
h. Copy of data recorded

Test reports shall be submitted to the Engineer at or before the time of shipment of the equipment to the Contractor's facility. [CDRL 18-016]

18.3.14  Compressor, Condenser, and Evaporator

Each unit shall be given a pressure test at 1.5 times the working pressure or 600 psig, whichever is greater, and leak tested with a leak detector calibrated for a rate of 1.5 ounces per year. Following leak testing, the units shall be dehydrated and evacuated to 50 microns or less and pressure charged to a minimum of five (5) psig with refrigerant specified in TS 8.3. As an alternative, the first coil may be burst tested to demonstrate a positive margin of safety and all other coils proof tested to 425 psig.

18.3.15  Destination Sign and Communication

A copy of test sheets with the serial numbers of all equipment tested shall be furnished to the Engineer certifying that the standards listed in TS 9, TS 13, and TS 15 have been met and that the method of measurement specified in the standards was followed in conducting the tests. [CDRL 18-017] During the testing all functions of the PA, IC, audio frequency induction loop, train to wayside, onboard video surveillance, onboard dynamic advertising, passenger wireless internet, wireless LAN, and all other communication equipment shall be exercised. At a minimum, the following testing shall be performed:

a. Train to Wayside Communication System – the following functions shall be demonstrated at a minimum:

1) Transfer of consist monitoring and diagnostic data from the train to the wayside
2) Transfer of train status information from the train to the wayside
3) Remote troubleshooting of the locomotive and car systems
4) Transfer of sign database updates from the wayside to the train
5) Transfer of software updates from the wayside to the train
6) Transfer of paging system messages from the wayside to the train
7) Transfer the trigger of train wide public and special messages to the communication system

8) Transfer of onboard dynamic advertising content

b. Onboard Video Surveillance System – the ability to record, download, and view onboard video shall be demonstrated.

c. Onboard Dynamic Advertising System – the ability to display content loops and dynamic data shall be demonstrated.

d. Passenger Wireless Internet (WIFI) – the operation and availability of the proposed expected passenger bandwidth shall be demonstrated.

e. Audio Frequency Induction Loop System – appropriate methods shall be provided to properly test the hearing loop system (such as playing test announcements over the hearing loop system while muting the PA system).

The Contractor shall provide as approved by the Engineer a suitable simulation of the wayside as necessary to test all communication systems.

18.3.16 Automatic Passenger Counting System

As a minimum, the factory tests shall include all technical parameters delineated in TS 13 and TS 15. A copy of test sheets with serial numbers of all equipment tested shall be furnished to the Engineer certifying that the standards listed in TS 13 and TS 17 have been met and that the method of measurement specified in the standards was followed in conducting the tests. [CDRL 18-018]

18.3.17 Monitoring Screens

As a minimum, the factory tests shall include all technical parameters delineated in TS 4, TS 7, and TS 15. Copies of test sheets with serial numbers of all equipment tested shall be furnished to the Engineer certifying that the standards listed in TS 4, TS 7, and TS 15 have been met and that the method of measurement specified in the standards was followed in conducting the tests. [CDRL 18-019]

18.3.18 Side Door Operator

Each side door operator and associated controls shall receive a routine test as defined by the manufacturer and approved by the Engineer.

18.3.19 End of Car Door Operator

Each end of car door operator and associated controls shall receive a routine test as defined by the manufacturer and approved by the Engineer.
18.3.20 Seat Tests

Seat cushions selected twice at random by the Engineer during cushion production shall be tested to verify compliance with TS 4.2.7.

18.4 PRE-DELIVERY TESTS

The following summary table is provided for convenience only and does not in any way alleviate the Contractor’s responsibility to ensure that all tests as required by this Specification are performed in accordance with the requirements listed herein:

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Performed By</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watertightness</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.1</td>
</tr>
<tr>
<td>Weight</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.2</td>
</tr>
<tr>
<td>Clearance Checks</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.3</td>
</tr>
<tr>
<td>Trainline</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.4</td>
</tr>
<tr>
<td>Door</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.5</td>
</tr>
<tr>
<td>Car Wiring</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.6</td>
</tr>
<tr>
<td>Auxiliary Circuits and Equipment</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.7</td>
</tr>
<tr>
<td>Heating</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.8</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.9</td>
</tr>
<tr>
<td>Headlight, Marker Light, and Auxiliary Light</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.10</td>
</tr>
<tr>
<td>Communication Systems</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.11</td>
</tr>
<tr>
<td>Friction Brake</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.12</td>
</tr>
<tr>
<td>Parking Brake System</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.13</td>
</tr>
<tr>
<td>Destination Sign</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.14</td>
</tr>
<tr>
<td>Leveling</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.15</td>
</tr>
<tr>
<td>Lubrication Checks</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.16</td>
</tr>
<tr>
<td>Safety Devices</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.17</td>
</tr>
<tr>
<td>Auxiliary Equipment</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.18</td>
</tr>
<tr>
<td>Cab Signal and PTC</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.19</td>
</tr>
<tr>
<td>Load Weigh System</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.4.20</td>
</tr>
</tbody>
</table>
As a minimum, the tests listed in this Section shall be performed on each car prior to the issuance of a release for shipment document by the Engineer. The Contractor’s production test shall include all tests and adjustments which can be made prior to delivery in order to keep car acceptance testing and adjustments to a minimum.

### 18.4.1 Watertightness Tests

Each car shall be tested for watertightness in both the completed shell and assembled car stages prior to pre-shipment inspection. All areas of the sides, ends, and roof of each car shall be given a complete test for watertightness. The first test shall be performed before the installation of sound deadening material, thermal insulation, and interior finish. The second watertightness test shall be conducted upon the completion of the final installation of all car subassemblies and apparatus but prior to the pre-shipment inspection. Water shall be sprayed from nozzles which are spaced no more than three (3) feet from and aimed directly at the surface being tested. The nozzles shall be positioned no more than 17 inches apart in an equilateral triangle pattern and shall produce an overlapping spray pattern. Not less than 0.625 gallon per minute shall be delivered to each square foot of the surface being tested, and the nozzle velocity of the water shall not be less than 150 feet per second. All spray applications for complete carbody assembly shall run for ten (10) minutes before the inspection for leaks and shall run continuously during the inspection. A local test can be used for parts leaking at the first test or that have been changed for any reasons. The local test will be conducted at a flow rate (0.625 gpm) and velocity (150 fps) equal to that used on the complete carbody assembly. Upon completion of the car, a spot test using localized nozzles shall be performed on the doors and windows. The Contractor shall submit as part of the watertightness test procedure an analysis of the water test fixture and apparatus demonstrating that all water nozzle pressures, amounts, and directions meet the requirements of this Section.

Certain equipment boxes, because of the nature of the equipment they enclose, may be required to be watertight. These boxes shall receive a water test similar to the watertightness test of the carbody. The watertightness test shall be performed on the individual boxes prior to installation under floor in a manner simulating the conditions as would be expected with the boxes mounted on the car and again during the test of the complete carbody. During the test of the boxes after installation, the required spray is to be directed at the exposed sides and ends of the boxes as would normally occur during car operations including car washing and as a simulation of water spray from the wheels. The water flow rate and velocity shall be as specified for the carbody water test.
18.4.2 Weight

The Contractor shall weigh each car and each truck at the time of shipment in accordance with TS 2.2. The weight of each end of the car shall be provided separately. A weighing device, which provides a permanent printed record of the weight, shall be used, and the weight tickets therefrom shall be submitted to the Engineer and copies thereof included in the car history book as detailed in TS 1.20 and recorded on the car marking plate as defined in TS 4.11.2.1.f.3). The weighing device shall be maintained within an accuracy of 0.2 percent. If the weighing device is electronic, it shall be calibrated at intervals of no more than 60 days. If mechanical, it shall be calibrated immediately prior to weighing the first car and annually thereafter. Any total car weight deviation of greater than 300 pounds from the weight of the pilot cars or other standard weight agreed to by the Contractor and the Engineer must be explained to the satisfaction of the Engineer prior to shipment.

18.4.3 Clearance Checks

Each car shall be measured and tested to assure compliance with the clearances specified in TS 2.2. In addition, the centering of the carbody with respect to the trucks shall be measured and corrected if necessary.

18.4.4 Trainline Tests

The Contractor shall verify the accuracy of each car's trainline connections by use of a test panel connected to each trainline and indicating that the proper trainline wires are energized when each of the various car controls (master controller, public address system, doors, etc.) is operated. This test shall be performed at both ends of each car. All spare trainline circuits shall also be tested. Where used, data communication trainline signals shall be tested for proper signal characteristics over the line end to end. A quantity of two (2) test panels shall become the property of SEPTA and delivered after trainline testing is completed on the last car. [CDRL 18-020]

With traction power disconnected, each controller and reverser shall be tested for the correct sequence of operation in both power and braking by operating both the master controller and reverser and observing the function of the various pieces of apparatus involved and the trainline signal response. Any component that fails to function in the proper sequence shall be repaired, and the test repeated until successful before proceeding with other tests.

18.4.5 Door Tests

All doors and their operating systems shall be tested and adjusted on all cars to assure smooth functioning, proper fit, attainment of the specified speed of operation, and proper functioning of controls, obstruction detection signals, cut outs, and interlocks. This shall include all locker doors, access hatches, and equipment boxes. All power operated doors shall be operated a minimum of 100 consecutive successful cycles. Initiation of the cycling shall be from the cab of each cab car and via an Engineer approved means for each trailer car to verify proper operation of the control circuits. Proper tension for opening and closing shall be checked on every door before and after the above test. Any door or door control failure occurring prior to completion of the test shall nullify the test requiring that it be repeated from the beginning following correction and documentation of the failure.
18.4.6 Car Wiring Tests

When all wiring is completed on each car, the Contractor shall test each wire to verify continuity and proper polarity, connections, and wire identification. A direct current insulation test shall then be performed on each car as listed below. Finally, the Contractor shall perform a high potential ground insulation test as listed below on all car wiring. All components and systems shall be in place when the high potential tests are performed except that electronic or other low voltage devices, which may be damaged by the test voltages, may be disconnected and their wire connections suitably jumpered. The Contractor shall jumper the various wires in a system to ensure that all parts of the system are tested. These tests shall be conducted at the Contractor’s plant to demonstrate compliance with the requirements of this Section prior to car shipment.

18.4.6.1 Wiring Continuity Test

All circuits shall be tested on each car to ensure continuity and correct polarity of equipment and devices. All wiring connections and terminals shall be examined for tightness.

18.4.6.2 Insulation Resistance Tests

Insulation resistance tests shall be conducted on all circuits within a device or system apparatus. Insulation resistance tests shall be conducted before high potential tests are conducted. Tests shall be conducted to verify the state of the insulation to the equipment case, between wiring of different voltage classes, and between the input and output circuit of high voltage by means of shorting jumpers if they are not inherently protected by the circuit in which they are used.

On items with double insulation such as resistor grids mounted on insulators to a frame insulated from the carbody, each set of insulation shall be individually tested, i.e., resistors to frame and frame to carbody. The following insulation resistance limits shall apply under all environmental conditions including high humidity when all circuits on the vehicle of a given voltage class are connected in parallel:

<table>
<thead>
<tr>
<th>Wire Class</th>
<th>Voltage</th>
<th>Minimum Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 volts</td>
<td>1000 volts</td>
<td>50 megohms</td>
</tr>
<tr>
<td>230 volts</td>
<td>1000 volts</td>
<td>25 megohms</td>
</tr>
<tr>
<td>37.5 volts or below</td>
<td>500 volts</td>
<td>5 megohms</td>
</tr>
</tbody>
</table>

The test limits for individual devices or apparatus shall be higher than the above listed limits as is appropriate for that hardware so that the limits for the completed vehicle can be met.
18.4.6.3 High Potential Tests

A high potential test shall be conducted after the insulation resistance test is completed and passed. The high potential test shall be conducted on all circuits within a device or system. Tests shall be conducted to qualify the state of the insulation to the equipment case, between the wiring of different voltage classes, and between the input and output circuit of high voltage line switches and circuit breakers. Semiconductor devices and lighting inverter ballasts may be protected against the test voltage by means of shorting jumpers if they are not inherently protected by the circuit in which they are used.

All components and systems shall be in place when the high potential tests are being performed. The Contractor shall jumper the various wires in a system to ensure that all parts of a system are tested and to prevent capacitive currents or fault currents from passing through and damaging low voltage devices.

On items with double insulation such as resistor grids mounted on insulators to a frame insulated from the carbody, each set of insulation shall be individually tested, i.e., resistors to frame and frame to carbody.

The test shall be conducted by applying the test voltage as listed below for a period of one (1) minute across the insulation being tested. The test shall be passed if there is no insulation breakdown or excessive leakage current. The test voltage shall be at a frequency of 60 Hz with a sinusoidal wave form. V in the formula below shall be the nominal system voltage for a circuit:

<table>
<thead>
<tr>
<th>Wire Class</th>
<th>Test Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 volts</td>
<td>2200 volts</td>
</tr>
<tr>
<td>230 volts</td>
<td>1400 volts</td>
</tr>
<tr>
<td>37.5 volts or below</td>
<td>500 volts</td>
</tr>
</tbody>
</table>

Standard apparatus may be production tested for one (1) second at a test voltage of 20 percent higher than the above listed one (1) minute test voltage. Alternative high potential test criteria may be proposed subject to approval by the Engineer.

18.4.7 Auxiliary Circuits and Equipment Tests

All auxiliary circuits and equipment shall be tested for proper operation and adjusted or corrected as required.

18.4.8 Heating Tests

The heating system including cab, windshield, and protective heaters shall be functionally tested in all cars. The operation of the thermostatic control system shall be demonstrated by test. Controls shall be checked and adjusted for even distribution and proper volume of heat. Heat shall be applied to the overhead heaters without airflow and a one (1) hour test shall be performed with the high limit control switch cycling.
18.4.9 Air Conditioning Tests
The air conditioning system shall be functionally tested in all cars. The thermostatic control system operation shall be demonstrated by test. All controls including the smoke detector shall be tested. All components shall comply with Engineer approved adjustments and parameters determined and/or confirmed by the climate room tests.

18.4.10 Headlight, Marker Light, and Auxiliary Light Tests
The headlights, auxiliary, and marker lights on each car shall be aimed and adjusted to meet the requirements of 49 CFR 229.125 and 49 CFR 221, respectively.

18.4.11 Communication System Tests
Each radio shall be tested and adjusted to meet all technical parameters delineated in TS 13 and TS 15. Additionally, the antenna shall be adjusted if necessary for conformance with its specified radiation pattern. The entire communication system (public address, radio, passenger emergency, cab intercom, train to wayside communication, onboard video surveillance, onboard dynamic advertising, passenger wireless internet (WiFi), and audio frequency induction loop including all car control logic/fault transmissions and train identification system) shall be tested for proper operation. Testing of the communication system from cab to wayside shall be conducted cooperatively with the supplier of the radio equipment. If these tests cannot be performed at the Contractor's plant, the facilities of SEPTA shall upon delivery of the cars be used at the Contractor's expense.

18.4.12 Friction Brake Tests
After the installation, connection, and cleaning of all piping, the piping shall be pressure tested in accordance with the latest edition of the Code for Pressure Piping, ANSI B31.1. All leaks which appear during pressure testing shall be repaired after which the system shall be retested until leak-free.

The Contractor shall perform a complete functional test of the friction brake system prior to the shipment of each car from their plant. This shall include, as a minimum, a test of command and load weigh signals, brake cylinder pressure settings, control and indicator tests, dead in tow operation, and leakage tests. Each car shall be subjected to an air leakage test prior to commencing the functional test of the friction brake system.

18.4.13 Parking Brake System Tests
Each car shall be subjected to a parking brake test. The parking brake shall be functionally tested to ensure full application with the specified activation force.

18.4.14 Destination Sign Tests
The destination sign system shall be completely and thoroughly tested on each and every car to demonstrate compliance with this Specification. All possible destination sign and message configurations shall be demonstrated.
18.4.15 Leveling Tests

The height of each corner of the carbody shall be measured from top of rail on a level section of track to check for proper carbody level with all air suspension components at proper design height. Side by side differences in height shall not exceed 0.25 inch. End to end differences in height shall not exceed 0.5 inch. When the carbody is leveled, all air bag pressures will be within one (1) psi of the nominal for the location and car type. The procedure used shall be approved by the Engineer.

18.4.16 Lubrication Checks

All lubrication points on the car shall be inspected for proper initial lubrication prior to shipment. All drain and fill plugs shall be lock wired, and all other fittings checked for proper configuration. Checking shall be followed by paint marking and shall be recorded with the type of lubricant used in the car history book.

18.4.17 Safety Devices

All safety devices including, but not limited to, ladders, Operator’s emergency valve, passenger’s emergency valve, emergency side door release mechanisms, and horn shall each be tested on all cars. Fire extinguishers, first aid kits, emergency tools, and auxiliary portable lighting shall be inspected for proper application.

18.4.18 Auxiliary Equipment

All auxiliary equipment including the 120 VAC and 74 VDC control circuits shall be tested for proper functioning on all cars.

18.4.19 Cab Signal and PTC

Prior to installation of the cab signal and PTC equipment, the Contractor shall verify the associated car wiring for accuracy, continuity, and insulation resistance prior to connecting energy carrying conductors to the cab signal and PTC equipment. Proper polarity and voltage shall be verified.

After installation of the cab signal and PTC equipment, a functional system test shall be conducted to verify proper installation and interface of the equipment.

During this test, all cab signal and PTC equipment and all interfaces shall be operated. This test procedure shall be submitted to the Engineer for approval a minimum of sixty (60) days prior to the scheduled date of the first test.

A record of the cab signal and PTC equipment (by serial number) installed in each car shall be made at the time of installation and shall be kept current by the Contractor until the car is accepted. This record shall be a part of the car history book.

Test reports of all tests conducted including discrepancies found, corrective action taken, and follow on action required shall be included in the car history book.
18.4.20 Load Weigh System

It shall be shown that the load weigh system recognizes weight changes in the car as well as determining that both empty and established parameters for the various loading conditions are met at all locations.

18.4.21 Monitoring and Diagnostic System

The monitoring and diagnostic system shall be tested to ensure that the system functions to meet all technical parameters defined in TS 16.

18.4.22 Automatic Passenger Counting System

The automatic passenger counting system tests shall include all technical parameters delineated in TS 13 and TS 15. A copy of test sheets with serial numbers of all equipment tested shall be furnished to the Engineer certifying that the standards listed in TS 13 and TS 17 have been met and that the method of measurement specified in the standards was followed in conducting the tests. [CDRL 18-021]

18.4.23 Wayside System Testing

Each wayside and Control Center component of the communication system installed under this Contract including the wireless local area network system, wayside diagnostic system, and all other communication and interface with the wayside shall be tested to verify that they function in accordance with the requirements of TS 13 and TS 16. The interface and functionality of the car networks, train to wayside system, and the wayside wireless local area network shall be fully tested.

18.4.24 Miscellaneous Tests

Functional tests shall be made on all cab functions and systems which interface with the cab and operator for proper operation as specified. All fault and failure operations and indications for all car systems such as door failures, overloads, system shutdowns, etc., shall be tested. Actual non-destructive failures shall be used. Simulated failures may be used with the approval of the Engineer. Included in this test shall be the cab information display system. This test shall include all levels of operations and maintenance displays and troubleshooting, information, warning, and indications. The specifics of this test shall be discussed during the design review stage.

18.5 CAR ACCEPTANCE TESTS

The following summary table is provided for convenience only and does not in any way alleviate the Contractor’s responsibility to ensure that all tests as required by this Specification are performed in accordance with the requirements listed herein:

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Performed By</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
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<td>Inspection and Repair Requirements</td>
<td>All Cars</td>
<td>Contractor</td>
<td>18.5.1</td>
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The tests specified in this Section shall be performed by the Contractor on SEPTA’s property. The tests shall be satisfactorily completed as a condition of acceptance. All tests shall be performed on all cars.

### 18.5.1 Inspection and Repair Requirements

After receipt of each car at the SEPTA site and before it is operated, it shall be carefully inspected jointly by the Engineer and the Contractor, and any part, device, or apparatus that requires adjustment, repair, or replacement shall be recorded by the Contractor who shall make such adjustment, repair, or replacement before acceptance testing is begun. All expenses and costs incurred in any necessary removal of the cars from the designated delivery point and their return there for correction of defects shall be borne by the Contractor.

### 18.5.2 Functional Tests

A complete orderly and comprehensive check of each and every vehicle system shall be performed to assure its proper operation before commencement of the test track operation. A SEPTA owned PTE shall not be used to perform any test. If any PTE is required, such PTE shall be furnished separately by the Contractor unless approved by the Engineer. Devices bypassed by the use of PTE (master controller, door open and door close buttons for example) shall also be functionally checked. The Engineer reserves the right to test/check the cars as deemed necessary.

### 18.5.3 Miscellaneous Tests

Auxiliary circuits and equipment shall be tested for proper operation. All interior and exterior car lighting shall be tested for proper function including emergency operation. The proper functioning of the radio and the automatic vehicle identification with SEPTA’s Central Control shall be tested. Any fault and failure operation and indication testing requiring road test and not completed under TS 18.4 shall be recorded.

Truck clearances, lengths, heights, and locations of electrical jumpers and any other end connections shall be validated.
Coupler installation shall be verified or adjusted to proper height and level.

Buffers shall be verified for proper alignment and level.

Air springs shall be leveled following the car leveling procedure in TS 11.8.2.

### 18.5.4 Cab Signal and PTS/ATC

Cab signal and PTS/ATC apparatus shall be road tested in operation to ensure that the systems are operating properly. A track loop simulator shall be used as the input of the cab signals for test purposes in the event coded track is not available. The over speed function shall be tested to assure proper functioning of the equipment. SEPTA and FRA cab signal test requirements shall be followed.

### 18.5.5 Car Performance Test

Performance tests shall be conducted by the Contractor on each car (except for the pilot cars if approved by the Engineer) according to the procedures given in TS 18.2 with the cars at AW0 load to demonstrate compliance with the requirements of this Specification, specifically TS 12.2 and TS 12.3, and shall be performed on SEPTA’s property and Amtrak’s NEC and Harrisburg Routes. These tests shall be conducted with the cars instrumented to monitor all parameters measured during the pilot cars’ testing. The performance of the cars shall be in accordance with the parameters and curves established with the pilot cars.

At SEPTA’s option, the cars shall be coupled with other rolling stock to verify compatibility during testing. The cab car may operate lead (push) or in trail (pull) mode with MU control of the locomotive.

The Contractor shall annotate all charts, reduce all data, prepare a written report, review them with the Engineer twenty-four (24) hours prior to car acceptance, fold the charts for envelope storage, and provide them to the Engineer within five (5) working days after car acceptance as part of the individual car log book.

Each car shall be subjected to the same group of tests. The performance tests shall include at a minimum:

- Full service braking
- Emergency braking
- Wheel slide
- Fault/status data transmission and cab message display
- No motion
- Monitoring systems

In addition, each car shall be subjected to a series of approved system functional tests including air system leakage tests to demonstrate proper operation of each car system. Trainline functional and performance tests (from both ends) to demonstrate proper operation of all appropriate trainline functions dynamically on the test track by mating with accepted cars shall be performed.
All defects found during performance and acceptance testing shall be promptly corrected by the Contractor prior to acceptance by the Engineer. These shall be noted in the individual car history book or the car log book. If any control logic of any system is modified, such modifications shall not be implemented until all documentation is approved by the Engineer.

**18.5.6 Operational Tests**

After completion of the car performance testing and adjustment work specified, each car shall be given an operational (shakedown) test using SEPTA’s operating and test crews. The operational test shall include 50 miles of operation of each car. The Engineer at their option may require that the instrumentation required by TS 18.5.3 be retained on the cars during this test. If in the Engineer’s opinion the quality and reliability of the previously accepted cars is at a high (or low) level such as to justify a reduction (or increase) in the test mileage, the Engineer may require adjustment at their discretion.

The test shall include simulated revenue operation with stops at every station. The side doors shall be cycled at each stop.

At the end of the operational test, an abbreviated car performance test AW0 only one (1) run from each category see TS 18.5.3 shall be performed and corrections made if necessary.

**18.5.7 Reliability Demonstration Test**

The purpose of this test is to establish a measure of system reliability and to demonstrate that the cars are free of design problems which could interrupt revenue service or which present hazards to property, personnel, and passengers. See TS 2.7 for additional reliability requirements.

Upon acceptance of the first seven (7) cars by the Engineer, the cars shall be operated as a train in revenue service for 600 hours without failure or service interruption. The Engineer may at their option couple and uncouple the cars and place them in differing relative orientations to exercise the couplers. The test shall be conducted through consecutive calendar days for a maximum of 20 hours per day as much as practicable. Failure of the cars to meet the test criteria at any time during the test shall result in the test time clock being reset to zero (0) and a new test begun but only after the redesign and the repair or replacement of the affected equipment has been completed.

SEPTA shall maintain and service the cars in accordance with maintenance schedules and procedures submitted by the Contractor and approved by the Engineer. Time for inspections and/or equipment maintenance and repair shall not be included in the test time. If any repairs or adjustments to the cars are required beyond those required by the approved maintenance procedures, they shall be considered failures. The Engineer reserves the right to make additional inspections to determine if failures have occurred.

Representatives of the Engineer, the Contractor, and major subcontractors shall be present when the reliability tests are conducted. The Engineer and the Contractor shall maintain separate logs which shall be used to document individual observations. All defects, failures, improper operations of an assembly, subassembly or component, and service interruption shall be recorded, and the Contractor shall take immediate corrective action.
The Contractor shall install (at their expense) instrumentation on the cars to monitor the proper operation of various systems during the test period.

A separate report for each failure or malfunction of equipment shall be prepared by the Contractor indicating the reason for the failure, the repair required to correct the condition, and where applicable corrective action is required to prevent similar subsequent abnormal operation and failures. These reports shall be reviewed and evaluated by the Engineer. Final acceptance of the repair or corrective actions and in the case of dispute the decision as to what constitutes failure or interruption in this test shall be made by the Engineer.

Depending on the season prevailing during the reliability test, the heating or air conditioning portion of the HVAC system shall be similarly tested. Upon the change of season, the untested portion shall be given its thirty (30) day reliability test.

In the event that a failure occurs in one (1) system under test causing an interruption in the reliability test, it shall not be considered an interruption for the other systems under test.

**18.5.8 Fleet Reliability and Availability Test**

The complete operational car fleet shall be monitored by the Contractor to demonstrate conformance with the reliability and availability requirements of TS 2.7 and TS 2.8 for a period of 24 months starting after the acceptance of the last car. On a monthly basis, the Contractor shall issue a report detailing the performance of each car and its equipment with regard to maintenance (which shall be detailed in an appendix by type), availability, and cumulative mean distance between failures (MDBFs) over the calculated period. Any component(s) found to cause the whole car and/or related subsystem MDBF to fall below the required performance level shall be subject to redesign and modification. During the period such efforts are carried out, failures due to these component failures shall not be counted. However upon completion, the modified car and/or subsystem shall be monitored for a period of no less than three (3) months or the remaining base period, whichever is greater, and the MDBF and availability requirements shall be achieved. If the use or failure of the component is weather or temperature related, the three (3) month period shall include those calendar months during which such use or failure is incurred. It shall be understood that the total test time period shall not be assumed to be 730 consecutive calendar days in the event that modification is required.

Following a satisfactory completion of the test for all subsystems, the Contractor shall issue a final report summarizing the results and with all interim reports appended for completeness.

If a satisfactory completion cannot be obtained before the end of the specified warranty period, the Contractor and SEPTA shall resolve any outstanding issues in accordance with the Contract terms and conditions.

Any failure in the fleet reliability and availability test shall be included in the fleet defect calculations (see Contract Documents).
18.6 PILOT CAR TESTING

The pilot cars shall be subject to all tests listed in this Specification including TS 18.2.1, TS 18.2.2, TS 18.2.3, TS 18.3, TS 18.4 and TS 18.5 unless specifically stated otherwise. The pilot cars shall be used to determine the baseline subject to approval by the Engineer of all system performance and quality.

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<th>Reference Paragraph</th>
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<td>All</td>
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<tr>
<td>18-002</td>
<td>Car Test Logs</td>
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<td>18.1.3.1</td>
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19 MANUALS AND TRAINING

19.1 GENERAL

The Contractor shall provide detailed education and training, plans, drawings, publications, and spare parts lists required for preventative maintenance, troubleshooting, repair, overhaul, and testing for all carborne elements and individual systems and operation of the car.

SEPTA considers the publications and related education programs, which will accompany the cars, to be of great significance and a major responsibility of the Contractor. Accordingly, all publications and education program activities described in this Contract shall be produced by an approved experienced third party American based subcontractor with professional technical writers that have had previous experience, under contract to a U.S. industrial firm or government client, in the preparation of publications for a rail transit car procurement or a commercial/military project of equal or greater magnitude and complexity.

Maintenance and operation manuals shall be the basis of all training. Each of these manuals shall include a high level of detail and illustrations sufficient to instruct students that are new to the railroad industry. Since many of the students will be inexperienced, the Contractor and supplier of the technical manuals and training guides shall not assume prior experience, however, it may be assumed that they have a basic knowledge of their craft (electrician, mechanic, welder, etc.).

The Contractor shall designate a technical document oversight team of in house personnel dedicated to the organization, interface, coordination, and flow of information from the originator of the equipment and the Contractor’s integration of the car as a whole. The personnel shall monitor, evaluate, and edit the level of completeness for each manual and have direct interface with the Contractor’s engineering department for integration issues. Third party developers and suppliers shall assure that submittals provided to SEPTA for review are complete in terms of being a finished professional product.

The Contractor shall facilitate any and all manual information changes associated with technical changes performed on the cars, after the initial acceptance of both the electronic and/or published versions, through the extent of the Contract and warranty period of the last car.

SEPTA shall have the right to duplicate and alter all manuals, training materials, training aids, and tools delivered by the Contractor. These manuals and training materials shall be considered to be the physical and intellectual property of SEPTA and free from patents and/or copyright restrictions.

19.2 MANUAL DEVELOPMENT PROPOSAL

Due to the need for technical information and training prior to the arrival of the cars, 180 days after Notice to Proceed, the Contractor shall submit an organized proposal on how the Contractor shall control the development of technical manuals and training guides required in this Specification in a timely fashion.
The proposal shall include flow of information from the originator of the equipment to the Contractor’s integration of the car as a whole as coordinated by the Contractor’s technical document oversight team per TS 19.1. Emphasis shall be placed on manual development as the initial stage and lead into the development of training documents as the manuals are developed.

The proposal shall include a full description of the planned activities and the coordination thereof. It shall contain written directives, flow chart schedules, and contain a CPM to identify the critical path relationships for all involved parties during the development.

The proposal shall be submitted to the Engineer for review and approval. [CDRL 19-001] Once approved, it shall be considered to be the official development plan. The plan shall be actively used as a coordination tool during the development of the material until final delivery of all deliverables.

19.3 MANUALS

19.3.1 General Requirements

All manuals shall be professionally developed as required in TS 19.1. Each volume, chapter, section, and subsection shall be written using the same organized format, level of detail, and in the aspect of “single voice” which will be defined as group writing with the same tone, language and inflection as if a single author developed the manual. All text must be in American (U.S.) vernacular.

Where applicable, the manuals shall highlight the precautions to be taken by operating, service, maintenance, and/or repair personnel to ensure their safety while performing the procedures described. Such items shall be applied using ANSI Z536.6 requirements.

All material used in the preparation of the manuals will be reviewed by the appropriate departments to assure that adequate information is included to satisfy the requirements of the training program as described in TS 19.1. All manuals shall be written in a full level of detail to fully explain the working of the systems and their components as applied to the car’s design. Systems shall be fully explained within the context of their integration within the car in respect to interfacing any other system and/or car wiring, applications, or controls. It shall be the Contractor’s responsibility to have the input of the Contractor’s design team to have hands on direct involvement in the explanation of the integration of such systems into manuals during the design review process.

Manual format throughout the documents shall be consistent from subsystem to subsystem. Individual stand-alone manuals presented by suppliers are not acceptable. All text and illustrations shall meet the requirements of this Specification and shall be incorporated, as applicable, into the manual sets being provided by the Contractor and/or third party developers. Primarily, illustrations used throughout the documents shall be sharp clear black line graphics. The “weight” of the line art (thickness of the line) shall be consistent throughout the illustrations.
The use of color and/or photographs may be used only where explicitly approved by SEPTA. They must first pass a test of being printed in black and white via ink jet printer, laser printer, and copier and found to have no loss of detail in the supporting text it is illustrating. Where color is used to differentiate categories, status, or screenshots of software monitors, the colors must be chosen so that if printed in black and white, the categories or status and/or nature of the screenshot must be easily identifiable and clearly understood. Photographs being submitted for approval by SEPTA shall reflect full details of the items meant to be shown; shall have professional properties with special detail given to contrast where they are not blended into the background or flared by flash and maintain the clarity and detail of the subject when printed out in gray scale and tested as mentioned above.

There shall be no visible pixilation of any line art, photo, or screenshot included within the files.

Manual requirements for microprocessor based systems are covered in TS 17.30.6, and they shall follow the guidelines for format, editable masters, and electronic versions.

19.3.2 Format

Main manual sets shall be grouped by volumes based on their content as identified in TS 19.3.6. Each volume shall contain individual chapters. Although hard copy publication will result in a single volume, all authoring software files and subsequent PDF copies shall be individual stand-alone files. Sections and subsections of each chapter shall be numbered starting with the number in a numeric or alpha-numeric sequence to delineate the hierarchy of the document. The Operator’s manuals’ content may differ from the maintenance manual content; however, all other maintenance manuals shall be developed using the following general format:

19.3.2.1 Title Page

The title page shall identify the SEPTA fleet type and the type of volume (Running Maintenance, Illustrated Parts Catalog, etc.) of the individual manual chapter. It shall contain a list of all chapters included in the volume. The subject of the individual section shall be highlighted in large bold text. The sheet shall also contain the SEPTA logo. The Contractor’s logo is permitted but may not dominate the page or the SEPTA logo.

19.3.2.2 Front Matter

In the front of each section, the following information shall be supplied:

a. List of Effective Pages – This page shall reflect the total number of pages for the chapter and the revision level of the main sections of the chapter such as front matter, technical data, front and back covers, etc.
b. Record of Revisions – The record of revisions is meant to be a record of each revision incorporated in the document. The Contractor may use this to record draft submittals to SEPTA; however, upon conditional approval or full approval, the revision level shall be reset to zero (0) and entered into the table as such. Any changes/updates by the Contractor after the initial approval shall be listed individually by subject within the record of revisions’ table with the appropriate revision number. (Example: the first update revised four (4) subjects. Each subject would be listed and the revision level would be increased to “A” since they were changed at the same time.)

c. Table of Contents – The table of contents shall be generated by the authoring software and be complete down to the lowest level of hierarchy.

d. List of Figures – Each figure (illustration) shall be numbered sequentially and listed within the table.

e. List of Tables – Each table found in the technical portion of the chapter shall be consecutively numbered and listed within the table.

f. List of Abbreviations – All abbreviations and/or acronyms used within the chapter shall be listed and defined.

Note: All table entries shall be bookmarked in the PDF version as an alternate aid in navigation of the electronic version of the manual set.

19.3.2.3 Technical Content

The body of the technical content shall be broken down into basic sections as follows:

a. Introduction – The introduction shall contain a general description of the subject or system in layman’s terms and include safety precautions, warning notices, and notes pertaining to the subject of the chapter. Safety precautions and alerts shall be reproduced within the associated procedures, as applicable, throughout the maintenance related chapters.

b. Operational and Functional Description – This section shall describe the integrated operation of the subject within the car’s design then introduce the major components of the system and provide detailed information of their function and purpose.

c. Troubleshooting – The troubleshooting section shall be split into two (2) subsections for system type chapters. The first section shall contain detailed troubleshooting information based on the system’s integration into the car and will cover car wiring, power, and any interfacing points with other systems. The second subsection shall contain the troubleshooting of the system’s equipment as supplied by the supplier both with and without any portable test device. The troubleshooting charts shall contain the symptom, probable cause, test, and checks for fault isolation and detailed corrective action.
d. Corrective Maintenance – The corrective maintenance section shall contain subsections of detailed instructions for the full repair, adjustment, removal, and installation associated with the subject of the section. Special attention shall be given to adjustment details to ensure they are easily understood and of sufficient detail so that adjustments can be made by inexperienced personnel. Each subsection shall contain a table where the consumable items special tools needed for the work can be listed. Special tools shall be other than a basic tool kit (sockets, wrenches, pliers, screwdrivers, etc.). Where some system components have been allowed metric hardware, “metric tools required” shall be noted in the special tools’ section of the table.

e. Preventative Maintenance – Procedures for all preventative maintenance requirements associated with the maintenance allocation chart shall be included in this section. The procedures shall be divided into subsections based on their calendar scheduled events as required by the system. The format, content, and level of detail shall be the same as required for the corrective maintenance section.

f. Portable Test Equipment – In system related chapters where portable test units (PTUs) will be used to troubleshoot or adjust parameters, a devoted section shall be included in the system’s chapter describing the full functionality of the unit and detailed instructions for its use.

g. Testing – A full system’s test shall be included. The test shall include step-by-step sequential details to fully test and confirm operation and include a test data sheet for recording the test. Any step requiring a particular value and/or tolerance shall be included in both the instructions and the data sheet.

h. Appendix – An appendix section shall be included with each chapter where any associated information to the chapter’s subject may be added. At a minimum, each appendix shall contain a torque chart for fasteners. The torque chart shall contain both wet and dry torque values. If some fasteners require additives such as anti-gauling or locking solutions, instructions shall be included to use the wet torque value.

19.3.3 Procedural Verification Program
The Contractor shall submit details for a proactive program for physically checking and evaluating all troubleshooting steps and adjustment procedures found within the running maintenance volume’s chapters. The program details shall be submitted to the Engineer on or before the design review mock up program. [CDRL 19-002] The program shall be completed prior to the video recording of such events per TS 19.4.7 and the completion of the pilot car programs. [CDRL 19-003]

19.3.4 Electronic Media for Manual Development
Multiple types of software shall be used in the development and production of electronic copies as follows:
19.3.4.1 Authoring File Software

Professional over the counter technical document software such as Adobe FrameMaker shall be used in the development of the manuals. Any other software will be subject to SEPTA approval. Any alternate software proposed must have the capability of auto generation of PDF bookmarks based on the document’s style setting when distilled into a PDF. The use of word processing programs shall not be used. The Contractor shall supply two (2) licensed copies of the software to the Engineer for SEPTA’s use. [CDRL 19-004]

19.3.4.2 Portable Document Format (PDF) Software

Distillation of authoring files into PDF documents for submission to SEPTA must be performed using Adobe Acrobat Pro. SEPTA has experience where PDFs produced by alternate PDF generating software have not been totally compatible with all Adobe Acrobat features used by SEPTA. All manual chapter files shall be fully bookmarked and available in the navigation window when viewed by the PDF viewer software. The properties of each file shall be set to show both bookmarks and page during the initial opening. All files shall be “tagged” for easy copying of text. No scans will be allowed, and all information must be distilled from the authoring file software. PDF chapter files shall contain spacer pages stating “Intentionally Left Blank” so that when printed double sided, the first page of the table of contents and the first page of each major section will end up on the right hand page.

19.3.4.3 Illustration Formats

Copies of all black line illustrations, whether two dimensional, isometric, or exploded view developed by the Contractor or supplier, shall be submitted in editable CAD format files. Any and all photographs and screen shots shall be submitted in high resolution JPG formatted files. Each photographic file shall be its original size before being adjusted for insertion into maintenance documents. The Contractor shall provide a separate electronic copy of each photographic file used in the manual after corrections to contrast and touch ups have been completed. Complete sets of illustration files shall accompany the authoring files when submitted to SEPTA as part of the approved version’s deliverables.

19.3.4.4 Printing Format

Electronic versions shall be set up to be printed in such a way that the printed file shall resemble a professionally published book. Each table of contents, the first page of each chapter and the first page of the second level major subsections shall automatically end up as “right hand pages” when printed double sided. This shall be achieved by the use of spacer pages stating “Intentionally Left Blank” which are inserted during the print process.

19.3.4.5 VTIL System Software

All manual and training documents will be integrated into SEPTA’s online Vehicle Technical Information Library (VTIL). The Contractor will not be responsible for adjusting maintenance and training documents for the integration into VTIL, however, the Contractor shall supply a single license for TRS Toolbox Professional as provided by Computer Sciences Corporation for this purpose. [CDRL 19-005]
19.3.5 Hard Copy Publications

All maintenance manuals and training documents shall use a loose leaf format. The paper shall be 100M non-reinforced 8.5 x 11 inches using a vertical format except for foldouts which shall be 11 x 17 inches. Diagrams shall not be loose in pockets. The binders shall be heavy duty vinyl three (3) post holes with clear front and spine pockets for display of printed manual designation inserts. A complete table of contents shall be given at the beginning of all manuals and a complete page numbered index at the end. Plastic coated tabs shall be used to segregate sections within each manual.

Electronic and pneumatic schematic publications shall be supplied in 11 x 17 format. Volume covers, front matter, and text information such as introductions, tables, etc., shall be in landscape format to be consistent with the schematics. Any dialog text that would normally be published in standard letter format may be dealt with by the use of two (2) side by side columns within the horizontal format to simulate an 8.5 x 11 format.

The Operator’s manual shall consist of a page size of 6.75 inches wide by 3.875 inches high and be presented in a horizontal format. The manual binders shall be of a lightweight plastic and bound using hardware which can easily be opened for page revisions. The binders shall over extend the page and allow for protection of edges of the pages and tabs.

19.3.6 Manual Types

Manuals shall be categorized by type and intent. All manuals shall display knowledge of standard practices conforming to SEPTA’s safety requirements.

When the type of manuals requires multiple subjects or chapters, it will be considered as a “Volume”. Electronic versions of the chapters shall be based on individual files. The following volumes and manuals required for this program are summarized as follows with specific details found below:

a. Operating Instruction Manual  
b. Volume 1 – Scheduled Inspection and Preventative Maintenance  
c. Volume 2 – Running Maintenance  
d. Volume 3 – Integrated Electrical and Pneumatic Schematics and Tables  
e. Volume 4 – Heavy Maintenance and Repair  
f. Volume 5 – Illustrated Parts Catalogs  
g. Volume 6 – Bench Test Equipment Repair Data and Procedures  
h. Software Book  
i. Engineering Data and Structural Repair Procedures Manual

19.3.6.1 Operating Instruction Manual

This manual shall contain all information needed by the engine crew covering the operation of the car. This shall include preparing the unit for operation and securing the unit from operation.

This manual shall be collaborated with SEPTA’s Operations Division Transportation and Mechanical Departments to include full approval.
The content shall consist of clearly defined descriptions and instructions with black line drawn illustrations identifying the equipment and supplementing the text where needed. All emergency procedures and safety precautions of a specific nature shall be included. The manual shall give troubleshooting and diagnostic procedures sufficient to isolate problems which are capable of reset by engine crews and arranged in a format to allow ease of use under emergency and time sensitive situations.

The manual shall be published as outlined in TS 19.3.5

This manual shall be extensively indexed by operation and component identifying technical descriptions and associated corrective actions for each.

19.3.6.2 Volume 1: Scheduled Inspection and Preventative Maintenance

This volume shall contain the following:

a. Detailed inspections required by the Contractor, system component suppliers, and/or FRA 49 CFR statutes consisting of preventative maintenance instructions and associated testing procedures and associated forms. The inspections shall be organized by the date requirements for the event such as daily, 92 day, 184 day, yearly, etc.

b. Lubrication requirements: listing of all lubricants including names of manufactures, the frequency, location; and type of lubricants for various components

c. Removal and installation procedures for consumables and replacement items

d. Installation and removal of equipment, in full detail, on a unit exchange basis

e. Detailed inspection tasks and servicing information and procedures including all measuring, gauging, and testing involved

f. The weights of all components of the car and assemblies that weigh more than 50 pounds

g. Supply and tool list

h. Carbody and truck hoisting and jacking instructions

19.3.6.3 Volume 2: Running Maintenance

This volume shall contain sections/chapters that provide a detailed description and analysis including the theory of operation of each subsystem, troubleshooting, and corrective maintenance procedures as defined in TS 19.3.2.3. Any maintenance activity deemed to be in excess of eight (8) hours to complete using a normal crew shall not be included. Such procedures will be added to the heavy repair volume. Running maintenance chapters shall include, but not limited to:
Section 19 Proposal Copy Revision 0

Southeastern Pennsylvania Transportation Authority
Multi-Level Car Technical Specification
Manuals and Training

a. Car system operation write up based on the integrated schematic manual, see TS 19.3.6.4
b. Carbody exterior
c. Car cab and interior
d. Lighting
e. Computer system
f. Cab and locomotive control
g. Operational safety systems
h. Monitoring and diagnostics systems
i. Door controls
j. HVAC
k. Communications
l. Auxiliary power
m. Coupler and draft gear
n. Friction and electric brake
o. Trucks

19.3.6.4  Volume 3: Integrated Electrical and Pneumatic Schematics and Tables Manual

The schematic manual shall be an integrated schematic defining the electrical and pneumatics arrangement and interfacing of the various car subsystems. The manual shall be in 11 x 17 format as described in TS 19.3.5. To facilitate double side printing, blank pages marked “Intentionally Left Blank” shall be inserted so that the first page of the section shows on the right hand page when bound. This manual set shall consist of three (3) parts; Part A, Part B, and Part C.

19.3.6.4.1  Part A – Narrative

Part A shall include:

a. A general description of what is included in the Integrated Electrical and Pneumatic Schematic volume and their intended use.

b. A list of symbols

c. A sample of how to interpret the schematic diagram

d. A sample of how to interpret the car wire/cable list

e. A device list of all apparatus including symbols, ratings, etc. Each device shall be listed by its name and/or number (such as terminal boards or multiple switches, etc.)

f. A simple location system shall be established for all components, devices, terminal strips, and junction boxes using a simple coordinate system (such as A-6) preceded by a prefix to indicate area or level in the car (R A-6 would be zone A-6 of the roof).

g. Information shall be supplied for all diagnostic test equipment
19.3.6.4.2 Part B – Schematics and Wiring Diagrams

Part B shall consist of two (2) major parts:

Full car internal car schematics – the schematic diagrams shall be comprehensive enough to allow troubleshooting down to the lowest replaceable unit. They shall contain sufficient information to easily troubleshoot and repair the car systems.

The schematic diagrams shall detail all electrical, electronic, and pneumatic systems and include all components, wiring, and piping on the car. It shall be possible to trace all signals through subsystems, systems, car wiring, and trainlines. Circuit identifications shall include, but not be limited to, waveforms, voltages, current and pressure for electrical, and electronic and pneumatic circuits. All wiring terminations shall be identified by connector and terminal or pin number for all connections.

The schematics shall be sorted by subject area or system/subsystem. Detailed trainline jumper/circuits shall be considered to be an individual subject and included within the sort.

Component wiring diagrams – all wiring diagrams internal to system/subsystem components, vendor components such as switch panels, relay panels, power distribution panels, etc., shall be provided in a second section of the car schematic package. They shall reflect all internal wiring and be suitable for tracing circuitry during troubleshooting. Component wiring diagrams shall also include the identification of the wire types and terminals used.

19.3.6.4.3 Part C – Car Wiring Lists

Part C shall include a complete wire/cable list showing point to point applications for each circuit arranged in tabular form. Separate tables shall be provided for each type of car.

The table shall include the following information:

a. Cable number
b. Cable type
c. Cable size
d. Color
e. Related drawings (schematic number)
f. Class
g. Circuit revision
h. Symbol
i. Total length for each point to point in inches and feet
j. Equipment association
k. Connector or terminal board designation
l. Pin or terminal number
m. Termination used (pin, lug, ferrule, etc.)
n. Bundle or harness assignment
Due to the amount of columns, the Part C manual shall be formatted the same as Parts A and B. The published version found in the manual shall be sorted by the cable/wire number. The wiring list table shall be formatted in an MS Office Excel file capable of filtering and sorting. The master file shall be provided to SEPTA as part of the master authoring documents sets.

19.3.6.5 Volume 4: Heavy Maintenance and Repair Manual

The heavy maintenance and repair manual shall contain a detailed description and analysis of all replaceable assemblies/subassemblies so that SEPTA's overhaul facilities can effectively and safely service, inspect, adjust, troubleshoot, repair, overhaul, and test these assemblies. All systems and associated components referenced from a thorough review of TS 19.3.6.3 shall be included within the manual set.

The Contractor and its suppliers shall provide all information needed for comprehensive repair and overhaul work to satisfy SEPTA's needs. The information provided shall be at least as comprehensive as that used by the suppliers' own service and repair shops whether the parts were manufactured by them or purchased from others. The manual shall provide information for the test, repair, and overhaul of each repairable component of the assembly down to the lowest level of replacement component. No component shall be considered as a throwaway item or deemed unrepairable except where agreed to by SEPTA.

The manual shall include:

a. Disassembly and/or removal instructions from the car. Weights shall be included.

b. Description of how each assembly/subassembly operates within the car system. Each shall include:
   1) Block diagrams
   2) Signal flow diagrams
   3) Simplified schematics
   4) Functional wiring and piping diagrams
   5) Completely detailed overhaul procedures

c. Test and evaluation procedures equivalent to that performed by the original manufacturer including the requirements for specialized test equipment with sufficient information for SEPTA to procure or fabricate such test equipment

d. Rewinding procedures in full detail for all rotating and wire wound apparatus except as otherwise agreed to by SEPTA

e. Complete instructions for use, drawings, and parts information for special tools so that they may be procured or fabricated by SEPTA
f. The weights of all components and assemblies that weigh more than 50 pounds. In addition, the weights of major component assemblies shall be supplied (e.g., truck, air conditioning module, air compressor).

g. Maintenance and repair of all diagnostic test equipment

The above items shall be organized by subsystem and/or function and shall be suitable for use in training programs. Where sufficient clarity of detail cannot be provided due to format size constraints, large scale originals shall be supplied and reference to these shall be made on the reduced size material. Isometric drawings shall show routings and locations of piping, wiring, cabling, and associated apparatus as accurately as possible with supplementary callouts and views to establish where the item may be located. Diagnostic test equipment usage shall be incorporated in the procedures in addition to providing procedures using generic test equipment. Schematics shall include an interface between subsystems and related equipment schematics. The schematics shall, where applicable, show pressure, volume, voltage current values, as well as wave forms. Completeness and accuracy shall be stressed.

19.3.6.6 Volume 5: Illustrated Parts Catalogs

The parts catalogs shall enumerate and describe every item used on the car along with the diagnostic test equipment and special tools with its related parts. All parts shall be included including materials down to the subcomponent levels of electronic printed circuit boards potentially used during repairs. Parts that are available on the common market ("brand name" items) and/or typical supply house catalog items shall be identified with the original manufacturer’s name and part numbers or the catalog supply house catalog numbers.

Each listing shall include the accepted generic modified noun name description, the original supplier, its part number and name, the Contractor’s part number, all commercial equivalents, and provision for entry of SEPTA’s class and lot number within the IPC’s format. An appendix giving the original supplier’s complete address and telephone numbers for their offices responsible for parts ordering shall be included. Email addresses for general inquiry or ordering parts shall also be included. Each component that can be disassembled shall be broken down in illustrations to its indexed parts.

Commercial items that have been reworked by the Contractor must be delineated on an "altered" or "modified" part drawing. This drawing shall list the manufacturer's part number and describe how the item has been modified. SEPTA shall decide whether to purchase a modified item from the Contractor or process it in house.

Computer prepared letter quality text (indented format) with line art work using exploded isometric view drawings of assemblies shall be used to permit identification of each and all parts. Illustrations shall be on a subcomponent level (vs. full component) and accompanied by an associated table. Identical parts regardless of where used shall have one (1) part number. Each part or other item shall be identified as being part of the next higher assembly. In the case of hardware such as nuts, bolts, washers, and similar hardware, information relative to material, coating if any, all dimensions, and type shall be included. All assemblies shall be listed alphabetically by name with reference to the corresponding figure number.
If the same drawing is used in both the illustrated parts manual and either the running maintenance or heavy maintenance and repair manuals, the reference index in both manuals must identify the same parts.

The Contractor shall also supply three (3) complete sets of the illustrated parts manual text database along with the approved data management software for its use licensed to SEPTA in compliance with TS 19.3.4.

### 19.3.6.7 Volume 6: Bench Test Equipment and Repair Data and Procedures

As part of the scope of this Contract, the Contractor shall be responsible for providing full bench test equipment procedures to repair electronic circuit boards within all system components found within the car.

Detailed instructions written to a level as used by the supplier in their own repair facility must be supplied by the supplier and Contractor sufficient to diagnose, repair, and test each board. Circuit board schematics, diagrams, part requirements (referrals to the IPC), software and firmware chipset identification, instructions for use of any special software for diagnosis, and special tool lists must be supplied.

The bench test equipment manuals shall be presented as a separate Part B of the associated system’s HRMM chapter within the Heavy Repair and Maintenance Manual.

### 19.3.6.8 Software Book

One (1) complete set of all program software documentation for the car shall be supplied to SEPTA in accordance with TS 17.30.6 as a reference document for SEPTA’s exclusive use. This restricted data shall not be included in other publications listed in this Section. Data shall be kept up to date as required for other publications per TS 19.3.7. Documentation software shall be developed using Adobe FrameMaker and provided in electronic PDF file form and published version as required in TS 19.3.9 and will be subject to SEPTA’s approval. [CDRL 19-006]

### 19.3.6.9 Engineering Data and Structural Repair Procedures Manual

The Contractor shall provide lower level drawings in sufficient detail to enable fabrication or reconstruction of cosmetic and structural members and materials of the carbody and trucks along with all relevant wiring, piping, schematics hardware appointments, and any other relevant information for purposes of wreck repair, including but not limited to:

- **a. Carbody information**
- **b. Materials**
- **c. Damage evaluation, trim back, parts salvage**
- **d. Structural repair**
e. Shop practices

f. All weld procedure specifications (WPS sheets), etc.

g. Procedure and list of all disconnections to sensitive electronic equipment required to perform welding repairs on the car

h. Full drawing tree of all structural drawings and components

19.3.7 Changes and Revisions
Following the approved draft issue of each manual and continuing with the final approved version, the Contractor shall provide revised pages within 90 days of the need for change being established covering any changes whether required by field modification instructions, engineering change notices, equipment modification, change of design, drawings or procedures, incompleteness due to error, or any other reason. The manuals shall be kept current during the warranty period interpreted as that of the longest warranted part of vehicle. Manuals shall not be considered complete or final until all revisions required due to changes or modifications have been included by the conclusion of the warranty.

19.3.8 Manual Review Process
As manuals or volume chapters are created, refined, and edited by the Contractor’s manual oversight team, the electronic PDF file may be submitted for review. If upon a cursory review by SEPTA the manuals are found not to significantly meet the requirements of format or level of detail, the manuals shall be rejected. It will be the responsibility of the Contractor to schedule a meeting with all interested parties including the oversight team and third party developer representative and/or supplier with SEPTA as soon as possible to rectify the problems found.

Manual files meeting the cursory review standards shall be officially commented on by SEPTA through normal Contract correspondence. Revised manual files shall be returned with all changes noted by change indicators located in the margin. Once a manual file has reached a potential conditional acceptance status, the Contractor shall be notified at which time all change indicators and any draft revision levels shall be removed. The revision sheet shall be reset to zero (0) with a notation and date of the original acceptance date. Any future changes due to errors, engineering changes, procedures, clarifications, etc. shall be recorded by individual subject in the revision history table.

19.3.9 Manual Delivery Schedule
180 days after Notice to Proceed, the Contractor shall submit a manual development overview proposal with schedule as defined in TS 19.2. [CDRL 19-007]

The Contractor shall start to initiate submissions of complete draft technical manuals no later than 360 days prior to the scheduled delivery of the pilot cars. [CDRL 19-008]

Draft copies of the Operator’s manual, QMP training guide, and maintenance related training guide shall be submitted to SEPTA for review and approval no later than 200 days prior to the scheduled delivery of the pilot cars for review and approval. [CDRL 19-009]
Ninety days prior to the scheduled delivery of the pilot Car, 200 advanced published copies (200/500 total) of the final approved draft of the operating instruction manual and one (1) approved electronic PDF version of each QMP training guide and appendices shall be delivered to SEPTA. [CDRL 19-010]

Sixty days prior to the scheduled delivery of the production car, an electronic set of the final approved draft of the running maintenance manual shall be delivered to SEPTA. These manuals shall be used for operation and maintenance of the first unit. Any errors discovered shall be corrected in the approved version. [CDRL 19-011]

Thirty days prior to the scheduled delivery of the first production car, one (1) copy of the approved electronic media (in accordance with TS 19.3.4) used in the preparation of the operating instruction manual, running maintenance manual, heavy maintenance and repair manual, integrated electrical schematic manual, integrated pneumatic diagram (schematic) manual, illustrated parts manual, and structural repair procedures manual shall be delivered to SEPTA. [CDRL 19-012]

Electronic versions shall be used during the start of the program with exception of the Operator’s manual. Published copies of the remaining final approved manuals with all information complete in the quantities listed below shall be delivered prior to the delivery of the 25th car to allow for any and all changes incurred during the commissioning of the pilot cars and early revenue service operation while the remaining cars are in production. A full set of updated documents in electronic media shall also be provided at the same time. [CDRL 19-013] Prior to the conclusion of the warranty, the Contractor shall supply to SEPTA a complete set of authoring electronic media documents and camera ready master sheets including art work for every manual. Documents should be in Adobe FrameMaker and PDF format. [CDRL 19-014]

The below is a list of manuals and the number of copies that are required:

   a. 500 copies (minus 200 advanced copies) – Operating Instruction Manual
   b. 10 copies – Running Maintenance Manual
   c. 10 copies – Heavy Maintenance and Repair Manual
   d. 40 copies – Integrated Schematic Manual sets
   e. 20 copies – Illustrated Parts Manual
   f. 5 copies – Structural Repair Procedures Manual
   g. 2 copies – Software Manual

19.4 TRAINING

19.4.1 General

The Contractor shall provide a SEPTA approved user training program. This program shall provide adequate coverage to ensure safe and satisfactory operation, servicing, troubleshooting, maintenance, and overhaul of the cars and all other furnished equipment such as diagnostic and shop testing equipment.
The Contractor may assume that SEPTA's maintenance personnel have the basic skills pertinent to their crafts and a high school education. When creating lesson plans and content, the Contractor shall also assume that such students will be new to the car equipment and its associated systems. Instructional content shall be sufficient to include the context of the subject matter along with theory of operation, troubleshooting, corrective actions for repairs, and preventative maintenance instructions. The manuals listed in Section 19.2 shall be used as the major element of the training program.

SEPTA and training subcontractors of the Contractor shall have access to all facets of car manufacture and component construction for the purpose of evaluating and/or reviewing training programs. This shall include, but is not limited to, the taking of photographs and video taping to supplement training programs. Such access shall be granted upon advance notification (five (5) days) with the sole purpose of gathering information for training, repair, and maintainability of said equipment.

SEPTA shall have access to the cars during performance testing for the purpose of getting hands on experience with their operating characteristics.

19.4.2 Scope

The training program shall employ a combination of formal classroom instruction and "hands on" training using either actual car equipment or partial subsystems or components to allow the introduction of faults, fault diagnosis procedures, and repair techniques.

The training program shall be designed to be primarily classroom oriented using the instructional guides and training aids as the primary training platform and be coordinated with “hands on training” on the car based on availability some time during the duration of the course.

The program shall be based on the use of the manuals as the central source of information to SEPTA personnel using instructor and student guides for the courseware. No other printed material may be used except as approved by SEPTA. The classroom instruction, however, shall be presented in an interesting manner with extensive use of audiovisual training aids, multimedia presentations, oversized diagrams from the manuals, models, computer based training, and special tools if applicable. Upon completion of the training, the student shall not only have a basic understanding of the subject matter but also be well versed in how to obtain any needed information from the manuals.

The training program shall be conducted in English. Instructors shall be experienced and have a good command of the technical English language used in the North American railroad industry. If English is the instructor’s secondary language, the pronunciation of any accented English must be good enough to where a classroom of students can easily understand the instructor even though they have never been exposed to the accent.
During each training course, periodic written quizzes shall be given concluding with a comprehensive written final examination. Those not showing an understanding of the material, as determined by test scores, shall repeat the subject or unit area found deficient. If an excessive number of personnel (as determined by SEPTA) fail a particular training unit, the Contractor shall investigate the areas in which personnel or the program have shown weaknesses and revise the training unit to provide more effective training in these areas. Upon the conclusion of each training unit, the Contractor shall have all participants fill out a questionnaire concerning the program’s strong and weak points and suggestions for improvement. These suggestions shall be incorporated, as appropriate, into the training program.

The instructors used by the Contractor shall be familiar with SEPTA’s operation to a degree appropriate for the particular material being presented, completely knowledgeable on the specific topic/equipment being presented, and have full understanding of the integration of the equipment being presented within the car as a whole and any interfacing to other car equipment. The instructors shall be totally prepared to present the course material including full responsibility to have available all audiovisual aids such as projectors, screens, flip charts, testing equipment, and mock ups necessary to present their course material. SEPTA reserves the right to check the qualifications and/or references of the proposed instructors and also to reject for cause any instructor not believed to be adequately qualified.

The formal classroom instruction shall be conducted in a suitable classroom furnished by SEPTA on its premises as required by SEPTA. Informal field instructions may also be conducted on SEPTA’s property at SEPTA’s discretion.

If deemed necessary, SEPTA may require the Contractor to provide tours and/or special instructions in the shop facilities of the Contractor and/or its suppliers and manufacturers for a limited number of SEPTA supervisory and technical personnel to familiarize them with the car assembly methods.

### 19.4.3 Format

The Contractor shall supply both a student guide and an instructor guide. Each guide shall be organized in such a manner to cover the following subjects:

a. **Theory of operation**

b. **Troubleshooting including instructions for the use of diagnostic test equipment**

c. **Corrective maintenance covering removal, replacement, and detailed adjustment instructions as applicable**

d. **Post-repair system and/or component testing**

e. **Preventative maintenance instructions**

Each guide may include, but not solely rely upon, PowerPoint presentations. Any PowerPoint pages and the pages within the guide referring to PowerPoint shall be crossed referenced to aid in the progression of the class. An appendix for 11 x 17 fold outs of any poster style visual aids graphics, tables, etc., used during the classroom training shall also be included within each guide.
The instructor’s guide shall mirror the student guide except that within the instructor’s guide, an open guide would show the instructor’s notes on the left hand page and the student’s presentation page on the right hand page. SEPTA shall provide the vendor with a sample of its format. Full copies of the originating file used to create the guides shall be provided along with Adobe Acrobat copies of each guide.

The Contractor shall meet with SEPTA’s Training Department supervisors during the development process to ensure compliance to the outlines are being met prior to the submittal of the training guides for official review.

19.4.4 Train the Trainer Approach

In the first session of every course, the Contractor shall provide a hands on, train the trainer course for SEPTA instructors consisting of running maintenance training and operational training. The purpose of this approach is to evaluate the proposed training program and to thoroughly familiarize SEPTA’s training staff with car assemblies and subassembly operation, and maintenance and troubleshooting in conjunction with inspection and testing.

Out of the car’s training course curriculum, two (2) train the trainer courses must be completed at the Contractor’s facility prior to the delivery of the pilot car. These courses shall be:

a. Operator’s course
b. Qualified mechanic personnel (QMP) course

All course material shall be complete and ready for actual training upon return to SEPTA.

The remaining train the trainer courses shall be performed at SEPTA’s training facilities prior to the delivery of the first production car. During the program, the SEPTA instructors shall review functional mockups, audio visual aids, and methods of instruction proposed in the Contractor’s training program. A summary review of the maintenance manual status will be confirmed and if found lacking for training, the Contractor will immediately improve it prior to delivery of the production car and/or the start of training of SEPTA personnel.

This train the trainer program shall include classroom instruction, instruction on the shop floor, and use of mockups. The time required for this instruction shall be at least as long as each of the training units and, if appropriate, longer to accommodate questions and discussion between SEPTA’s training staff and the Contractor’s training staff. Student and Instructor Guides must be used. Multimedia visual aids shall be included. If production of the visual aids is not complete due to being developed on the first production car, the train the trainer program may continue with the guides only; however, the multimedia visual aids must be delivered prior to the delivery of the first production car and will be subject for review and acceptance via the train the trainer program. [CDRL 19-015]

19.4.5 Local Training

SEPTA shall make available to the Contractor upon seven (7) days’ advance notice space at accessible shop locations for educational purposes and shall arrange for a car for both the operational and classroom hands on training portion as needed.
19.4.6 Systems Training Software

It is the intent that all systems training be classroom based as required in TS 9.4.2 resulting in the need for in-depth hands-on training aids.

The Contractor shall provide software based interactive multimedia instruction in the form of virtual reality simulations for mechanical and electrical systems as determined by SEPTA. These programs would be designed to run on laptop or desktop computers on an operating system specified by SEPTA. Each simulator program shall have the ability to simulate the operation of the system it has been created for. It shall also be designed to be a troubleshooting simulator so that the software can be set up where certain operations can be “bugged” with one (1) or more problems to create faults that the student can troubleshoot. Troubleshooting shall offer interactive corrective actions that once chosen allow the virtual system to run fault free. The following systems shall have virtual reality simulator programs:

a. Door system [CDRL 19-016]
b. Brake system [CDRL 19-017]
c. HVAC system [CDRL 19-018]
d. Communication system [CDRL 19-019]
e. Diagnostic system [CDRL 19-020]
f. Power distribution and vehicle control circuits [CDRL 19-021]

It is SEPTA’s desire to have software based virtual reality simulations as described. SEPTA recommends the use of gaming technology to achieve this since it provides optional actions and decision making by the user. If the Contractor or supplier feels it is not possible to provide, the Contractor/supplier shall supply functioning and hands on mock ups including all stands, equipment, and instructions for use for the system in question. Any mock up shall be fully functional and capable of being bugged for use in troubleshooting and making adjustments. All mock ups shall be designed to be used in a classroom environment or shop floor as appropriate for the subject.

It is the ultimate responsibility of the Contractor to meet these requirements for the systems listed without the use of an actual car or component assembly. Due to the need for actual cars to be in service, cars shall not be made available for the classroom portion of the training, and SEPTA capital spares shall not be provided in lieu of these training aids.

All simulators/virtual simulation software programming and/or functional mock ups must meet the approval of SEPTA’s Training Department. It is the responsibility of the Contractor to work closely with SEPTA’s Training Department and to make arrangements to establish the depth and level of detail at the beginning of the project.

Capital spare parts shall not be considered for use as training aids. All training aids shall be as required in this section.
19.4.7 Visual Aids

It is the intent that visual aids shall be developed for all courses to enhance and complement training guides during training where needed to enhance the training experience. The Contractor shall provide visual aids using multimedia formats including text, audio, still imagery, animation, and video to produce its content. [CDRL 19-022]

Visual aid productions shall be of high quality and professionally produced by an independent experienced supplier of such a product.

19.4.7.1 Video Productions

The Contactor is required to produce a collection of videos that cover general overall instruction on the equipment operation and maintenance consisting of installation and removal, repair, adjustments, and troubleshooting procedures for each major component for the cars’ electrical, mechanical, and pneumatic systems.

The Contractor shall provide three (3) sets of multimedia video aids of professional quality suitable for instruction in DVD format. [CDRL 19-023] These DVDs shall be provided in library format with an index cross reference between performance symptoms, component generic name, manufacturer, etc. Videos shall be produced with the use of non-studio railroad shop type personnel for personal identification with the subject by SEPTA personnel.

The video files produced shall contain all necessary information pertaining to the procedures and have the technical data necessary to perform a specific function such as repair, maintain, or operate all car equipment. Additional written handouts shall also be furnished by the Contractor to cover and support the computer based training.

At least nine (9) months prior to delivery of the first car, the Contractor shall identify and submit a list of all items or functions that shall require video or animated visual aids for review by the Engineer. [CDRL 19-024] The Contractor shall assist in the coordination and presentation of the visual aid subjects and content during review meetings with SEPTA representatives from the Operating, Maintenance, and Training Departments. Full approval must be obtained for each video or animated visual aid prior to final submittal of the master list. [CDRL 19-025]

All multimedia file scripts and shot lists shall be submitted to SEPTA for evaluation by their Engineering, Maintenance, and Training Departments to assess the training content to ensure the multimedia file scripts and shot lists meet the training needs prior to development. [CDRL 19-026]

Multimedia files shall maintain a quality standard which includes, but is not limited to, the following:

a. Picture depicts normal working light or better
b. No jerking motions; i.e. tripods are to be used whenever possible
c. Picture is supported by appropriate text, overlays, arrows, and graphics
d. Clean breaks and wipes between scenes
e. No unsafe acts or scenes
f. SEPTA’s safety rules are adhered to in all visual aids
g. Audio is professionally narrated
h. Only appropriate background noise
i. Audio matches the picture at all times
j. Digital DVD resolution of 500 lines
k. Professionally constructed front ends on all DVD menus

Format of the multimedia files shall include a "standard series" title at the beginning with the date produced, topic title (introduced by audio plus text) which includes the objective of the DVD, a standard length of 10 to 15 minutes, and a closure which includes appropriate safety, quizzes, and quality messages. Where topics shall need more than 10 to 15 minutes of time for completion, they shall reside on the same DVD but shall be broken down into chapters.

One (1) complete set of DVDs shall be delivered to SEPTA for review at least one (1) month prior to delivery of the first production car. [CDRL 19-027]

In the event that changes or modifications are performed after delivery of the cars, the Contractor shall make reasonable changes to all visual aid presentations that would render them accurate.

All multimedia productions shall be the property of SEPTA at which time SEPTA shall assume all copyright privileges.

19.4.8 Training Program Overview Submittal

The Contractor shall submit an overview of the training program with schedule to SEPTA for approval 360 days after Notice to Proceed. [CDRL 19-028] 30 days after SEPTA’s approval of the course overview, the Contractor shall submit draft copies of all instructor and student guides to SEPTA for approval. [CDRL 19-029] After SEPTA’s approval of the guides’ format, the Contractor shall submit the full training program for approval. [CDRL 19-030] Prepilot car delivery training consisting of Operator and QMP train the trainer programs shall be required a minimum of 90 days prior to the scheduled shipment of the pilot car from the Contractor’s facility. [CDRL 19-031] All remaining courses will be due at least 180 days prior to delivery of the first production car. [CDRL 19-032]

Program design, format, and delivery shall be in accordance with SEPTA’s Training Department’s instructional standards. The scope of each course shall be outlined and submitted to SEPTA for SEPTA’s Training Department’s approval. [CDRL 19-033] The outline shall include, as a minimum, the following:

a. Clear instructional objectives
b. Delivery method
c. Evaluation methods
d. Student aids
e. Instructional aids including multimedia visual aids
f. Training schedules
g. Train the trainer programs
h. Hours of classroom and hands on training
i. Qualifications of the instructors
j. A list of training aids to be used
19.4.9 Organization

The training program shall consist of the following courses developed from the technical manual sets for the maintenance, troubleshooting, repair, and testing of the car. These courses shall be developed covering all aspects of the car and its associated systems in a comprehensive manner per the subjects listed below:

a. Initial Operator training course operations and transportation management
b. Operator training (car)
c. Car equipment introduction – management and supervision
d. Car equipment introduction – maintenance personnel
e. Theory of operation, troubleshooting, and repair
f. Manual familiarity
g. Inspection and servicing
h. Computer and power electronics theory
i. Equipment overhaul
j. Specialized qualified maintenance personnel (QMP) training
k. Bench test procedures and repairs

19.4.10 Operator Training

SEPTA’s operations and transportation managers shall attend the initial Operator training course presented at SEPTA’s training facility by the Contractor. The initial Operator training course shall be at least 24 hours in length. This course shall be in addition to the scheduled Operator training courses.

Manual familiarity shall be a complete overview and explanation of the various manuals and their use. This shall be included in the introduction courses.

Engineer training shall provide information needed for the operation of the cars including definitions giving nomenclature, function, location and operation of all indicators, controls, trainline functions, components, and subsystems utilized in the operation of the equipment. This shall include preparing the unit for operation and securing the unit from operation. There shall be special emphasis placed upon on the road troubleshooting, emergency procedures, use of all bypass functions and the possible hazards associated with their use, and the operation of the car under unusual conditions such as adverse weather, degraded power supply, or other abnormal factors. This course shall include at least four (4) hours in the cab of an operating car.

19.4.11 Maintenance Training

The following subjects shall be included in the maintenance portions of the car training.
19.4.11.1 Car Equipment Introduction for Management

Management and supervision shall be a course of at least 12 hours in length provided for SEPTA’s management and supervision personnel and shall be an introduction to the car equipment and its features, operation, capabilities, and maintenance. This course shall be conducted a minimum of three (3) times at a site to be chosen by SEPTA.

19.4.11.2 Car Equipment Introduction for Maintenance Personnel

Maintenance personnel shall be a course of at least 24 hours in length provided for SEPTA’s mechanical and electrical equipment maintenance personnel and shall be an introduction to the car equipment and its features, operation, capabilities, maintenance, and troubleshooting. This course shall be conducted a minimum of three (3) times at the Contractor’s training facility.

19.4.11.3 Manual Familiarity

Manual familiarity shall be a complete overview and explanation of the various manuals and their use. This shall be included in the equipment introduction courses.

19.4.11.4 Inspection and Servicing

Inspection and servicing shall be presented to all shop maintenance personnel. It shall demonstrate all preventative maintenance functions needed on the car for up to a five (5) year period. This shall include all inspection, servicing, and lubrication tasks necessary in the running maintenance of the unit. Coverage shall also include demonstrations of lifting and jacking the car under normal and emergency (i.e. derailment) conditions. Methods of testing the unit to verify proper repair shall be covered. This course shall be at least 40 hours in length.

19.4.11.5 Theory of Operation, Troubleshooting, and Repair

Theory of operation, troubleshooting, and repair shall be presented to the appropriate qualified shop maintenance personnel. This course shall be divided into subsets for equipment subsystems. Each subset shall include a detailed system description including all components, their function and operation; adjustments and testing; disassembly and assembly; and removal and installation of the components on the car. The subsets shall individually address the Operator’s controls; auxiliary power inverters, battery, and controls; heating and air conditioning including controls; electric braking, friction braking, and slip/slide control; air compressor, trucks including suspension; and the use of onboard diagnostics and fault detection equipment. Special tooling and test equipment necessary to service and maintain each system shall be used and shall become the property of SEPTA upon the conclusion of the training program. Time for each subset shall vary in length.
19.4.11.6  Equipment Overhaul

Equipment overhaul shall be presented on a subset basis to SEPTA's shop personnel responsible for the respective subject area. Each subset shall include a detailed component description, instructions for removal of the car (including weight of the equipment), complete disassembly, inspection, wear limit tests, and complete overhaul or remanufacturing instructions including motor rewinding, assembly, balancing, seasoning, lubrication, tests, and adjustments. The subsets shall individually address the couplers and draft gear; auxiliary power subsystem including inverters, wiring, battery, and controls; heating and air conditioning including controls and auxiliary heaters; friction braking and subsystem; and the trucks including suspension and tilt system (if provided).

A special subset shall address carbody structural repairs including metal shaping, welding, finishing, and other required functions. Any special tooling and test equipment necessary to overhaul the equipment shall be used and shall become the property of SEPTA upon the conclusion of the training program. Each subset shall be at least 16 hours in length.

19.4.11.7  Qualified Maintenance Personnel Course

A qualified maintenance personnel (QMP) qualification course shall be developed to establish training to certify and qualify maintenance personnel as required by 49 CFR 238.109 to actively perform inspection and testing to certify equipment for service per 49 CFR 238.301 through 49 CFR 238.319 of the Code of Federal Regulations.

The following inspections and activities shall be developed by the Contractor and submitted to and approved by SEPTA prior to the course being developed. [CDRL 19-034] Each inspection and/or test shall have two (2) separate parts consisting of a standalone procedure and a separate data sign off sheet. The courses shall consist of, at a minimum:

a. Calendar day exterior mechanical inspection  
b. Calendar day interior mechanical inspection  
c. 92 day inspection  
d. 3 year air periodic brake equipment maintenance  
e. Single car test  
f. Class 1 brake test  
g. Class 1a brake test  
h. Class 2 brake test  
i. Running brake test

19.4.12  Bench Test Equipment Training

Training for each system designated to have bench test equipment associated with it shall be included within the training program. The courseware shall be based on the same level of detail as all other courses. The software book found in TS 19.3.6.8 shall be available and referenced in BTE training material. Training shall be scheduled based on the fully acceptable commissioning of the bench test equipment. Train the trainer courses will not be required.
19.4.13 Courses, Frequency, and Class Sizes

The following are the requirements for the courses, course frequency and class sizes:

<table>
<thead>
<tr>
<th>Course</th>
<th>Location</th>
<th>Frequency</th>
<th>Class Size</th>
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<tbody>
<tr>
<td>Operator Training (T-t-T)</td>
<td>Contractor's Facility</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>QMP (T-t-T)</td>
<td>Contractor's Facility</td>
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<td>Initial Operator’s Training Course</td>
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<tr>
<td>(Operations and Transportation Management)</td>
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<td>Car Equipment Introduction (Management and Supervision)</td>
<td>SEPTA</td>
<td>3 (includes T-t-T)</td>
<td>15</td>
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<tr>
<td>Car Equipment Introduction (Maintenance)</td>
<td>SEPTA</td>
<td>5 (includes T-t-T)</td>
<td>15</td>
</tr>
<tr>
<td>Inspection and Servicing</td>
<td>SEPTA</td>
<td>5 (includes T-t-T)</td>
<td>15</td>
</tr>
<tr>
<td>Theory of Operation, Troubleshooting, and Repair</td>
<td>SEPTA</td>
<td>5 (includes T-t-T)</td>
<td>15</td>
</tr>
<tr>
<td>Computer and Power Electronics Theory</td>
<td>SEPTA</td>
<td>5 (includes T-t-T)</td>
<td>15</td>
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<tr>
<td>Equipment Overhaul</td>
<td>SEPTA</td>
<td>5 (includes T-t-T)</td>
<td>15</td>
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<tr>
<td>QMP</td>
<td>SEPTA</td>
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<td>15</td>
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<tr>
<td>Bench Test Equipment – Numerous as determined by system</td>
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<td>8</td>
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</tbody>
</table>

Note 1: Manual familiarity will be given with all introduction courses
Note 2: “T-t-T” denotes Train the Trainer course events

19.4.14 Scheduling

The scheduling of all courses shall be developed concurrently with the development of the maintenance manuals as follows:

a. 360 days after Notice to Proceed, the Contractor shall submit a training program overview proposal with schedule. [CDRL 19-028]

b. 450 days after Notice to Proceed, the Contractor shall submit instructor and student guide samples in addition to a major list of all subjects, items, and functions identified for multimedia visual aids. [CDRL 19-035]
c. 210 days prior to scheduled delivery of the pilot car, the Contractor shall submit the full training program proposal. [CDRL 19-036]

d. 180 days prior to scheduled delivery of the pilot car, the Contractor shall submit the final Operator training program and qualified maintenance personnel (QMP) training courseware. [CDRL 19-037]

e. 210 days prior to the scheduled delivery of the first production car, in progress reviews shall be initiated on all remaining training courseware. [CDRL 19-038]

f. 90 days prior to the scheduled delivery of the pilot car, the Contractor shall submit approved Operator’s training and QMP training courseware. [CDRL 19-031]

g. 30 days prior to the delivery of the pilot car, the Contractor shall present train the trainer, Operator’s training, and qualified maintenance personnel training courses at the Contractor’s facility. [CDRL 19-039]

h. 90 days prior to the scheduled delivery of the first production car, the Contractor shall present the initial Operator’s training course to SEPTA's Regional Rail Transportation and Maintenance Department supervision. This course shall be in addition to the scheduled Operator training. [CDRL 19-040]

i. 30 days prior to the scheduled delivery of the first production car, the train the trainer program shall commence with the first class being conducted at SEPTA’s designated training facility. [CDRL 19-041]

j. 21 days prior to the scheduled delivery of the first production car, the car equipment introduction – management and supervision course shall be presented at the Contractor’s training facility. [CDRL 19-042]

k. Upon completion of the car equipment introduction management and supervision course, the car equipment introduction – maintenance personnel course shall be presented at the designated SEPTA training facility. [CDRL 19-043]

19.4.15 Continuing Training

SEPTA's Training Department shall have the right to record whichever portions of the training program it desires for future SEPTA training use.

A complete set of all materials used by the Contractor during the training program including lesson plans, training aids, manuals, mockups, special tools, displays, and all other components used shall be presented to SEPTA within 30 days of the conclusion of the complete training program which shall be properly revised and updated by the Contractor to reflect all equipment modifications until the end of the warranty period. [CDRL 19-044]

In addition to the above, the lesson plans, manuals, and training aids shall be provided to SEPTA on electronic media in accordance with TS 19.3.4. [CDRL 19-045]
### 19.5 CONTRACT DELIVERABLE REQUIREMENTS LIST

<table>
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<th>Car Type</th>
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<td>Start Submissions of Complete Draft Technical Manuals</td>
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<td>19-010</td>
<td>200 Published Copies of Final Approved Draft of Operating Instruction Manual and Approved Electronic PDF Version of Each QMP Training Guide and Appendices</td>
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<td>19-011</td>
<td>Electronic Set of Final Approved Draft of Running Maintenance Manual</td>
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<td>Copy of Approved Electronic Media Used in Preparation of Manuals</td>
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END OF SECTION
NOTES:


2. THE STATIC OUTLINE AND DYNAMIC OUTLINE IS REFERENCED TO THE PLANE OF THE TOP OF RAILS, FOR TRACK WITH AND WITHOUT SUPERELEVATION, FOR A VEHICLE HAVING A MAXIMUM LENGTH OF 86'-0", AND A TRUCK CENTER DISTANCE OF 96'-0".

3. THE VEHICLE MUST REMAIN WITHIN THE DYNAMIC OUTLINE UNDER ALL CONDITIONS, INCLUDING LATERAL AND VERTICAL MOVEMENT OF THE VEHICLE ON ITS SUSPENSION, ROLL INDUCED BY UP TO 6" SUPERELEVATION (WITH THE VEHICLE STOPPED OR IN MOTION), ROLL INDUCED BY THE DESIGN CANT DEFICIENCY. RANGE OF MOTION OF THE TILT SYSTEM (IF SO EQUIPPED), NORMAL WEAR, VARIATIONS OF LOAD, FAILURE OF ANY SINGLE SUSPENSION COMPONENT, AND ANY COMBINATION OF THESE CONDITIONS.

4. THE HORIZONTAL DISTANCE FROM CENTER LINE OF TRACK, FOR VERTICAL DISTANCES BETWEEN 2.75' AND 1'-1" ABOVE TOP OF RAIL, MUST ALLOW FOR THE INSIDE AND OUTSIDE OVERTURNING OF THE VEHICLE ON A 12'-30 CURVE, AS SHOWN ON SHEET 3 AND THE SHAPED AREAS OF THE STATIC OUTLINE AND THE DYNAMIC OUTLINE. ALL VEHICLE STRUCTURE, EQUIPMENT, AND APPLIANCES MUST REMAIN WITHIN THIS OUTLINE UNDER ALL CONDITIONS.
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