SUBWAY CAR PROCUREMENT
FOR THE
A DIVISION

SECTION V - TECHNICAL SPECIFICATION

Kawasaki Rail Car, Inc.

NEW CAR PROCUREMENT CONTRACT
R34142A (R142A)

(Original Issue: June 11, 1996)

Current Revised Issue: April 2005
## CHANGE ORDER LOG

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**Note:** Previous to this issue, changes to the contract were either Modifications or Change Orders, but as of August 13, 1999, all changes to the contract will be via Change Orders.
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**NYCT Division A**

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SECTION 1

SCOPE OF SPECIFICATION

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1.0 SCOPE OF SPECIFICATION

1.1 General

These Specifications set forth the requirements for the performance, design, manufacturing, assembly, testing, delivery, and Acceptance of heavy rail transit cars, to be configured in Units. In addition, the Specification includes requirements concerning program management, compliance demonstration, product support and data submittal.

These Specifications are generally complete and comprehensive, but are not intended to describe all work details to be performed and therefore must be supplemented by the Contractor's experience in building heavy rail transit cars, on its examination of the NYCT System, and on its detailed design and testing capabilities.

References to commercial, industrial and NYCT standards, specifications and recommendations, whether stated or not stated as the latest revision, pertain to the version in effect at the time of the Request for Proposal (RFP) release, unless specifically indicated otherwise.

References to Specification sections within these Specifications are provided for convenience. If errors exist, or references are incomplete, the Contractor shall bring it to the NYCT's attention, in writing, for clarification.

If at any time the Contractor finds that any requirement of these Specifications appears to be in error or in conflict with the general intent of these Specifications, then it shall immediately bring the apparent problem to the NYCT's attention, in writing. The NYCT will determine whether or not the Specification needs to be modified.

The Contractor shall be solely responsible for the detailed design of the Units and shall provide Units which are in all respects compliant with this Specification.

1.2 Car

<table>
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<th>Description</th>
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<tr>
<td><strong>NYCT Car Class Designation</strong></td>
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<td>&quot;R142A&quot;</td>
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<tr>
<td><strong>Type</strong></td>
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<tr>
<td>Heavy rail, semi-permanently coupled multi-car Unit</td>
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<td><strong>Passenger Seated Positions</strong></td>
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<td>A Car: 34</td>
</tr>
<tr>
<td>B Cars: 40</td>
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<tr>
<td><strong>Primary Power Source</strong></td>
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<tr>
<td>3rd rail, 600 Vdc nominal</td>
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</table>
1.3 Compatibility Requirements

MOD 02

The cars purchased under this Contract will be the first of a new generation car design. As a result, it will be necessary for NYCT to have complete information affecting form, fit and function as well as all necessary interface and performance information to enable interchangeability and operational compatibility with future car orders. These R142A Units are not required to be electrically, nor mechanically compatible with existing NYCT car classes; however, the Units shall be capable of mechanically coupling with NYCT’s existing cars, through the use of a mechanical coupler adapter, when interfacing with an H-2-C coupler, as described in Section 5. Cars shall be compatible with existing NYCT maintenance facilities and signal system.

The R142 and R142A Units shall be mechanically and electrically compatible such that R142 and R142A Units could be coupled to form trains of 9, 10 and 11 cars suitable for revenue service in NYCT. Under this condition, the train as a whole shall respond to trainline commands, provide the performances defined in Sections 2.4, 2.6, 2.7.8, and provide the functionality defined throughout the Specification except for the MDL maintenance information which is tracked on a per-Unit basis. Motoring and braking effort shall be distributed on each Unit as it would normally be if Units were of the same design/manufacture.

1.4 Replacement Parts Interchangeability with Existing Fleets

MOD 02

To the degree practicable, and except as otherwise specified, all consumable parts, such as glass, hardware, lamps, lubricants, air hoses, brake shoes, etc., shall be interchangeable with elements on existing NYCT cars. All consumable parts shall be available from at least two sources unless otherwise approved.

1.5 Materials

Materials for the construction of the cars shall be selected to obtain the maximum strength and reliability balanced against minimum weight and reasonable costs consistent with the Specification. All materials and equipment furnished by the Contractor shall be new and shall be subject to inspection by the NYCT. However, full responsibility for inspection and quality of material and workmanship shall be the Contractor’s.

1.6 Microprocessor Hardware and Software

The NYCT requires a high level of integration of microcomputer design, compatibility and documentation. This necessitates a high level of both technical management and technical guidance by the Contractor of the various subsuppliers of microprocessor based equipment. The Contractor shall dedicate experienced people who are knowledgeable about the state-of-the-art in the use of microprocessor hardware and software in real time control systems design. Successful integration shall eliminate undesired redundant hardware and software, while providing optimum functionality and diagnostics.
1.7 Commonality Requirements MOD 02

The R142 and the R142A Cars shall meet the commonality requirements of Section 1.7 and its subsidiary sections.

1.7.1 Appearance MOD 02

The following components shall have the same general appearance to passengers:

1. Car body exterior appearance.
2. Door lights and audible signals for both the passengers and operating personnel.
3. Car cab exterior ends.
4. Interior: color scheme, seats, stanchions, fluorescent light lens, signage/graphics.
5. Passenger side door panels: as viewed by the public.
6. Information Signs: same appearance and all displayed information must be identical.
7. Threshold plates: similar finish and pattern.
8. Window sashes, when viewed from the exterior, with the exception of treatment of interface with car exterior side sheets.

1.7.2 Seamless Operation MOD 02, 04

Train operation between R142 and R142A Cars shall be seamless as follows:

1. Cab and Cab Controls: Controls, control functions, locations, colors, labels, acronyms, mechanics, visibility, so that the conditioned responses of a trained operator are identical from cab to cab. Kawasaki will follow the Bombardier general cab arrangement, console arrangement, and T/O and C/R interfaces.

2. Train Operator Display: All screens used by the T/Os, including those defined in Technical Specification Sections 6 and 8, are to be similar except for those differences resulting from variations in screen technology. Maintenance functions may be different, but only for those functions accessible by the NYCT maintainer.

3. Passenger and NYCT T/Os, C/Rs and emergency personnel-accessible devices are to be located in corresponding locations and are to function in a similar manner: (i.e., Passenger Intercoms, PEHU, bypass switches, cutout switches, door releases, manual uncouple levers), with the exception of the brake cutout handles.

1.7.3 Identical and Interchangeable Systems and Components MOD 02 CO 03

The following systems and components shall be identical and/or interchangeable:

1. All glass, including type and dimensions, everywhere and in every application, shall be identical and/or interchangeable with the exception of the left and right side cab windshields.
2. Axles (motor and trailer).
3. Battery cells and 5-cell trays.
4. Brake shoes.
5. Collector fuses.
6. Coupler, adapters.
7. Coupler, electric portions.
8. Coupler, mechanical portions (exclusive of draft gear).
9. Passenger side door control components, including: relays, switches, cutout locks, and crew switches.
11. Floor covering.
12. Fluorescent tubes.
13. Headlights and taillights.
15. Passenger seat shells.
16. Operator's (T/O's) seat.
17. Wheels.

1.7.4 Other Part Interchangeability Goals

The Contractors shall make a special effort towards interchangeability of the following components:

- Brake system (valves) components.
- All consumables (lubricants, cleaners, electric fuses, etc.)
- Cab window drop sash glass
- Windscreen (if used) glass
- Door operator motors
- Door Control MDCs

1.8 Definitions and Abbreviations

1.8.1 Definitions

The following terms used in the Contract Documents shall, except where, by the context, it is clear that another meaning is intended, be construed as follows:

A Car - The car located at each end of a Unit. This car contains an operating cab and an automatic mechanical and electrical coupler at the No. 1 End.
ADA - The Americans with Disabilities Act of 1990. As used in the Technical Specifications, references to ADA requirements or compliance means the requirements for accessibility of Rapid Rail Vehicles and Systems for people with disabilities, as specified in the regulations of the U.S. Department of Transportation, published at 49 CRF Part 38, Subparts A and C, in effect as of the date of the award of this Contract.

Addenda or Addendum - Revisions to any of the Contract Documents issued in writing by the Authority subsequent to the issuance of RFP 34142 Phase 2 and prior to the Award Date.

Adhesion, Coefficient of - During rolling contact, the ratio between the longitudinal tangential force at the wheel-rail interface and normal force.

Agent - Any employee of, or contractor to the Authority, or any subsidiary or affiliate agency of the Authority or of the MTA designated as such by the Authority.

Alertness Control - A function of controls that continuously monitors the activities of a Train Operator and takes pre-defined actions to forestall and/or protect against inattention or incapacitation of that Train Operator.

Allowable Stress - The maximum stress permitted in a structure under specified design conditions. The allowable stress is less than the stress causing damage because of various factors, including: (a) uncertainty as to conditions of service, e.g., loads and forces imposed during the lifetime of the structure, (b) non-uniformity of material, and (c) inaccuracy of stress analyses.

Alteration - A change or substitution in the form, character, or detail of the work done or to be done within the original scope of the Contract.

Anti-climber - A structural reinforcement at each car end to discourage either car in an end-to-end collision from overriding the other.

Approval or Acceptance - Review and acceptance, in writing, by the NYCT. NYCT approval in no way relieves the Contractor of meeting all requirements of the Specification.

Approved or Approved Type - Design, type of material, procedure, or method given approval by the NYCT.

Authority or the initials "TA" or "NYCT" - the New York City Transit Authority, a public benefit corporation existing by virtue of the New York Public Authorities Law and any successor public benefit corporation or governmental agency.

Automatic Stop Arm - A mechanical device located on the wayside that when activated by the signal system places the passing car in emergency braking.

Automatic Train Operation - An operating mode in which any or all of the functions of speed regulation, programmed station stopping, door control, performance level regulation, and other functions normally assigned to the Train Operator are performed automatically.
Automatic Train Protection - The vital component of an automatic train control system responsible for providing protection against collisions, derailments, excessive speed, and other hazardous conditions through a combination of train detection, train separation, and route interlocking.

Auxiliary System - Any mechanism or structure, other than the car body and propulsion system which functions during car operation, e.g., door operators, lighting, HVAC, communications, etc.

AW0 - The assigned weight of an empty car, ready for revenue service, with neither crew nor passengers aboard.

AW1 - The assigned weight of a car ready for revenue service, with a full crew and all passenger seats occupied.

AW2 - The assigned weight of a car ready for revenue service with a full crew, all passenger seats occupied, and an equal number of passenger standees.

AW3 - The assigned weight of a car ready for revenue service with a full crew, all passenger seats occupied, and with the largest number of passengers that can occupy the car (crush load).

Award Date - The date the Notice of Award is issued.

B Car - A Non-Cab Car located between A Cars.

B-10 Life - The average car mileage at which no more than 10 percent of a particular piece of equipment, or component, shall have failed, with a 90 percent confidence.

Base Speed - The maximum speed at which the traction motors produce full tractive effort in motoring.

Baseline Design - The design of the car or any of its components, apparatus, systems, subsystems, or materials which has received both drawing approval and first article approval by the NYCT.

Blending - In braking, a simultaneous dynamic and friction brake application, with the effort of each continuously proportioned to achieve the required total braking effort.

Braking, Dynamic - See electrical braking.

Braking, Electrical - Braking in which power generated by traction motors, when driven as generators, is either dissipated as heat by dynamic brake resistor grids or returned to the third rail as regenerative electrical energy.

Braking, Emergency - Braking that results in an irrevocable open-loop friction braking effort to a stop, at the maximum design brake rate.

Braking, Full Service - A non-emergency brake application which obtains the maximum brake rate consistent with the design of the primary brake system.
**SCOPE OF SPECIFICATION**

**Contract No. R34142A**

**NYCT Division A**

**Braking, Open-Loop** - Braking without a feedback control.

**Buff Load** - A horizontal compressive load applied to the car, usually along the car centerline at the couplers or anti-climbers.

**Cab Car** - See A Car.

**Calculations** - Numerical computations performed to demonstrate compliance with the Specifications.

**Car** - A complete assembly of an A or B type R142A passenger car.

**Carbuilder** - That person or persons, firm, partnership, corporation, or combination thereof which has entered into a Contract with the NYCT to supply the services required.

**Carline** - Framing members that extend across the top of a car from one side to the other and support the roof and other loads.

**Change Order or Modification** - An order executed by the NYCT and issued to the Contractor amending the Contract Documents. The Change Order establishes the basis for payment and program adjustments, if any, of the work affected by the changes. The Change Order becomes a part of the Contract when executed by the Contractor and the NYCT.

**Circuit, Vital** - Any circuit that affects the safety of train operations.

**City** - The City of New York, according to its boundaries at the date of this Contract.

**Coast** - The mode of operation of a car or train in which propulsion (positive traction) and brake (negative traction) are inactive and the apparent braking effort results from the train's rolling resistance and aerodynamic drag.

**Comment** - Written critiques of the Contractor's submittals to the NYCT.

**Commercial Test** - A test wherein the equipment is tested to determine that it has been manufactured in accordance with the Specification and within tolerances permitted; plus, that all normal safety and quality assurance procedures have been met.

**Communications-Based Train Control** - An automatic train control system, comprised of wayside and on-board vital processors and a high capacity, bi-directional, radio-based train-to-wayside communications network, capable of providing Automatic Train Protection and Automatic Train Operation functions.

**Component** - Parts, devices, and structure performing a distinctive function necessary to the operation of a subsystem or system.
SCOPE OF SPECIFICATION

Contract No. R34142A

NYCT Division A

Concept Drawings or Plans - An initial set of drawings showing the general car layout and arrangement provided by the NYCT with the Specification.

Consumable Items - Those parts, components and materials of a particular system which, pursuant to the manufacturer's maintenance manual, are required to properly maintain such system for a one-year period based upon the Authority's expected usage of 60,000 miles per year per Car.

Contact Rail - A third rail located outside the running rails which supplies the external source of 600 Vdc electrical power.

Contact, Contract Documents or Agreement - The ATTACHMENTS, CONTRACT TERMS AND CONDITIONS, CONTRACT TESTIMONIUM, REQUEST FOR PROPOSAL (RFP), TECHNICAL SPECIFICATIONS, CONTRACT DRAWINGS (if any), all ADDENDA, if any, hereafter issued, the Notice of Award, if any, change orders executed by the Authority and the Contractor subsequent to award of the Contract.

Contracting Party - The Metropolitan Transportation Authority for which the Authority is herein acting as agent.

Contractor or Carbuilder - The proposer to whom this Contract is awarded, its successors and assignees. For convenience the Contractor is hereinafter referred to as if the Contractor were an individual. The word "he" shall, as the sense may require include "she", "it" and "they"; the word "him" shall include "her", "it" and "them"; and the word "his" shall include "her", "its" and "their".

Contract Amendment - See "Change Order".

Contract Data Requirements List (CDRL) - Each and every item to be delivered by the Contractor to the NYCT as defined in this Technical Specification.

Contract Drawings - Drawings provided by the NYCT as part of the Document.

Contractor's Drawings - Items such as general arrangement drawings, detail drawings, graphs, diagrams, and sketches which are prepared by the Contractor to detail its work.

Converter - A direct current to direct current solid state device using a nominal 600 Vdc input to provide a 37.5 Vdc power source.

C/R - Train Conductor.

Critical Area - The region of a structure requiring higher than normal quality of material and manufacture because stresses are at or near the limits of allowable stresses specified by the Modified Goodman Diagram.

Critical System - shall mean each of the following: AC Propulsion, Auxiliary Power, Doors (side doors), Friction Brakes, HVAC, and Trucks.
### SCOPE OF SPECIFICATION

**Cross Level** - Relative transverse elevation of the two running rails on level or superelevated track

**Current Collector** - A carborne device to conduct electrical power from the contact rail to the car.

**Days** - Unless otherwise designated, days as used in the Contract Documents means calendar days.

**Days, Working** - Those calendar days during which regular business is conducted, excluding Saturdays and Sundays and all NYCT-observed Federal, State, and municipal holidays.

**Deadman Control** - A device to detect inattention or disability of the Train Operator.

**Diagnostic Test Equipment (DTE)** - Any test equipment, whether portable or not.

**Dispatching** - The process of starting a train into revenue service from a terminal zone or transfer switch.

**Display** - An electronic device that visually presents textual and/or graphical information to a human operator in a computer-generated format; may also include provision for operator input.

**DOT** - The United States Department of Transportation.

**Drive** - A system consisting of one or several motors, their direct control equipment (power circuits) and the associated mechanical devices required to produce a useful output.

**Duty Cycle** - The period or percentage of time associated with the activated state of operation, occurring during normal cyclic operations, in relation to the elapsed time of a full cycle.

**Dwell Time** - The total time from the instant that a train stops in a station until the instant it resumes moving.

**Dynamic Outline** - The largest dimensional cross sectional area generated by a moving train under worst-case conditions.

**Endurance Limit** - The maximum stress in a material that can be completely reversed an infinite number of times without causing fracture.

**Engineering Test** - A test wherein the equipment is operated to simulate actual operation either by itself or in a subsystem to determine that all functions specified are met and are within the tolerances permitted. The testing shall provide engineering information of all of the operating parameters of the equipment.

**Equal or Approved Equal** - In connection with make or quality of material or equipment in these Contract Documents, the NYCT's decision that any material or equipment proposed by the Contractor is equal to that specified.

**Factor of Safety** - The ratio of the load that would cause failure of a structure to the design load.

**Fail-Safe** - A characteristic of a system, component, or device which insures that any malfunction affecting safety will cause the system to revert to a state that is known to be safe.
Failure - An improper condition which requires unscheduled equipment maintenance or replacement to restore affected equipment to its normal operating condition.

Failure Rate - The frequency of failure, expressed as failures per hour or failures per mile. Failure rate is the mathematical reciprocal of MTBF or MDBF.

Fatigue - Failure of a structure by progressive fracture under large number of repetitions of stress considerably less than the yield stress.

Federal Government - The government of United States of America.

Field Jumper - A short piece of wire or cable with appropriate terminations on each end to permit connection to terminals within a terminal board or to an adjacent terminal strip.

Field Modification - Any change, alteration, adjustment, or modification to the equipment or any part not done at the original manufacturer's plant.

First Article - The first one of any production component of the car that is produced. The Specification provides that nothing be manufactured prior to approval, so the First Article shall have been made to approved drawings.

First Article Approval - The examination of and approval by the NYCT of an initial production part, major assembly, subassembly, system, subsystem, apparatus, or material, manufactured or assembled by either the Contractor or subcontractors.

First Article Inspection (FAI) - An extraordinary inspection of a First Article which accomplishes two purposes:

- First, it permits the NYCT to see, in three dimensions, what could be seen only on two-dimensional drawings up to that point. If the First Article Inspection is of a component that the Contractor is purchasing, rather than making itself, the First Article Inspection discloses details that were not visible before hand. The First Article Inspection is usually the first point at which maintainability of the component can be evaluated, inasmuch as it is the first point at which relationships between elements can be appreciated. The NYCT may approve the design that is revealed at the First Article Inspection, or may require changes in order that the component can meet the requirements of the Contract.

- Second, it is used to establish the quality level of workmanship that will be maintained for the balance of the components. The level is established jointly by the NYCT and the Inspector.

Freewheeling - The mode of operation of a vehicle in which both propulsion and braking are inactive, that is, tractive effort is zero.
SCOPE OF SPECIFICATION

Frog - Track structure at the intersection of two running rails to support wheels and provide passageways for their flanges as wheels on either rail pass through the intersection.

FTA - Federal Transit Administration of the United States Department of Transportation.

Furnishing - Furnishing, manufacturing, fabricating, and completely assembling all materials, plant, power, tools, pattern, supplies, appliances, vehicles and conveyances necessary or required for the completion of the Work.

Gauge, Track - Distance between the inside face of rails measured 0.626 inch (15.9 mm) below the top of the running rails at right angles thereto.

Guard Rail - A rail or other structure laid parallel with the running rails to contain and control car movement following derailment by holding the wheels in correct alignment to prevent their flanges from striking either crossing frogs or the point of switches.

Headway - The time separation between two trains, both traveling in the same direction on the same track. It is measured from the time the head-end of the leading train passes a given reference point to the time the head-end of the train immediately following passes the same reference point.

Independent Failure - A failure which is not the result of another failure, either directly or indirectly.

Indicated - As used in these Contract Documents, "Indicated" shall be understood to mean, "as shown on the Concept Drawings", or "as described in the Contract Documents".

Inspector - Any representative of the Project Manager designated to act as an inspector for the NYCT for the purposes of quality assurance.

Interchangeable - Said of two modules or components that, although possibly of different design, perform identical functions and have identical interface characteristics.

Interface - The points where two or more systems, subsystems or structures meet, transfer energy, or transfer information.

Inverter - A solid state device that converts direct current to alternating current.

Irretrievable - Condition where a brake application cannot be released until the train has come to a complete stop.

Jerk Rate - Time rate of change of acceleration and deceleration, equal to the second time derivative of velocity.

Jumper - A short piece of wire or cable with appropriate terminations on each end to permit connection to terminals within a terminal board or to an adjacent terminal strip.
Law - Each and every law, rule, regulation of the United States and the State of New York, as well as any requirement, order, judgment, decree, or ordinance issued by any government entity, applicable to or affecting the Contract, the Work and all persons engaged in the Work (including any of the foregoing which concern health, safety, environmental protection, and non-discrimination).

Legal Proceeding - Every action, litigation, arbitration, administrative proceeding, and other legal or equitable proceeding of any kind whatsoever.

Liens - Any and every lien of any kind whatsoever against the Work, any monies due or to become due from the Contracting Party to Contractor, and/or any other property of the Contracting Party, for or on account of the Work, including any public lien.

Line Breaker - A current sensing switch which interrupts maximum fault currents to protect power circuits. May also perform line switch functions.

Line Replacement Unit (LRU) - Unit (component) or subsystem which is normally replaced at the Service and Inspection Facility (S&I).

Line Switch - A switch without self-sensing overcurrent capability used to disconnect the propulsion system from external power supply. Remotely operable as opposed to a manual knife switch. May be used to interrupt overcurrent fault if tripped by pilot overload relay.

Load Weighing - A function incorporated in the traction system which measures changes of gross car weight. Its purpose is to permit control of tractive effort or braking effort in order to achieve a constant effort-to-weight ratio.

Low Voltage Distribution Network (LVDN) - A general reference to the wiring and protective devices that are involved in the distribution of low voltage power.

Low Voltage Power Supply (LVPS) - The solid-state power supply that converts a high voltage input to a 37.5 Vdc output.

Lowest Level Replaceable Unit (LLRU) - The lowest level component or part which can be replaced, but cannot be repaired.

Main Knife Switch - A manual disconnect switch.

Maintainability - A characteristic of design and installation, expressed as the probability that an item shall be restored to a specified condition within a given period of time when maintenance is performed in accordance with prescribed procedures and resources.

Maintenance, Corrective - Repair or replacement of components as a result of failure.

Maintenance, Scheduled - Inspection and repair or replacement of components at intervals measured by time or usage.
SCOPE OF SPECIFICATION

Major Supplier - A supplier of a System or of a Subsystem of a System.

Manual Operation - An operating mode in which the train responds to the actions of its operator through manual control of the operator's master controller.

Manufacturer or OEM - The original builder or producer supplying materials, equipment, or apparatus for installation on the car.

Mean Distance Between Component Failures (MDBCF) - The mean distance (in miles) between component failures. (Reference Section 18.2 of TECHNICAL SPECIFICATION)

Mean Distance Between Failures (MDBF) - The mean distance (in miles) between “train delays” attributed to car equipment. (Reference Section 18.2 of TECHNICAL SPECIFICATION)

Mean Time To Repair (MTTR) - The arithmetic mean of all active repair time.

Mock-up - A full-scale model used to demonstrate Specification compliance.

Monitoring and Diagnostic Logic (MDL) - A system that collects, processes and displays operating and fault data for the car, Unit and train.

MTA - The Metropolitan Transportation Authority (same as Contracting Party), a public benefit corporation existing by virtue of the New York Public Authorities Law and any public benefit corporation or government agency.

New York City Transit System (or NYCTS) - The rapid transit system within the City of New York operated by the Authority.

No. 1 End - The end of the car where the parking brake is located; and in the case of the A Car, where the cab is located.

No. 2 End - The end of the car opposite to the No. 1 end.

No-Motion - A referenced state of Unit velocity of 0.5 mph (0.8 km/h) or less.

Noise Level - As defined by the latest version of ANSI S1.4: The weighted sound pressure level measured by the use of a metering characteristic and weighting A, B, or C as specified in ANSI A1.4. The unit of noise level is the decibel (dB), and the reference pressure is 20 micropascals.

Notice or notice - a written announcement.

Notice of Acceptance - Notice given by the Authority pursuant to Article 207 to the Contractor that the Operating Unit or an individual car, if applicable, has passed all required tests and is being accepted by the Authority.
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Notice of Arrival - Notice given by the Authority that a shipment of Cars has been delivered to the designated point.

Notice of Award - A document that apprises the Contractor that this Contract has been approved by the Board of the Authority.

Notice to Proceed - Same as "Notice of Award".

NYCT - Same as “Authority”.

Operating Unit - Same as “Unit”.

Party, Parties - Entity(ies) entering into the Contract.

Plans - See Concept Drawings.

Portable Test Equipment (PTE) - Laptop PCs for testing all systems and subsystems and any other portable testers.

Portable Test Units (PTU) - Any portable testers.

Profile Grade - A straight line along the centerline of track representing an established slope to the horizontal, usually expressed in percent, i.e., rise over run.

Project Manager or Engineer - Person designated by the NYCT to be its liaison with the Contractor on all matters pertaining to the work. The Project Manager is empowered to act on behalf of the Authority in such matters as approval of Contractor's Drawings, test procedures, First Article approvals, and Car or Unit Acceptance, payments to Contractor and contractual issues.

Proof (used as a suffix) - Apparatus is designated as splashproof, dustproof, etc., when so constructed, protected, or treated that its successful operation is not interfered with when subjected to the specified material or condition.

Purlin - A longitudinal roof frame member extending over the carlines, extending from one end of the car to the other, to which the roof sheets are fastened.

Qualification Test - A test performed on a production item to show that it is capable of achieving all of the performance requirements over the specified operating range and therefore, is more likely to perform in accordance with the Contract requirements.

Rail Gap Detector - An electrical device able to sense the absence of third rail voltage.

Railroad - Same as New York City Transit System.
Redundancy - The existence of more than one means of accomplishing a given function.

Regenerative Braking - Process of returning the braking energy of the Unit to the third rail power system through the conversion of kinetic energy to electrical energy.

Reliability - The probability of performing a specified function without failure and within design parameters for the period of time specified under actual operating conditions.

Safe - The condition in which passengers, crew, or repairmen are secure from threat or danger, harm, or loss arising from improper design, manufacture, assembly, malfunction, or failure of the car or any of its components or systems.

Sample Car - The first production car of each type.

Screen - A pre-defined set of information presented on a display, typically optimized in content and format for a particular task or situation.

Service, as in Service Use, Service Braking - The operation of the Units under normal conditions with passengers.

Shell - That part of a car body composed of roof, sides, end and underframe structure, floor and sheathing but devoid of any interior finish, windows, doors and exterior accessories.

Shop Drawings - Drawings or sketches prepared by the Contractor for use in its manufacturing facility, assembly facility, or shop, to fabricate, assemble, and/or install parts of the vehicle, whether manufactured by it from raw materials or purchased from others in a ready-to-use condition.

Side, Left - The side of the car to the left of a person facing the No. 1 End of the car from inside the car.

Side, Right - The side of the car to the right of a person facing the No. 1 End of the car from inside the car.

Slide, Wheel - During braking, the condition existing when the rotational speed of the wheel is less than that for pure rolling contact between tread and rail.

Speed, Balancing - The steady-state speed attained by a train when resisting forces exactly equal the maximum available tractive forces on level tangent track.

Speed, Schedule - The average speed of a train from terminal to terminal obtained by dividing the distance between these points by the time taken to make the trip, including time for intermediate station stops.

Spin, Wheel - During acceleration, the condition existing when the rotational speed of the wheel is greater than that for pure rolling contact between tread and rail.
Standard Generalized Markup Language (SGML) - A vendor-neutral international standard for information exchange, incorporating hypertext.

**State** - The State of New York.

**Step Signal** - A signal having a constant value prior to the step and a different constant value immediately thereafter.

**Stop, Emergency** - The stopping of a train by an emergency brake application.

**Stop, Service** - The stopping of a train by application of service braking. Brake application can be released and reapplied.

**Subcontractor** - A person, firm, contractor, corporation or combination thereof who enters into a contract to furnish labor or services only or labor and materials or apparatus in connection with the Work directly or indirectly for or in behalf of the Contractor and whether or not in privity of Contract with the Contractor.

**Subsystem** - A defined portion of a System which consists of component, parts, or both.

**Superelevation** - The amount by which the outer rail within a curve, is higher than the inner rail. Usually measured in inches.

**Supplier** - A person, firm, contractor, corporation or combination thereof who furnishes materials, equipment or supplies for the Work to the Contractor either directly or indirectly and whether or not in privity of Contract with the Contractor.

**Tamperproof** - Fasteners are designated as tamperproof when they are selected so that they can not be easily loosened with common tools such as a flat blade screwdriver, Phillips screwdriver, or pliers.

**Technical Specifications, Specifications or specifications** - As used in this Volume, shall mean that portion of the Contract Documents that detail the technical requirements for the supply of rail cars and associated equipment, including any changes or addenda made.

**Tight (used as a suffix)** - Apparatus is designated as watertight, dusttight, etc., when so constructed that the enclosing case will exclude the specified material.

**Time Constant** - Time interval from the beginning of change of a controlled variable in response to a step-forcing function to the attainment of a stated value.

**Time, Build-up** - Time interval from the beginning of change of a controlled variable (defined as being at 10 percent of the new steady state value) in response to a step-forcing function to the attainment of 90 percent of the new steady state value of the controlled variable.
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Time, Dead (also, Time, Response) - Time from the occurrence of a step change of the control signal to the beginning of a change of the controlled variable defined as being to the attainment of 10 percent of the new steady-state value of the controlled variable.

Time, Down - The elapsed time during which equipment is not capable of doing useful work because of maladjustment, malfunction, or maintenance in progress.

Time, Recovery - The time required for a system or condition to return to its original state (or some stated percentage of its original value) after being disrupted or destabilized.

Time, Response - Time interval from the occurrence of a step change of control signal to the attainment of 90 percent of the new steady-state value of the controlled variable, equal to the sum of dead time and build-up time.

Time, Warmup - The elapsed time from application of power to an operable device until it is capable of performing all of its intended functions.

T/O - Train Operator.

Track Tests - Tests of Units or any subsystem which is run on the NYCT's track or a track simulating, as much as practicable, the actual track conditions found on the NYCT's system to verify performance parameters of the Specification.

Traction System - The system of wheels, motors, driving mechanisms, brakes, direct controls and appurtenances that propels or retards a Unit in response to control signals.

Tractive Effort - Accelerating and braking forces.

Train - A configuration of 5, 6, 9, 10 or 11 Cars to be used in revenue service.

Train Delay - An incident causing a revenue train to be: a) More than five minutes late at its destination terminal; b) Canceled (either at its original terminal or en route); and c) Rerouted.

Train Operator - The individual who normally occupies the head end cab of a train and is responsible for performing functions necessary for train movement and monitoring.

Train Operator Display (TOD) - Touch-screen display(s) in the Train Operator’s console.

Trainline - A wire, or bus, for transmitting signals and data to all cars in a train, via a continuous circuit connected through appropriate coupling devices.

Tram - A condition of ideal truck geometry in which the axles are perfectly parallel and the wheels longitudinally in perfect alignment. The centers of the journal bearings represent the corners of a perfect rectangle. Tram is checked by measuring the diagonal and longitudinal distances between reference points on the axle bearing housing.
Trip Cock - A mechanical device located on the train which when hit by an automatic stop arm, results in an emergency brake application.

Truck, No. 1 - The truck located nearest to the No. 1 End of a car, which includes the parking brake.

Truck, No. 2 - The truck located farthest from the No. 1 End of a car.

United States Government - See "Federal Government."

U.S. Department of Transportation - U.S. Department of Transportation (DOT) means the Secretary of the (DOT) and other persons who may at the time be acting in the capacity of the Secretary, or authorized representative or any person otherwise authorized to perform the functions to be performed hereunder, including representatives of the Federal Transit Administration (FTA).

Ultimate Tensile Strength - The maximum tensile stress that a material can sustain under uni-axial tension, calculated on the basis of the load at rupture and the original unstrained dimensions.

Unit - Four to six semi-permanently coupled cars. (Reference Sections 2.1.2 and 2.2.)

Vehicle - Same as "Car".

Vital Circuit - Any circuit and its elements, the function of which affects the safety of train operations.

Warp, Track - The vertical distance between the plane of any three of four rail head contact points (two on each rail) forming a plane and the remaining point.

Weight, Actual - The measured weight of a finished AW0 car, with all fluid levels topped off, ready for revenue service.

Wheel Loads-Maximum - That loading representing total car weight transferred to the running rails from each wheel at AW3.

Work or Project - All required obligations of the Contractor hereunder, including but not limited to, Car and Unit design and manufacture, delivery, including loading and unloading, testing, submission of deliverables, performance of warranty obligations, furnishing of all equipment, items, materials, parts, systems, data, design, services, and other matters and things necessary or the required labor and management to be done by the Contractor pursuant to this Contract, including all miscellaneous and incidental work.

Yield Stress - The stress at which a material exhibits a specified deformation or set.

As used herein the singular shall mean and include the plural; the masculine gender shall mean the feminine and neuter genders; and vice versa.
Whenever in the Specifications or on the Plans the words "required", "determined", "directed", "specified", "authorized", "ordered", "given", "designated", "indicated", "considered necessary", "deemed necessary", "permitted", "reserved", "suspended", "established", "approval", "approved", "disapproved", "acceptable", "unacceptable", "suitable", "accepted", "satisfactory", "unsatisfactory", "sufficient", "insufficient", "rejected", "condemned", or words of like import are used, it is understood as if such words were followed by the words, in writing, "by the NYCT", "to the NYCT", unless otherwise specifically stated.

Wherever the words "provided", "supplied" or "installed" are used in the Contract Documents in reference to work to be performed by the Contractor, it is understood to mean "furnished and delivered completed".

1.8.2 Abbreviations
MOD 02

The following is a list of abbreviations used in the Specification. The list is not intended to be all inclusive.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>Association of American Railroads</td>
</tr>
<tr>
<td>AATCC</td>
<td>American Association of Textile Chemists and Colorists</td>
</tr>
<tr>
<td>ac</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ADA</td>
<td>Americans with Disabilities Act of 1990</td>
</tr>
<tr>
<td>AFBMA</td>
<td>Anti-Friction Bearing Manufacturer's Association</td>
</tr>
<tr>
<td>AFI</td>
<td>Air Filter Institute</td>
</tr>
<tr>
<td>AISC</td>
<td>American Institute of Steel Construction</td>
</tr>
<tr>
<td>AISI</td>
<td>American Iron and Steel Institute</td>
</tr>
<tr>
<td>AMCA</td>
<td>Air Moving &amp; Conditioning Association</td>
</tr>
<tr>
<td>Amp</td>
<td>Amperes</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
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<tr>
<td>APA</td>
<td>American Plywood Association</td>
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<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>APS</td>
<td>Auxiliary AC Power Supply</td>
</tr>
<tr>
<td>APTA</td>
<td>American Public Transit Association</td>
</tr>
<tr>
<td>AREA</td>
<td>American Railway Engineering Association</td>
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<tr>
<td>ARI</td>
<td>Air Conditioning and Refrigeration Institute</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigeration and Air Conditioning Engineers</td>
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<td>ASC</td>
<td>Air Spring Cutout</td>
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<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
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<tr>
<td>ASIC</td>
<td>Application Specific Integrated Circuit</td>
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<tr>
<td>ASM</td>
<td>American Society for Metals</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
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<tr>
<td>ATA</td>
<td>Air Transport Association of America</td>
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<tr>
<td>ATO</td>
<td>Automatic Train Operation</td>
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<tr>
<td>ATP</td>
<td>Automatic Train Protection</td>
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<tr>
<td>ATS</td>
<td>Automated Timekeeping System</td>
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<tr>
<td>AVI</td>
<td>Automatic Vehicle Identification</td>
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<tr>
<td>AWG</td>
<td>American Wire Gauge</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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</tr>
<tr>
<td>AWS</td>
<td>American Welding Society</td>
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<tr>
<td>BHP</td>
<td>Brake Horsepower</td>
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<tr>
<td>BNC</td>
<td>Baby &quot;N&quot; Connector</td>
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<tr>
<td>BTL</td>
<td>Battery Trainline</td>
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<tr>
<td>Btu</td>
<td>British Thermal Unit</td>
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<tr>
<td>°C</td>
<td>Degrees Centigrade</td>
</tr>
<tr>
<td>C</td>
<td>Capacitance</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>CBMA</td>
<td>Certified Ballast Manufacturer's Association</td>
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<tr>
<td>CBTC</td>
<td>Communications-Based Train Control</td>
</tr>
<tr>
<td>CGHAZ</td>
<td>Coarse Grain Heat Affected Zone</td>
</tr>
<tr>
<td>CDA</td>
<td>Copper Development Association</td>
</tr>
<tr>
<td>CDR</td>
<td>Critical Design Review</td>
</tr>
<tr>
<td>CDRL</td>
<td>Contract Data Requirements List</td>
</tr>
<tr>
<td>CFC</td>
<td>Chlorofluorocarbon</td>
</tr>
<tr>
<td>cfm</td>
<td>Cubic Feet Per Minute</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>CPM</td>
<td>Critical Path Method</td>
</tr>
<tr>
<td>C/R</td>
<td>Conductor</td>
</tr>
<tr>
<td>CRF</td>
<td>Critical Radiant Flux</td>
</tr>
<tr>
<td>CTS</td>
<td>Console Touch Screen</td>
</tr>
<tr>
<td>DOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>dB</td>
<td>Decibel</td>
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<tr>
<td>dBA</td>
<td>Decibel, A Scale Reading</td>
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<tr>
<td>DB</td>
<td>Dry Bulb</td>
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<tr>
<td>dc</td>
<td>Direct Current</td>
</tr>
<tr>
<td>$D_s$</td>
<td>Specific Optical Density</td>
</tr>
<tr>
<td>E</td>
<td>Modulus of Elasticity</td>
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<tr>
<td>ECR</td>
<td>Engineering Change Request</td>
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<tr>
<td>ECU</td>
<td>Electronic Control Unit</td>
</tr>
<tr>
<td>EER</td>
<td>Energy Efficiency Ratio</td>
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<tr>
<td>EIA</td>
<td>Electronic Industries Association</td>
</tr>
<tr>
<td>EMI</td>
<td>Electromagnetic Interference</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>EPROM</td>
<td>Erasable Programmable Read Only Memory</td>
</tr>
<tr>
<td>ETFE</td>
<td>Ethylenetetrafluoroethylene</td>
</tr>
<tr>
<td>ETP</td>
<td>Electrolytic Tough Pitch</td>
</tr>
<tr>
<td>°F</td>
<td>Degrees Fahrenheit</td>
</tr>
<tr>
<td>°FDB</td>
<td>Degrees Fahrenheit Dry Bulb</td>
</tr>
<tr>
<td>°FWB</td>
<td>Degrees Fahrenheit Wet Bulb</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>FAI</td>
<td>First Article Inspection</td>
</tr>
<tr>
<td>FCC</td>
<td>Federal Communications Commission</td>
</tr>
<tr>
<td>FE</td>
<td>Finite Element</td>
</tr>
</tbody>
</table>
SCOPE OF SPECIFICATION

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FEA  Finite Element Analysis
FH1  Floor Heat 1
FH2  Floor Heat 2
FMEA  Failure Mode and Effects Analysis
FMECA  Failure Mode and Effects Critical Analysis
FMVSS  Federal Motor Vehicle Safety Standards
fpm  Feet Per Minute
FRA  Federal Railroad Administration
FRP  Fiberglass Reinforced Plastic
FTA  Federal Transit Administration
ft-lbs  Foot-Pounds
GP  General Purpose
GTO  Gate Turn-Off
HAZ  Heat Affected Zone
HCFC  Hydrochlorofluorocarbon
HFC  Hydrofluorocarbon
HP  Horsepower
HPCU  Hydraulic Pressure Control Unit
HSCB  High Speed Circuit Breaker
HVAC  Heating, Ventilation, and Air Cooling
Hz  Hertz
I/O  Input/Output
IACS  International Annealed Copper Standard
IC  Integrated Circuit
ICC  Interstate Commerce Commission
ICEA  Insulated Cable Engineers Association
IEC  International Electrotechnical Committee
IEEE  Institute of Electrical and Electronics Engineers
IES  Illuminating Engineering Society
IPC  Institute of Printed Circuits
IPS  Iron Pipe Size
ISO  International Standards Organization
Is  Flame Spread Index
j  Joules
JEDEC  Joint Electronic Device Engineering Council
JIC  Joint Industrial Council
km  Kilometer
kHz  Kilohertz
kPa  Kilopascal
km/h  Kilometers per hour
LAHT  Low Alloy High Tensile Strength (Steel)
LAN  Local Area Network
lbs  Pounds
lbf  Pounds force
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LED  Light Emitting Diode
LLRU  Lowest Level Replaceable Unit
LRU  Line Replacement Unit
LVDB  Low Voltage Distribution Bus
LVDN  Low Voltage Distribution Network
LVPS  Low Voltage dc Power Supply
m  Meters
mm  Millimeter
MA  Motor Alternator
MC  Master Controller
MDL  Monitoring and Diagnostic Logic
MHZ  Megahertz
MIL  Military Specification
mph  Miles Per Hour
mphps  Miles Per Hour Per Second
mphpsps  Miles Per Hour Per Second Per Second
ms  Millisecond
MSDSs Material Safety Data Sheets
MTBF  Mean Time Between Failure
MTTR  Mean Time To Repair
MU  Multiple-Unit
μA  Micro Ampere
N  Newton
NBS  National Bureau of Standards
NCA  Noise Criterion, Alternate
NEC  National Electrical Code
NEMA  National Electrical Manufacturers' Association
NFL  No Field Lubrication
NFPA  National Fire Protection Association
NIST  National Institute of Standards and Technology
NTP  Notice to Proceed
NYCT  New York City Transit
OD  Outside Diameter
OFE  Oxygen Free Electronic
OHDS  Overhead Heat Duct Sensor
PA  Public Address
Pas  Pascals
PC  Printed Circuit
PCU  Pneumatic Control Unit
PCMCIA  Personal Computer Memory Card International Association
PDR  Preliminary Design Review
PEHU  Passenger Emergency Handle Unit
PFC  Pulling Face of Coupler
PIV  Peak Inverse Voltage
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ppm</td>
<td>Parts Per Million</td>
</tr>
<tr>
<td>ppmh</td>
<td>Parts Per Hundred Million</td>
</tr>
<tr>
<td>PROM(s)</td>
<td>Programmable Read-Only Memory (ies)</td>
</tr>
<tr>
<td>PS</td>
<td>Pressure Switch</td>
</tr>
<tr>
<td>psi</td>
<td>Pounds Per Square Inch</td>
</tr>
<tr>
<td>psia</td>
<td>Pounds Per Square Inch, Absolute</td>
</tr>
<tr>
<td>psig</td>
<td>Pounds Per Square Inch, Gauge</td>
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<tr>
<td>PTE</td>
<td>Portable Test Equipment</td>
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<tr>
<td>PTFE</td>
<td>Polytetrafluoroethylene</td>
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<tr>
<td>PTU</td>
<td>Portable Test Unit</td>
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<tr>
<td>PWM</td>
<td>Pulse Width Modulation</td>
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<tr>
<td>QA</td>
<td>Quality Assurance</td>
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<tr>
<td>QFR</td>
<td>Quality Failure Report</td>
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<tr>
<td>R-C</td>
<td>Resistive-Capacitive</td>
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<td>RAM</td>
<td>Random Access Memory</td>
</tr>
<tr>
<td>RFI</td>
<td>Radio Frequency Interference</td>
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<tr>
<td>RH</td>
<td>Relative Humidity</td>
</tr>
<tr>
<td>rms</td>
<td>Root Mean Square</td>
</tr>
<tr>
<td>rpm</td>
<td>Revolutions Per Minute</td>
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<td>ROM</td>
<td>Read-Only Memory</td>
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<td>RTO</td>
<td>Rapid Transit Operations</td>
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<tr>
<td>R-22</td>
<td>Refrigerant 22</td>
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<tr>
<td>s</td>
<td>Second</td>
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<tr>
<td>S</td>
<td>Flexural Strength</td>
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<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
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<td>SCFM</td>
<td>Standard Cubic Feet Per Minute</td>
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<td>SCR</td>
<td>Silicone Controlled Rectifier</td>
</tr>
<tr>
<td>SDD</td>
<td>Software Design Description</td>
</tr>
<tr>
<td>SGML</td>
<td>Standard Generalized Markup Language</td>
</tr>
<tr>
<td>SIC</td>
<td>Standard Industry</td>
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<td>SMS</td>
<td>Scheduled Maintenance System</td>
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<td>SPL</td>
<td>Sound Pressure Level</td>
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<td>SSP</td>
<td>System Safety Program</td>
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<tr>
<td>S&amp;I</td>
<td>Service and Inspection Facility</td>
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<tr>
<td>S/N</td>
<td>Signal To Noise</td>
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<tr>
<td>$T_a$</td>
<td>Ambient Temperature</td>
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<tr>
<td>$T_i$</td>
<td>Interior Temperature</td>
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<td>TFE</td>
<td>Tetrafluoroethylene</td>
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<td>TIG</td>
<td>Tungsten Inert Gas</td>
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<tr>
<td>TIR</td>
<td>Total Indicated Runout</td>
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<tr>
<td>T/O</td>
<td>Train Operator</td>
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<tr>
<td>TOD</td>
<td>Train Operator's Display</td>
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<tr>
<td>TOR</td>
<td>Top-of-Rail</td>
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<tr>
<td>TTCS</td>
<td>Train Trouble Control System</td>
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## SCOPE OF SPECIFICATION

**Contract No. R34142ANYCT Division A**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>TXV</td>
<td>Thermal Expansion Valve</td>
</tr>
<tr>
<td>UA-Factor</td>
<td>Car Body Heat Transmission Factor</td>
</tr>
<tr>
<td>US, U.S.</td>
<td>United States</td>
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SECTION 2
SYSTEM DESIGN

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SECTION 2

2.0 SYSTEM DESIGN

2.1 Design Basis and Parameters

2.1.1 General

This Section establishes the functions, subsystem performance, and general design criteria for the NYCT R142A heavy rail rapid transit cars. Included are requirements for configuration, capacity, dimensional, performance, environmental, noise and vibration, ride quality, weight, and other requirements that impact system and subsystem design. These requirements apply to all aspects of the car and the car equipment design. Detailed system and subsystem requirements are further defined in the sections explicitly covering those systems and subsystems.

Quantitative values are stated both in customary North American English units and in metric S.I. units. In a case where the stated values for any quantity may be in or appear to be in conflict, the value in customary English units shall govern unless an explicit clarification is given by addendum.

The vehicles shall be designed to have a minimum service life of 40 years for the car body and truck frame and 20 years for the systems and subsystems, unless otherwise specified. The achievement of design life assumes compliance with the Unit and car maintenance intervals specified in Section 18.3.4, with subsequent NYCT approved modifications arising from any Contractor recommendations, and assumes conventional NYCT maintenance practices and normal industry-accepted operating procedures. For design purposes, the annual average operating distance per car is 60,000 miles (96,540 km).

2.1.2 Operating Train Configuration

The R142A cars will be operated as trains comprised of five, six, nine, ten and eleven cars, assembled as one or two operating Units, with each operating Unit comprised of four, five or six cars. The outer ends of each Unit shall be provided with operator cabs and automatic couplers. Five- and six-car Units shall be capable of being deployed for independent operation and for multiple-Unit operation in revenue service. Four-car Units shall be capable of operation in non-revenue service. Two-Unit trains can be assembled either from two R142A Units or from one R142A and one R142 Unit. Alterations in train composition will be performed at any location, by coupling or uncoupling of Units using the automatic couplers. The functional design shall maximize in-service reliability and mission completion probability for the complete Unit since Unit replacement rather than car replacement will be the revenue service adjustment capability.

2.1.3 Operating Physical Environment

The R142A cars will operate on NYCT Division A. Approximately 2/3 of Division A operation is underground. Division A infrastructure constraints originate from its IRT predecessor and require a relatively short and narrow car. The R142A car dimensions as specified in Section 2.2.3 perpetuate prior Division A car dimensions and are known to fit the infrastructure constraints.
Reference Appendix A and NYCT MW-1, Track Standards and Reference Manual, 1995, and NYCT Standards, Specifications and Publications, "Standard Specification for Track and Structures Material" within Appendix C, for a description of the fixed facilities over which trains will operate. The train design shall be consistent with all of the conditions specified within Appendix A. If any portion of the Specification is found to describe the fixed facilities in a manner other than described in Appendix A, Appendix A shall govern. If any portion of the Specification is found to require other than that required by Appendix A, the more stringent shall govern.

Car and equipment clearance limits, on tangent track, are depicted on NYCT Clearance Diagram, Division “A”; Drawing No. 205-3004. Each R142A car shall remain within the clearance outline shown for all conditions and/or combinations of dynamic motion, wear of components, passenger loading, suspension system deflection, and any single suspension system failure. No part of the trucks, except wheels, power collector shoes, trip cocks, and axle-mounted equipment, shall be less than 2.5 inches (64 mm) above the plane of the top of the rails. Clearance shall be provided under all conditions of dynamic motion, wear of components, passenger loading, vertical and horizontal curves, suspension system deflection, and any single suspension system failure.

The car shall be designed to have the top of the threshold at or above the platform for all loading conditions, assuming no failures. For purposes of this requirement only, assume that the platform height is 3 feet, 6.375 inches, with a tolerance of +2/-0 inches (1.076 m, +0.051/-0 m).

2.2 Configurations

Operating Units shall be assembled using two types of cars, designated as A and B. Connections between cars within a Unit shall be by means of a mechanical coupling (link bar), electrical jumper cables, and control/communications jumper cables. Alterations of the car composition within a Unit will be a shop/yard level activity. Unless requested otherwise, and except for test purposes, all Units shall be assembled using five cars.

Connections between cars within a Unit shall accommodate inter-car passenger movement in a safe and environmentally protected manner.

At least 70 percent of the axles on a 5-car unit shall be powered.

A uniform and logical system for identification of equipment and components on Units and cars shall be devised and submitted for NYCT approval. It shall be based on the A and B car designations, No. 1 End and No. 2 End conventions, and "Left Side" and "Right Side" as defined in Section 1.8. For an example of equipment numbering refer to Appendix C, Designation of Sides and Ends of Locomotives. Equipment and components that are common across all car types in a Unit shall have a single unique identification common to all car types. Equipment and components that are unique to any particular car type shall be identified so as to indicate that type of car as well as the unique identification. Refer to Section 3.17.1.2 for related requirements.

2.2.1 Car Types

All cars shall be stainless steel, rigid-bodied, four-axle with two trucks.
The two different car types that are required to produce the specified Unit configuration are generally differentiated by the provision of an operating cab and automatic coupler on one end of cars designed to be Cab Cars, and by the lack of those provisions at either end on cars designed to be Non-Cab Cars. Cab Cars are designated as A Cars, and Non-Cab Cars are designated as B Cars.

The A Car (cab car) shall provide a minimum of 34 passenger seat positions. The B Car shall provide a minimum of 40 passenger seat positions. Both car types shall have three passenger side doors located on each car side, in coordination with the interior seating arrangement, to facilitate a rapid interchange of patrons.

Equipment and components shall be identical for generally equivalent functions that are used on more than one car type.

### 2.2.2 Provisions for Passengers with Disabilities

Car design shall comply with all requirements for rapid rail cars of the Americans with Disabilities Act of 1990, as set forth in U.S. Department of Transportation regulations, published at 49 CFR, Part 38, Subparts A and C, in effect at the time of award of this Contract.

### 2.2.3 Car Dimensions

The overall dimensions shall be as listed below for a new car, AWO loaded, ready for revenue service. The dimensions given are nominal unless otherwise indicated.

- Length over anti-climbers: 51 feet 0.5 inches (15.56 m)
- Linked or coupled/linked length: 51 feet 4.0 inches (15.65 m)
- Truck center spacing: 36 feet 0.0 inches (10.97 m)
- Body width at side sills: 8 feet 7.1875 inches +0.125, -0.375 inches (2.62 m)
- Width over door thresholds, maximum: 8 feet 9.5 inches (2.68 m)
- Width at belt rail (side window sill): 8 feet 7.1875 inches +0.125, -0.375 inches (2.62 m)
- Height, top of rail to top of roof, new wheels: 11 feet 10.625 inches (3.623 m)
- Height, top of rail to top of finished floor, new wheels: 3 feet 8.75 inches (1.137 m)
- Height, top of rail to top of anti-climber, new wheels: 3 feet 7.5 inches (1.105 m)
- Height, top of rail to coupler centerline with face of coupler vertical: 2 feet 4.875 inches (0.733 m)
- Side door clear opening minimum height: 6 feet 2.724 inches (1.898 m)
### System Design

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<th>Requirement</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Side door clear opening minimum width</td>
<td>4 feet 6.0 inches (1.372 m)</td>
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<tr>
<td>Cab end door clear opening minimum height</td>
<td>6 feet 2.0 inches (1.88 m)</td>
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<tr>
<td>Non cab end door clear opening minimum height</td>
<td>6 feet 2.8 inches (1.9 m)</td>
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<tr>
<td>End door clear opening minimum width</td>
<td>2 feet 6.0 inches (813 mm)</td>
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<tr>
<td>Interior height, floor to normal ceiling, minimum</td>
<td>7 feet 0.5 inches (2.146 m)</td>
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<tr>
<td>Interior height, floor to low ceiling if used, minimum</td>
<td>6 feet 7.5 inches (2.019 m)</td>
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#### 2.2.4 Truck Dimensions MOD 02

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<th>Requirement</th>
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<td>Truck axle spacing, maximum</td>
<td>6 feet 10.0 inches (2.083 m)</td>
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<tr>
<td>Wheel diameter, new</td>
<td>34.0 inches (864 mm)</td>
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<td>Wheel diameter, fully worn</td>
<td>31.0 inches (787 mm)</td>
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<tr>
<td>Mounted wheelset back-to-back distance</td>
<td>4 feet 5.375 inches +0, -.125 (1.3557 m)</td>
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#### 2.2.5 Car Loadings and Assigned Weights

The following are maximum allowable car weights. Contractor shall endeavor to keep the Unit weight to a minimum consistent with strength and stability requirements. Design of all systems and equipment, including propulsion and braking systems, shall be consistent with the as-delivered Unit weights. To ensure adequate design, these systems shall be designed for a weight not less than 105 percent of the weight estimated in the Contractor’s proposal.

Car weights shall be as follows:

- **In a five-car Unit**, the average car weight shall not exceed 70,000 lbs. (31,752 kg).
- **Under all uniform loading conditions up to AW3**, at least 70 percent of the Unit weight shall be over powered axles.
- **Under all loading conditions up to AW3**, the maximum wheel loading shall be at least five percent less than that shown in Appendix A.

#### 2.2.5.1 A Cars

<table>
<thead>
<tr>
<th>Requirement</th>
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<tbody>
<tr>
<td>AW0, empty car ready for service without crew or passengers</td>
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<tr>
<td>AW1, AW0 plus 34 passengers at 154 lbs (70 kg)</td>
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</tr>
<tr>
<td>AW2, AW0 plus 68 passengers at 154 lbs (70 kg)</td>
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<tr>
<td>AW3, AW0 plus 182 passengers at 154 lbs (70 kg)</td>
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</table>
2.2.5.2 B Cars

- AW0, empty car ready for service without passengers
- AW1, AW0 plus 40 passengers at 154 lbs (70 kg)
- AW2, AW0 plus 80 passengers at 154 lbs (70 kg)
- AW3, AW0 plus 182 passengers at 154 lbs (70 kg)

2.2.5.3 Intentionally Blank

2.2.5.4 Balancing

All cars and trucks shall be designed and manufactured to achieve minimum weight, minimum side-to-side and end-to-end weight unbalance, and maximum weight uniformity on powered axles. The side-to-side unbalance of each completed car at AW0 condition shall not exceed 20,000 inch-pounds (2,260 Newton-meter) or as approved by NYCT. The end-to-end truck pivot weight difference of each completed car at AW0 condition shall not exceed 500 pounds (227 kg), without approval.

2.2.5.5 Weight Records

The Contractor shall keep detailed weight records for the first 10 cars of each type. These weight records shall itemize each major car item starting with the initial design estimated weight and continuing with refined design estimates, first piece measured weights, and production piece measured weights. The Contractor shall maintain accurate and up-to-date cumulative car weights and cumulative car balance data for review by NYCT.

2.2.5.6 Weighing

The Contractor shall individually weigh each car of each complete Unit at shipment using a scale that produces a printed record of the weight, measured in pounds. The weight ticket shall be furnished to the NYCT in the shipping documents and data entered into the Car History Books.

2.2.6 Unit and Car Reliability

The R142A Contractor shall establish a data base for an IBM PC or compatible microcomputer to monitor the reliability of the cars, measured as Mean Distance Between Failures (MDBF) and Mean Distance Between Component Failures (MDBCF). Reliability requirements are provided in Section 18.2.
2.3 Supply Voltages

All equipment on the car shall function normally, without failure or degradation of service or in-service life, at any voltage between the maximum and minimum voltages defined for the system from which the equipment is supplied for any duration, and shall not be damaged by the continuous application of any voltage between zero volts and the minimum or any polarity thereof.

Unless otherwise specified, rated performance shall be delivered at any voltage between nominal and maximum voltages. Between the minimum and nominal voltages, analog measured performance such as brightness of lamps, motor power output or rating of heaters may be reduced in proportion to the available voltage or in proportion to the square of the available voltage in accordance with the inherent physical characteristics of that item. The performance of control components such as energization of relays, solenoids or magnet valves shall be fully functional at any voltage between the minimum and the maximum.

All equipment on the Unit shall be self-protected from damage and improper operation due to:

- High-voltage transients across the supply terminals of that equipment,
- High-voltage transients impressed between either supply terminal and the Unit body, and
- Long-term over-voltage and under-voltage conditions resulting from other equipment failure modes.

The contact rail system voltage will contain high voltage transients generated by wayside sources, vehicle loads, regeneration from other NYCT trains, lightning, and other transient generators. If quantification of those high voltage transients is a critical design information item, the Contractor shall conduct transient voltage studies as appropriate and with the cooperation of NYCT to obtain all required data beyond that available within NYCT. Any data obtained in the course of these studies shall be provided to NYCT for use by NYCT without limitation.

2.3.1 Contact Line

- Maximum Voltage 780 Vdc
- Substation Light Load Voltage 675 Vdc
- Nominal Voltage 600 Vdc
- Minimum Voltage 450 Vdc

2.3.2 AC Auxiliary Power

The nominal auxiliary ac voltage for the car may be either 240 Vac or 480 Vac. All carborne rotating machines, with the exception of door operator motors, shall be three phase ac powered, unless otherwise approved by NYCT.
2.3.3 Low Voltage Power

The Units shall contain low voltage power supplies and secondary batteries to supply the control power for all car equipment. The Low Voltage Distribution Network (LVDN) shall supply each piece of equipment with power conforming to the following voltage range:

- Maximum Voltage: 44 Vdc
- Nominal Voltage: 37.5 Vdc
- Minimum Voltage: 24 Vdc

When apparatus and circuits are powered through trainlines, powered apparatus shall function satisfactorily in all cars, including the last car of a ten-car train, when the train lines are powered from the lead car, using battery power only. The minimum voltage at the load apparatus under these conditions shall be sufficient to reliably operate these loads.

2.4 Performance Requirements

2.4.1 System Performance

Section 2.4 establishes the performance required of the R142A Unit as an integrated system. Equipment shall be designed to successfully produce the specified performance values. All equipment on the Unit shall be protected from damage caused by random interruptions of the contact rail system power due to gaps, shoe bounce, or other conditions. Braking system performance, whether dynamic, friction, or a combination of dynamic and friction, shall be met regardless of the third rail voltage, or its absence. All specified rates and tolerances are instantaneous as measured with an inertial accelerometer.

All acceleration and braking rates shall be based on level tangent dry track, in still air, except as otherwise noted. Individual car performance shall be designed to be manually reprogrammed so that Unit braking performance is met for all Unit types and so that 6-car Unit accelerating performance can be limited to that of a 5-car Unit.

2.4.1.1 Voltage Range

At nominal third rail voltage and above there shall be a single tractive effort versus speed characteristic.

Below nominal third rail voltage the base speed shall be reduced in direct proportion to the ratio of the third rail voltage to the nominal voltage. The constant tractive effort level shall not be reduced under low voltage conditions.

2.4.1.2 Passenger Load Compensation Requirements

A passenger load compensation system shall adjust car motoring tractive effort to compensate for varying passenger load, with car weights between AW0 and AW2. At loads greater than AW2, tractive effort shall be held at the AW2 level.
All specified braking requirements shall be met under all car loading conditions between AW0 through and including AW3.

Failure of the load compensation system shall not result in acceleration or braking effort less than that normally provided for the AW0 weight and shall not result in more effort than provided for the AW3 weight.

2.4.1.3 Wheel Size Compensation

A wheel size compensation system shall be provided for each motored truck to permit adjustment of tractive effort to maintain rated positive acceleration and braking performance over the entire range of wheel wear. The wheel size compensation system for each truck shall include a self-check and automatic calibration function. Discrepant settings and similar anomalous conditions shall be annunciated if appropriate and shall be logged for maintenance attention. The derivation of reference speed for automatic calibration may include up to one manual wheel diameter setting per car.

2.4.1.4 Train Resistance

The propulsion and braking equipment shall compensate for train resistance. Beneficial retarding effects of train resistance shall not be used when designing brake system capacities. The Modified Davis Equation formula for train resistance, as shown below, shall be used.

Train Resistance:

\[
TR = 1.3W + 29n + 0.045WV + [0.0024 + 0.00034(Q-1)]AV^2 \text{ pounds force where:}
\]

- \(TR\) = Total train resistance in pounds force
- \(W\) = Total train weight in short tons
- \(V\) = Train speed in miles per hour
- \(A\) = Frontal area in square feet
- \(Q\) = Number of cars in the train
- \(n\) = Number of axles in the train

or

\[
TR = 6.4M + 130n + 0.14MS + [0.046 + 0.0065(Q-1)]AmS^2 \text{ Newtons where:}
\]

- \(TR\) = Total train resistance in Newtons
- \(M\) = Total train mass in metric tonnes (long tons)
- \(S\) = Train speed in kilometers per hour
- \(Am\) = Frontal area in square meters
- \(Q\) = Number of cars in the train
- \(n\) = Number of axles in the train

2.4.1.5 Propulsion and Dynamic Brake Mode Change Dead Times

Single mode changes shall have dead times not exceeding 300 milliseconds. Single mode changes are transitions from propulsion to coast, coast to brake, brake to coast, and coast to propulsion. The dead times shall be measured from the time when the master controller is moved into the zone corresponding to the new
command until the acceleration or deceleration reaches either 10 percent of the new command value for an increasing level mode change command, or 90 percent of the old command value for a decreasing level mode change command. Changes in the acceleration and deceleration rates are subject to the jerk limit and are not included in the mode change dead time.

Multiple mode changes, such as propulsion to coast to brake, shall be measured consecutively, adding the jerk limited power or brake removal time (if it is to take place) to the two mode-transition time intervals, as appropriate.

2.4.1.6 Jerk Limit

In response to a step input command signal, the average rate of change of actual instantaneous acceleration or deceleration, after the dead time, shall be 2.0 mph/sec² (.894 m/sec³) ±20 percent for car weights up to and including AW2 under all normal operating conditions. Above car weights of AW2, the jerk rate may vary in direct proportion to the ratio of the AW2 car weight to the actual car weight as loaded. Where the command signal is changing at a rate that is less than the specified jerk rate, the system shall follow the command signal rate of change within specified accuracy limits. Jerk limiting achieved by dedicated circuits shall produce linear outputs and shall be designed such that maximum available braking rate shall not be reduced due to failure within the circuits.

The jerk limiting feature shall also meet the following requirements:

- The jerk limits specified shall apply to all normal power and service braking applications.
- Reapplication of power after traversing non-bridging third rail gaps shall be jerk limited.
- Emergency brake applications shall not be jerk limited, for either power removal or brake application.

2.4.2 Motoring Performance

2.4.2.1 Acceleration

All specified rates are instantaneous rates as would be measured by an inertial accelerometer. The acceleration capabilities shall be as follows:

- Full acceleration rate shall be 2.50 mph/sec² (1.117 m/sec²), ±7 percent, for Unit weights up to AW2 from zero to at least 15.0 mph (6.70 m/sec), with the master controller handle in the MAXIMUM POWER position. Lower rates shall be provided in proportion to the master controller handle position. The rate tolerance percentage for these lower rates shall be as the maximum power rate tolerance.

- The instantaneous acceleration rate with the master controller handle in the MINIMUM POWER position shall not be greater than 0.7 mph/sec (0.313 m/sec²). Between
MINIMUM POWER and MAXIMUM POWER, acceleration shall vary linearly in proportion to master controller handle position.

- Refer to Performance, Speed vs. Distance Curve within Appendix D for minimum requirements of performance capability. The tolerance on the individual curves shall be as results from the specified acceleration tolerance.

- The tractive effort versus speed curve shall be adjustable through propulsion software modification to any curve equal or below the design maximum. Performance at delivery will be confirmed in design review but shall be initially considered to be as follows:

  With tractive effort at the upper limit of its tolerance band, the speed versus distance characteristic shall approximate, but not exceed, the Acceleration Performance of Passenger Cars for Trip Stop System within Appendix D. These requirements shall be met at the nominal third rail voltage and above at the contact rail, and with all Unit weights up to AW2.

2.4.2.2 Maximum and Continuous Speed Requirements

The maximum driven operating speed of the Unit shall be 55 mph (24.58 m/sec) with all conditions of wheel wear. Tractive effort shall be removed at 55 mph (24.58 m/sec).

Propulsion and drive unit apparatus shall be designed to operate continuously at maximum speed without damage, heating, or wear in excess of values used to calculate design life. Maximum equipment safe design speed with fully worn wheels shall be at least 66 mph (29.5 m/sec).

Balancing speed is not explicitly specified. The equivalent design point illustrated in Performance, Speed vs. Distance Curves within Appendix D.

Traction inverter controls shall limit the motoring speed to an adjustable value. The speed limit shall be initially set to 50 mph (22.35 m/sec). The inverter speed limit controls shall use a ramped removal of tractive effort and shall not apply braking effort if the train speed exceeds the limit.

Traction inverter controls shall limit the generated motor frequency to the synchronous frequency for fully worn wheels and approximately 60 mph (26.82 m/sec) speed.

2.4.2.3 Train Speed Limited Operation

Car wash operation shall be in accordance with Section 6.6.9. The car wash speed shall be adjustable and shall be initially set per Section 6.6.9.
2.4.3 Braking Performance

2.4.3.1 Service Braking

The service braking system capabilities shall be as follows:

- Instantaneous full service deceleration rate shall be of 3.0 \( \text{mph/sec} \) (1.34 \( \text{m/sec}^2 \)) for all Unit weights up to AW3, over the entire speed range, for all wheel diameters, with the master controller handle in the **FULL SERVICE BRAKE** position. The tolerance on the instantaneous brake rate shall be ±7 percent for pure dynamic braking, and ±20 percent for friction-only braking with the tolerance for blended braking (combined dynamic and friction braking) being calculated according to the percentage of each type of brake applied. Lower rates shall be provided in proportion to the master controller handle position. The rate tolerance percentage for these lower rates shall be as the full service brake tolerance.

- The maximum dynamic brake effort shall produce the equivalent of a 2.1 \( \text{mph/sec} \) (0.98 \( \text{m/s}^2 \)), ±7 percent rate per 5-car Unit, up to 40 mph (17.88 \( \text{m/sec} \)), for all car weights. Above 40 mph (17.88 \( \text{m/sec} \)) dynamic brake effort may taper, limiting the braking power to that of 40 mph (17.88 \( \text{m/sec} \)). Alternative taper characteristics may be submitted for consideration. The Unit system shall utilize all available dynamic brake before adding B Car friction brake to achieve the desired service braking rate.

- The dynamic brake fade speed shall be selected as low as practical, subject to NYCT approval, with blended friction brake completing the stop. To ensure smooth blending, the brake shoes shall be in light contact with the wheels prior to dynamic brake fade.

- In the event of dynamic brake failure at any speed, the friction brakes shall provide all of the required service braking effort. The friction brake tractive effort and thermal dissipation capability shall be sufficient to replace failed dynamic brake over the worst case combination of worst case segments of the entire Division A duty cycle.

- The instantaneous deceleration rate with the master controller handle in the **MINIMUM BRAKE** position shall not be greater than 0.7 \( \text{mph/sec} \) (0.313 \( \text{m/sec}^2 \)). Between **MINIMUM BRAKE** and **MAXIMUM BRAKE**, braking rate shall vary linearly in proportion to master controller handle position.

2.4.3.2 Emergency Braking

The emergency braking system shall produce a stop distance that does not exceed the distance represented by the curve on NYCT Drawing No. 103-9002 for all Unit weights up to AW3, over the entire speed range with new wheels on level tangent track. The tolerance on the instantaneous braking rate during emergency braking shall not exceed ±20 percent.
2.4.3.3 Parking Brake

The parking brake system, with all parking brakes of a Unit applied, shall hold a Unit loaded to AW3 on 5.5 percent grade indefinitely.

2.4.4 Wheel Slip System

2.4.4.1 Wheel Slip Correction

The wheel slip system shall detect all spins and slides, whether they are random or synchronous, under all adhesion conditions at all speeds.

At a coefficient of adhesion of 0.05 or greater, the efficiency of the wheel slip system shall be at least 80 percent in acceleration and braking over the speed range between maximum and approximately 5 mph (2.23 m/sec).

The wheel slide efficiency shall be defined as the ratio of the actual braking rate to the theoretical braking rate from an initial speed (entry speed) to a lower speed. The spin efficiency shall be defined as the ratio of the actual accelerating rate to the theoretical accelerating rate, from an initial speed to a higher speed. The theoretical rate is that which is obtained by continuously utilizing the available track adhesion. Efficiency shall be calculated over slip-affected portions of operation.

The wheel slip system shall not be enabled during emergency brake applications.

2.4.4.2 Self Calibration for Wheel Diameter

The wheel slip protection system shall include a self calibration function to null out all wheel diameter errors in the relative speed sensing functions and the individual axle rate of change of speed sensing functions.

2.4.5 Thermal Duty

The Units shall be capable of operating under all conditions in the Division A service area, including those conditions listed below, meeting the Specification requirements without exceeding the traction equipment design ratings and without producing equipment temperatures in excess of those recommended by the manufacturers.

The propulsion and braking systems' capacities shall enable all trains, with 25 percent loss of propulsion and braking capability to operate continuously over the A Division, making all station stops and observing all speed restrictions. Ratings shall be based on continuous operation with AW2 passenger load. Propulsion ratings shall be based on the use of electric braking. Friction brake ratings shall be based on full friction brake with no electric brake. Acceleration and deceleration rates under these conditions will vary in proportion to the number of operable propulsion and braking systems in the train. Division A operation includes starting and stopping on grades.
The propulsion and braking systems’ capacities shall enable all trains, with 50 percent of the propulsion and braking capability to negotiate the A Division, making all station stops and observing all speed restrictions. Ratings shall be based on AW3 passenger load to the next station stop, followed by AW0 passenger load for the duration of the trip. Propulsion ratings shall be based on the use of electric braking. Under these conditions, reductions in electric braking, based on dynamic calculations of excess motor temperature, are acceptable, and motor temperatures may increase to the thermal class of the motor insulation. Friction brake ratings shall be based on full friction brake with no electric brake. Acceleration and deceleration rates under these conditions will vary in proportion to the number of operable propulsion and braking systems in the train. Division A operation includes starting and stopping on grades, where starting on grade considers those cases where load distribution and grade allow an acceleration rate of 0.25 mph/sec (0.11 m/sec) or greater.

2.5 Equipment Design

2.5.1 General Equipment Requirements

Equipment shall be designed in accordance with the following requirements:

- Human interfaces with all equipment shall be designed in accordance with the requirements of MIL-STD-1472, latest revision, paragraphs 5.1 through 5.9.
- Control equipment shall be mounted underfloor or with the equipment being controlled.
- Equipment boxes shall be mounted to allow adequate space for maintenance. Access covers shall be provided where access to lights, switches, breakers, PTU ports, maintenance indicators, fluids, filters, or other devices requiring maintenance is required.
- Wiring entrance for underfloor equipment boxes shall be no more than 8 inches (200 mm) from the top of the box roof, except as otherwise approved. Wiring entrance for interior boxes shall be at least 8 inches (200 mm) above the floor.

All equipment shall be designed for ease of handling. Protective guards, legs, or similar devices shall be provided, if required, on each component that may be removed for preventive or corrective maintenance or at overhaul.

Components shall be arranged by function and grouped so as to simplify diagnostic procedures and facilitate replacement.

Components at all levels of assemblies and subassemblies shall be mounted so that the mounting hardware is completely accessible with standard tools. All mounting hardware shall be hex head bolts of an appropriate size.

Wire harnesses, pipes, support brackets and other appurtenances shall not obstruct mounting hardware.
Replaceable components shall not be "stacked" in such a way that one component must be removed to access another, without approval. In cases where approval may be granted, obstructed equipment shall only consist of passive devices and there will never be more than two levels permitted.

Multiple PC board arrangements shall have the boards slide mounted with two-part quick disconnects. Terminal boards shall be used if current demands require AWG No. 16 or larger wire.

Terminal board hardware for terminals of the same size range shall be standardized throughout the Unit.

Refer to Section 3.19 for related equipment enclosure requirements.

2.5.2 Pneumatic System Pressures

The system pressures shall be as follows:

<table>
<thead>
<tr>
<th></th>
<th>Normal Operating Range</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Reservoir and Brake</td>
<td>130-150 psig*</td>
<td>160 psig**</td>
</tr>
<tr>
<td>Pipe Pressures</td>
<td>(900-1030 kPa)</td>
<td>(1100 kPa)</td>
</tr>
</tbody>
</table>

* Compressor Governor Settings
** Air Compressor Overpressure Relief Valve Settings

Equipment subject to the maximum pressures listed above shall not be damaged or fail prematurely. At times when the main reservoir pressure fluctuates between the normal operating pressure range and the maximum pressure, all pneumatically powered equipment shall continue to operate as required by the system design.

2.5.3 Adjustments

2.5.3.1 Electrical Adjustments

Electrical adjustments are permitted only with NYCT's approval.

2.5.3.2 Mechanical Adjustments

Mechanical adjustments will be allowed only to compensate for a device's manufacturing tolerances and wear. Once adjusted, like assemblies shall be interchangeable without further adjustment. Mechanical adjustments shall occur in fixed, discrete steps using serrations, notches, pins or similar schemes to insure positive adjustment retention. Mechanical adjustments shall include positive locking devices. Mechanical adjustments with threaded members and jam nuts are permitted only with NYCT approval.
2.5.3.3 Software Adjustments

Adjustments to be made by stored parameters in software shall reside in non-volatile memory. The location and scaling of all adjustment parameters shall be clear to service personnel. Parameter values shall be in decimal notation and expressed in customary Units. The use of both a PTE password and a PTE hard key (dongle) used in tandem shall be required in order to initiate parameter changes. The hard key shall be specified in Section 16.4.1. Parameter adjustment features shall not allow adjustment beyond safe and reasonable limits.

2.5.4 Illuminated Indicators

All illuminated indicators, other than those on the Train Operating Display (TOD), shall be LEDs and not incandescent lamps except where otherwise approved by NYCT. They may consist of individual LEDs or clusters of LEDs, depending on the requirements of the application, including brightness and safety.

In order to identify LED failures, each LED or group of LEDs shall have a push-to-test switch located conveniently near the LED or group. Alternative methods of LED failure identification may be proposed and shall then be submitted for approval. When depressed, this test switch shall disconnect the normal circuit feed and cause the LEDs to be illuminated.

Indicator colors shall be based on its function as follows:

- Red shall be used to annunciate failures or inoperative conditions. Red shall also be used to indicate a restrictive condition or to annunciate a function that has been bypassed.
- Yellow or amber shall be used for warnings. The illumination of a yellow or amber indicator does not necessarily indicate a failure; however, the condition may require close observation by a Train Operator or other personnel.
- Green shall be used to indicate the normal state of a device or system. Whether illuminated or not, no failure shall be indicated by the green indicator.

2.5.5 General Control Circuits

2.5.5.1 Bypass and Cutout Circuits - Hardwired

Some control circuits will include bypass switches and cutout switches. These switches will allow the Operator, or other personnel, to override or disable certain functions. Typically, a bypass switch is used when equipment (a door interlock, for example) has failed. Typically, a cutout switch is used when equipment is to be disabled. Unless specifically noted otherwise, all bypass and cutout circuits shall have the following features:

- An indicator shall be illuminated while the corresponding bypass function is engaged.
- All bypass switches must include provisions for approved wire or plastic seals.
2.5.5.2 Software and Touch Screen Bypass and Cutout Functions

Where approved, certain non-safety-related cutout and bypass functions may be implemented by means of the touch screen display(s) in the cab, utilizing the same principles as for hardwired circuits.

2.5.5.3 Automatic Fault Reset

Fault detection circuits and devices shall be configured to electrically reset using a manual switch, or automatic reset, or both, as specified for the application. However, automatic resets shall not be applied to safety-related functions. All automatic resets shall be configured as follows:

- No reset shall be allowed while the fault is still detected.
- There shall be an acceptable delay before an automatic reset.
- The circuitry shall allow for an adjustable number of automatic resets after which the system shall lock out all resets, requiring a manual reset action at the auto-reset device.
- Reset logic shall eliminate resets of progressively worse faults, thereby protecting equipment from increased damage.
- The automatic reset device shall retain memory of the number of resets and memory of lockout status during control power interruptions. Memory shall be retained for at least 10 days of continuous unpowered time.
- To prevent random, unrelated trips from causing a lockout, the automatic reset device shall have a count reset. This count reset shall not function if the automatic reset device has reached the lockout stage. The mechanism for causing a count reset shall be approved on a case-by-case basis and in some cases will not be utilized.
- The automatic reset device shall display the number of resets it has accumulated.
2.6 Electro-Magnetic Compatibility and Interference

2.6.1 General Requirement

The Unit shall be electromagnetically compatible within itself, with other Units provided by the Contractor, with all other trains in operation at NYCT, with the NYCT signal system, with NYCT communications systems, and with other NYCT electronic equipment, as specified elsewhere within this Specification.

The Contractor shall conduct a program which achieves and documents electromagnetic compatibility (EMC). The Contractor shall apply the EMC program requirements to all subsystems and suppliers. The Contractor shall ensure that all equipment, both individually and together, complies with the EMC requirements. This equipment includes the future addition of FCC compliant Communications-Based Train Control equipment for which the Contractor shall make reasonable assumptions regarding its emissions and susceptibility. The Contractor shall ensure that each train configuration complies with the EMC requirements, in all possible operation modes, including all allowed modes of degraded performance and failure modes. The Contractor shall work with NYCT and its suppliers to resolve any EMC problems, as they relate to the cars and their operation, discovered during execution of this Contract.

The Contractor shall conduct a program in which train electromagnetic interference (EMI) emissions comply with EMI emission limits specified within Sections 2.6.4, 2.6.5 and 2.6.6, and applicable portions of Title 47CFR.

The laboratory testing of various subsystems and Cars is required as a guide during the design phase to ensure a high probability of EMC compliance for the complete train. Successful testing on the Car and subsystem level does not ensure EMC compliance. Final approval of EMC compliance will be based on testing of full trains, under worst case conditions on the actual NYCT right of way.

2.6.2 EMC Plan

The Contractor shall develop an EMC Plan (EMCP) which describes the Contractor's organization to achieve EMC, activities and schedule, qualifications of personnel, and procedures and methods to achieve and document compliance with EMC requirements.

The EMCP shall address all requirements in the Specification, including scope, purpose, and requirements; project organization, schedule, and deliverables; EMC design report; EMC safety analysis; and emission limits test plans and testing. The Contractor must also include what procedures and testing will be carried out on a routine basis, on all production trains after proof of design testing is achieved. This includes all EMC critical components and subsystems in each train.

The Contractor shall submit a draft EMCP, at the Preliminary Design Review.

The Contractor shall conduct and document activities described in the approved EMCP.
2.6.3 Emissions Tests and Limits

2.6.3.1 Worst-Case Tests

The Contractor shall demonstrate through specified conducted, inductive, and radiated emissions tests that the train worst-case emissions are electromagnetically compatible with all NYCT systems.

To determine the worst-case emissions, the Contractor shall perform the specified tests for normal, abnormal, and failed operating conditions; and in the full range of applicable operating modes, speeds, voltages, train lengths, and loading. The Contractor shall test modes including appropriate combinations of maximum and minimum acceleration; dynamic braking; regenerative braking, with varying line receptivity; HVAC and auxiliaries at maximum and minimum power; in forward and reverse directions; and under failure conditions. Failure conditions shall include failures of all EMI control components or subsystems, all EMI detection component and subsystems, all EMI sources that affect amplitude or frequency, all failures identified in the safety analysis of Section 18.4, including relevant unannounced failures as well as failures under which the train can continue running at reduced performance, such as degradation or partial loss of a line filter capacitor bank.

For each test below, the Contractor shall develop a test procedure, and submit it for approval. The Contractor shall perform the tests to the satisfaction of NYCT. In each case, the Contractor shall document the test and submit a test report for approval. Lab tests shall be conducted as part of the subsystem qualification test. Field tests shall be conducted as part of the train qualification test. Note that both single-rail and double-rail track circuits may be present.

2.6.4 Conducted Emissions

2.6.4.1 Lab Conducted EMI Test MOD 02

The Contractor shall perform Lab Conducted EMI Tests. The Contractor shall perform a test for each power unit with a rating greater than 10 kW, including the propulsion system, auxiliary electric converters, and any other converters such as HVAC motor inverter. In addition to separate tests, a combined test of the propulsion system and the auxiliary converter(s) shall be performed to ensure EMC.

The Contractor shall submit a Lab Test Procedure for each power unit and the combined test for approval. The Lab Test Procedure shall include an analysis of the relationship between conducted currents measured on a unit under test in the lab and the anticipated results of the planned train Field Test. The draft test procedure shall be available at the Preliminary Design Review.

The Lab Test Procedure shall be compatible with Method RT/CE02A in UMTA-MA-06-0153-87-2, Conductive Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures, May 1987, adapted for lab operation. Section 2.6.4.3 below specifies conducted emission limits and refers to harmonic emission levels which can be used as a design guideline. Appendix A of the NYCT Conducted EMI Test Procedure (NYCT CETP), included within Appendix C of this Specification, provides a calculation method for relating vehicle and train emissions to harmonic emission levels.
The Contractor shall submit a Test Report which relates Lab Test results to anticipated results of the planned train Field Test.

2.6.4.2 Field Conducted EMI Test

The Contractor shall develop a Contractor Conducted EMI Test Procedure (Contractor CETP) compliant with the NYCT Conducted EMI Test Procedure (NYCT CETP).

The Contractor shall perform a Field Conducted EMI Test compliant with the Contractor CETP. The Contractor shall demonstrate that the train's worst-case emissions on the NYCT test track do not disturb the worst-case NYCT track circuits, with the required margin. The Contractor shall submit a test report for approval which is compliant with the Contractor CETP and Section 5 of the NYCT CETP.

2.6.4.3 Conducted Emission Limits

The conducted emission limits shall be as measured in and determined by a Conducted EMI Test of worst-case train emissions in worst-case NYCT track circuits. Worst-case train emissions shall be as determined per Section 3.1, and shall include operation of any or all train equipment alone or in combination, and in normal, abnormal, and failed conditions. Worst-case track circuits shall be as described in Section 6.5 of the NYCT CETP.

A test instrument setup supplied by the Carbuilder shall monitor the voltage across or current in the track relay, called the In-Circuit Relay. The test setup shall amplify the monitored In-Circuit Relay signal by a selected gain, and drive the amplified signal into a separate track relay, called the Margin Test Relay. The amplified signal shall not disturb the normal operation of the Margin Test Relay. The selected gain is the margin against false operation of the relay.

NYCT has separated train emissions into three general categories: impulse emissions, repeating broadband emissions, and harmonic emissions, as defined in Section 2.2.3 of the NYCT CETP. The Carbuilder may use these categories in evaluating the margin against false operation of the relay.

In summary, the CETP defines an impulse emission as an abrupt and brief change or set of changes in current which contains broadband energy and which, if of sufficient amplitude, can cause a track relay to wrongly change state, either by pickup or dropout, for a short time, such as for up to a half-second. Repeating broadband emissions are comprised of several impulses occurring sequentially within a few seconds. Harmonic emissions are sustained emissions at a fixed or sweeping frequency which carry energy at a fundamental frequency.

The margin against false operation of the worst-case track circuit shall be at least 12 dB, or a gain factor of 4.0, for repeating broadband emissions, harmonic emissions, or emissions with mixed or other characteristics. The margin against false operation of the worst-case track circuit shall be at least 6 dB, or a gain factor of 2.0, for impulse emissions. The NYCT Engineer shall solely determine which category and corresponding margin applies, in case of ambiguity or conflict.
The Carbuilder shall arrange test runs so that usual test artifact events at block entry and turn-on of the regeneration load can be clearly distinguished from train events, such as mode transition and regeneration variation. The NYCT Engineer shall solely determine whether an event is a train event or a test artifact event, in case of ambiguity or conflict.

The Carbuilder may use track circuit harmonic emission levels as a design guideline. In using the harmonic emission levels as a guideline for designing components which affect EMI levels, the Carbuilder shall apply minimum margins noted above against false operation of a relay.

The harmonic emission levels and corresponding third rail currents are shown in the table below. Parameters and terms are defined in the NYCT CETP. Appendix A of the NYCT CETP provides a calculation method for relating vehicle and train emissions to harmonic emission levels.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Track Circuit Current Level (A rms)</th>
<th>Condition</th>
<th>Repeating BroadBand</th>
<th>Harmonic</th>
<th>Impulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>21.9</td>
<td>Unoccupied</td>
<td>5.47</td>
<td>5.47</td>
<td>10.95</td>
</tr>
<tr>
<td>60</td>
<td>2.52</td>
<td>Unoccupied</td>
<td>0.63</td>
<td>0.63</td>
<td>1.26</td>
</tr>
<tr>
<td>25</td>
<td>14.67</td>
<td>Occupied</td>
<td>3.66</td>
<td>3.66</td>
<td>7.33</td>
</tr>
<tr>
<td>60</td>
<td>4.1</td>
<td>Occupied</td>
<td>1.02</td>
<td>1.02</td>
<td>2.05</td>
</tr>
</tbody>
</table>

In case of conflict between the Conducted EMI Test limits and harmonic emission levels, the Conducted EMI Test limits shall prevail.

2.6.5 Inductive Emissions

2.6.5.1 Lab Inductive EMI Tests

The Contractor shall perform Lab Inductive EMI Tests. The Contractor shall perform a test for each power unit with a rating greater than 10 kW, including the propulsion system, auxiliary electric converters, and any other converters such as HVAC motor inverter. In addition to separate tests, a combined test of the propulsion system and the auxiliary converter(s) shall be performed to ensure EMC.

The Contractor shall submit a Lab Test Procedure for each power unit and the combined test for approval. The Lab Test Procedure shall be compatible with Method RT/IE04A in UMTA-MA-06-0153-85-8, Inductive.
SYSTEM DESIGN

Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures, March 1987, adapted for lab operation. The draft procedure shall be available at the Preliminary Design Review.

2.6.5.2 Field Inductive EMI Test MOD 02

The Contractor shall perform a Field Inductive EMI test.


The Contractor shall submit a Field Inductive EMI test procedure for approval. The draft procedure shall be available at the Preliminary Design Review.

2.6.5.3 Inductive Emission Limits

The per car emission limits in the following table shall not be exceeded.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Most Sensitive Relay Pickup Level (mV)</th>
<th>Emission Limit (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 30</td>
<td>220 RMS</td>
<td>55 RMS</td>
</tr>
<tr>
<td>50 to 70</td>
<td>220</td>
<td>55</td>
</tr>
<tr>
<td>2 kHz to 10 kHz</td>
<td>*</td>
<td>20</td>
</tr>
</tbody>
</table>

* Track signals in this frequency range may be used by NYCT at a future date. Harmonic emissions in this range must be stable, predictable and fully documented.

At other frequencies, train emissions shall be limited to reasonable values.

The Contractor shall document the Inductive test results in a report that shall be submitted for approval. The report shall identify the source of all narrow band emissions from 20 Hz to 20 kHz.

2.6.6 Radiated Emissions

2.6.6.1 Field Radiated EMI Test

The Contractor shall perform a Field Radiated EMI Test. The Field Test Procedure shall be compatible with UMTA-MA-06-0153-85-11, Radiated Interference in Rapid Transit Signaling Systems - Volume II: Suggested Test Procedures. The Contractor shall submit a Field Radiated EMI Test plan for approval. The draft procedure shall be available at the Preliminary Design Review.
2.6.6.2 Radiated Emission Limits

Both parts a. and b. must be satisfied:

a. The Radiated emissions shall not exceed the emission limit of MIL-STD-461C, Curve RE02 for broadband emissions, which applies to Class B equipment, "Equipment and Subsystems in Non-Critical Areas."

b. The Radiated emissions shall not exceed the following table:

Emission limits are, on a plot of dB microvolts per meter per megahertz (dbuV/m/MHZ) versus log frequency:

- At 150 kHz, the lower limit, a level of 108 dbuV/m/MHZ.
- A straight line from 108 dbuV/m/MHZ at 150 kHz to 75 dbuV/m/MHZ at 200 MHZ.
- A straight line from 75 dbuV/m/MHZ at 200 MHZ to 90 dbuV/m/MHZ at 1000 MHZ.
- 90 dbuV/m/MHZ from 1000 MHZ to 3000 MHZ.

Measured 50 feet (15.24 m) from the center line of the rails.

The Contractor shall document the Radiated test results in a report that shall be submitted for approval. The report shall identify the source of all narrow band emissions from 150 kHz to 1000 MHZ.

The Contractor shall be responsible to cooperate in the satisfactory resolution of any complaints received by NYCT and attributed to the Units. Complaints of radio, television and telephone interference are included.

2.6.7 Safety Provisions

The Contractor shall conduct and submit for approval a safety analysis which demonstrates that NYCT is protected against hazards due to EMI.

2.6.7.1 Safety Analysis

The Contractor shall submit for approval a safety analysis which shows that the train's EMI emissions are safe under normal conditions, and that the train equipment provides adequate detection, annunciation, and response to failures which could cause EMI to increase above tested levels. The safety analysis shall include a Preliminary Hazard Analysis (PHA); a Fault Tree; and Failure Modes, Effects, and Critically Analysis (FMECA) of appropriate equipment.

The safety analysis shall document the protective actions which prevent a hazard occurrence. The safety analysis shall demonstrate that the equipment and its actions are adequate to prevent an EMI hazard.
The safety analysis shall distinguish between EMI-affecting failures which are automatically protected, those which are annunciated for operator or maintainer action, and those which are unannunciated failures. Train worst-case tests specified above shall include all annunciated and unannunciated EMI-affecting failures.

The safety analysis shall consider all relevant failures of train equipment, including failures of line filter components, EMI detection and annunciation systems, and any other components that can affect the level or frequency of the generated EMI; unusual operating conditions; and failures of wayside equipment affecting and involving trains, such as a substation rectifier diode failure.

The safety analysis must also include any equipment used for self testing in areas that affect EMI.

2.6.7.2 EMI Detector

If the Contractor elects to use an EMI detector as part of the EMC control plan the following specification will apply.

The EMI Detector shall include a continuous or regular self-test provision to ensure its integrity. The detection levels, response times, frequencies, and bandwidths shall be compatible with the safety analysis and FMECA. The software in this detector shall ensure that no EMI hazard exists while maximizing car availability. False EMI detections shall not be permitted. Positive measures shall be taken to prevent the accidental or intentional tampering with the EMI Detector detection characteristics and response actions.

The Contractor shall submit for approval at the Preliminary Design Review, a preliminary description of the EMI Detector, if used as part of the EMC plan.

The Contractor shall submit for approval a Final Design Review document describing the EMI Detector design; detection frequencies, response times and processing; emission thresholds and corresponding protective actions; impacts on train and system operation of EMI Detector action, and Contractor recommended procedures for NYCT staff to restore service; car-level and driver's console annunciations; and EMI Detector self-test, failure modes, and failure annunciation. The Contractor shall analyze and document the interactions and response of all EMI Detectors on a train to: failures on one or more cars; to failure on the wayside, such as of a substation diode; and to failure of the EMI Detector.

2.6.8 EMC Design Report

2.6.8.1 Emissions

The Contractor shall control on-board equipment emissions to achieve EMC. The Contractor shall submit a completed Emissions Report for approval at the Final Design Review. The Emissions Report shall document the design provisions to achieve the:

- EMC emission control methods, including equipment layout, circuit routing, frequency coordination and stability, filters, interconnections, grounding, and shielding. The Contractor
method shall conform to IEEE Std 1100-1992, Recommended Practice for Powering and Grounding Sensitive Electronic Equipment, unless otherwise approved.

- Description of each unit with peak power rating of greater than 20 kW, including the emission characteristics versus operating mode, voltage and loading, as well as line filter, output filter, line input impedance, and circuit and operating mode considerations.

- EMI Detector.

- For the car as a whole, the simulated or calculated emissions of the car.

- For each train configuration, the simulated or calculated combined emissions in the NYCT worst-case track circuits.

2.6.8.2 Susceptibility

The Contractor shall control on-board equipment susceptibility to achieve EMC. The Contractor shall submit a completed Susceptibility Report for approval at the Final Design Review. The Susceptibility Report shall document the design provisions to achieve suitable susceptibility control of train equipment:

- EMC susceptibility control methods, including equipment layout, equipment enclosure design, circuit routing, frequency coordination and stability, filters, interconnections, grounding, and shielding.

- The vehicle high voltage and low voltage circuits, classification, arrangement, separation and routing.

- The high voltage and low voltage grounding arrangement, and provisions for worst-case ground voltages within the train.

- The normal and fault paths for ground currents.

- For each type of electrical interface between subsystems or enclosures, such as battery, digital logic, analog, regulated power supplies, and serial data communications:
  - The driving circuit, including impedance and maximum and minimum output voltage and current levels.
  - The receiver circuit, including maximum and minimum voltage or current thresholds, margin against error, destructive threshold.
  - All aspects of the connection requirement, such as single wire, double wire, twisted pair, shield, and shield grounding.
Any special circuit or connection provisions needed to ensure EMC.

Contractor shall ensure that the vehicle equipment is adequately protected against radio frequency emissions from nearby mobile and handheld radios or cellular telephones that the equipment can encounter during normal passenger use or NYCT operations.

- Circuits which require attention include microprocessors, low level signals, and data communication buses.
- The Susceptibility Report shall describe the equipment protections as well as any restrictions on equipment operation or maintenance necessary to ensure susceptibility control, such as leaving covers off of equipment enclosures.

The Contractor shall demonstrate the adequate susceptibility control of any non-service proven interface.

### 2.6.8.3 Frequency Stability

If any repeating, narrow band emissions are found during testing with amplitudes above the limit but at frequencies outside of the specified bandwidth, these emissions shall be examined in detail by the Contractor to ensure EMC. In particular the stability of the emission frequencies must be demonstrated, under any condition, to remain outside the critical bandwidth of NYCT track circuits, communications, and wayside equipment. This analysis must be documented to the satisfaction of NYCT.

### 2.7 Noise, Vibration, and Ride Quality

#### 2.7.1 Noise - General

Maximum noise level requirements and testing requirements shall be as shown in Appendix C, Noise Test Procedure. Where conflicts arise between Specification text and Appendix text regarding maximum allowable noise levels, the Specification text takes precedence.

#### 2.7.2 Emergency Vent Valve Noise

No silencers are to be installed to suppress the noise level in “A” and “B” cars during emergency brake application except the silencer on the Brake Control Unit Emergency Vent Valves.

#### 2.7.3 Interior Noise

Interior noise requirements and test shall be as shown in Appendix C, Noise Test Procedure.

#### 2.7.4 Wayside Noise

Wayside noise requirements and test shall be as shown in Appendix C, Noise Test Procedure.

- Unit stationary, empty, ready for service, all systems operating: 75 dBA
- Unit stationary in lay-up: 65 dBA
2.7.5 Equipment Noise Prior to Installation on Unit

Noise levels produced by each truck's drive train operating shall not exceed 93 dBA at 15 feet (4.57 m) from the geometric center of each motor/gearbox, in any direction, and with gears rotating in either direction at all speeds from zero to the equivalent of 50 mph (22.35 m/sec) Unit speed and at all loads equivalent to maximum tractive effort (motoring and braking).

At the Contractor's option, the motor and gear unit can be tested separately. The Contractor shall submit noise criteria for the motor, gear unit, and the remainder of the drive train. These optional criteria shall be submitted by the Contractor for NYCT approval prior to testing.

Noise produced by the individual operation of all undercar and ceiling-mounted equipment which normally operates (except traction motors, gear units, and equipment which only operates occasionally, such as a circuit breaker or pneumatic venting device) shall not exceed 80 dBA at 15 feet (4.6 m) from the center of the equipment while it is operating under normal conditions and loads. This equipment includes motors, generators, blowers, brakes, compressors, valves and other noise generating components.

2.7.6 Vibration

Equipment and auxiliaries mounted anywhere on the Unit, car body, or trucks shall not cause vertical or horizontal vibrations anywhere on the floor, walls, ceiling, panels and seat frames in excess of the following:

- Below 1.4 Hz: Maximum deflection (zero to peak) of 0.10 inch (2.54 mm).
- 1.4 Hz to 20 Hz: Peak acceleration of 0.01 g (0.10 m/sec²).
- Above 20 Hz: Peak velocity of 0.03 inches/sec (0.76 mm/sec).

2.7.7 Shock

Shock and vibration requirements depend, in part, on the type of truck and spring system and roadbed conditions. The Contractor, in conjunction with its subcontractors, shall jointly determine the most severe shock and vibration values arising from the combination of the proposed equipment and operation on Division A so that apparatus suitable for the service intended shall be provided.

2.7.8 Ride Quality

2.7.8.1 General

The Unit and constituent cars shall be designed to be free from objectionable vibration and shock. All equipment mounted in the passenger area shall be free from resonance to avoid annoying audio and visual distraction.
2.7.8.2 Ride Quality Requirements

The ride quality shall be evaluated according to ISO 2631. The rms acceleration values shall not exceed the "4 hr, reduced comfort level (vertical)" and "2.5 hr, reduced comfort level (horizontal)" boundaries derived from Figure 2a (vertical) and Figure 3a (horizontal) of ISO 2631 over the range of 1 Hz to 80 Hz, for all load conditions AW0 to AW3 and all normal Unit acceleration, deceleration, and speed conditions. Acceleration values outside this frequency range shall be subject to NYCT review and approval. The Unit shall be evaluated with new wheels on tie and ballast track with non-corrugated welded rail.

2.7.8.3 Ride Quality Analysis

The Contractor shall perform a three-dimensional dynamic simulation of its vehicle to show by analysis that the design meets the specified ride quality requirement.

Simulation is required for the worst-case vehicle. Track-geometry input data will be supplied by the NYCT.

Prior to performing the analysis, the Contractor shall submit a description of the dynamic simulator for approval. Included with the description shall be a list of the input data, a sketch showing a sample representative physical model, a list of possible output with samples of each.

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 car body excursions shall not exceed the clearance requirements specified in Performance, Speed vs. Distance Curves within Appendix D.

NYCT approval of the final report shall be required prior to approval of the truck drawings.

2.8 Subsystem Interface Detail

The Contractor, as part of his responsibility for system design of the entire car and its equipment, shall be responsible for the proper interrelation and interdependence of all car subsystems and their proper interfacing.

For each system/subsystem, the interface details shall be completely documented, such that future equipment purchases from alternate sources shall be possible. (Refer to Section 1.7 for details.)

The interface documentation shall be maintained and updated throughout the design, manufacturing, test, and until the design ceases to change, so that the document always reflects the best information regarding the interface.

A summary drawing defining the relationship between subsystems shall be presented by the Contractor at the preliminary design review.
The interface documentation shall include as a minimum the following items:

- **Mechanical**: outline, attachment, shock, vibration;
- **Power**: type and quality, load (starting and steady-state), power factor where applicable;
- **Pneumatics**: control definitions, measurement definitions, air consumption;
- **Electrical Control**: local, trainlined, signal definition, response characteristics;
- **Software Interface**: data definition, protocols, response characteristics;
- **Weather Environment**: temperature, humidity;
- **Electromagnetic Compatibility**: emissions, susceptibility; and
- **Diagnostic Interface**: data storage, data retrieval, test procedures.

Interface characteristics appropriate to specific systems/subsystems shall be added to the above list as necessary to provide a full interface definition.
## SECTION 3

**CAR BODY**

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SECTION 3

3.0 CAR BODY

3.1 General

The car body and attached equipment shall be designed to provide necessary clearances for the truck and track profiles. The design must allow for 1½ inches (38 mm) of clearance between car body and trucks for worst case operating conditions, except for any stops attached to the car body for limiting truck movement or for truck lifting during maintenance. Worst case conditions may result from horizontal and vertical curves, tracks superelevation, worn wheels, maximum passenger load, roll, yaw, lateral motion, and suspension system failures.

The car body shall have a minimum design life of 40 years.

The car shell construction shall provide structural stiffening and reinforcing members as required for structural integrity, mounting of equipment, and cosmetic appearance. The vehicle body shall consist of the roof, side frames, underframe, and end frames. The underframe shall consist of two end underframes, two side sills, body bolsters, and floor beams. Intermediate body sills may be used in the underframe, if necessary. The cab-end bonnet may be constructed from fiberglass reinforced plastic panels to provide the end contours.

There shall be collision posts at the ends of the car body shell. Two primary center collision posts shall be located on each side of the end doors and two primary side collision posts shall be located at the corners of the car. On the cab-end of the car, there shall also be two secondary side collision posts in each side wall at the edge of the cab bulkhead, and two secondary center collision posts in line with the cab bulkhead and near the longitudinal center of the car.

The car body structure shall be designed to make effective use of metal in providing the required strength and stiffness. Portions of the roof, side frame, and underframe shall be designed to form a modified girder to carry the longitudinal and vertical shear, and bending loads resulting from the specified vertical loads. In selecting the type and thickness of material to be used, the Contractor's design shall optimize strength, durability, and weight.

The structural design shall be based on the specified loads and deflections. For structures not covered by this Specification, the design shall be based on the Contractor's experience, subject to successful stress analysis and testing. The structure and equipment supplied shall resist the specified loads with factors of safety consistent with those which have been successful for passenger rail transit equipment.

3.1.1 Safety Appliances

All safety appliances such as loop steps, hand holds, and walkways shall meet the requirements for support of car body-mounted equipment in addition to the corresponding requirements for the safety appliance.
3.2 Materials

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Except for the end-underframe units, the car body structure, including sheathing, shall be constructed of austenitic stainless steel. The stainless steel shall be the extra-low carbon type, with carbon content less than or equal to 0.03 percent. All stainless structure which is in public view shall be AISI 301LN (low carbon, with nitrogen) or SUS301L (with Nitrogen) with a brush finish. Stainless steel hidden from public view may be as permitted by Section 15.3.2.

Stainless steel sheathing on the side walls shall be flat. The stainless steel sheathing on the roof may be flat or corrugated. Corrugations shall have a depth of not greater than ½ inch (12.7 mm) and shall not trap moisture.

The end underframe and body bolster shall be constructed of low alloy high strength (LAHT) steel; see Section 15.4. Steels requiring pre- and/or post-fabrication heat treatment to develop acceptable strength or toughness are prohibited.

3.3 Construction Methods

3.3.1 General

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 car body structure shall be assembled by welding. Sheathing shall be attached to the framing by resistance welding. Stiffeners shall be attached to the sheathing by resistance welding. Fusion welding or resistance welding shall be used for the construction of the remainder of the car body structure. All welding and fastening shall be in accordance with Section 15. Where car body structure must be assembled with mechanical fasteners, the fasteners shall be high-strength lock bolts (see Section 15.2.2).

Hangers and brackets may be resistance welded to car framing in sub-assembly for subsequent attachment of equipment. Otherwise, brackets, supports, pipe hangers, conduit supports and other attachments which are not part of the car body structure shall be attached to the structure with mechanical fasteners. The car framing members shall be reinforced in subassembly to accept attachments during assembly. To the maximum extent practical, the holes for attachments shall be in the webs of framing members rather than in the flanges. Wherever attachment is made to a flange, suitable bulkheads shall be provided in the member at the location of the attachment to assist in transferring the load into the web. Gussets are to be full height. All connections are to be analyzed per Section 3.4.3.

Where dissimilar metals are joined, they shall be protected against electrolytic corrosion.
Adequate drainage shall be provided in all body-structure members, and elsewhere as necessary to preclude water entrapment. Enclosed structural cavities shall be vented to prevent accumulation of condensate. In areas where water might be ingested, corrosion-resistant drain pans and drain lines shall be provided and shall be arranged to divert the discharge clear of all equipment and structure. Means shall be provided to prevent clogging of drain lines and drain holes. Any enclosed structural cavities of carbon steel members shall be treated with a rust-inhibiting coating as specified in Section 15.24.

3.3.2 Camber and Deflection

Camber of the car body is defined as its curved shape viewed in side elevation. Car body camber shall be a smooth arc from end to end of the car body, and shall be measured from a datum line drawn between the intersections of the arc with the centerlines of the body bolsters to a line tangent to the arc midway between bolsters. A condition of the tangent point of the arc being above the datum line is defined as positive camber.

The car body shall be built with positive camber such that camber shall not become negative with the car at AW3 load. Positive camber up to 5/8 inch (16 mm) in AW0 condition shall be permitted.

The vertical deflection of a completely-equipped car under AW3 passenger load shall be a maximum of 1/4 inch (6 mm). All equipment including side doors shall operate satisfactorily and shall not bind due to deflection caused by variations of load from AW0 to 105 percent of AW3.

3.3.3 Structural Connections

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.

Connections consisting of a primary structural member that resists the end sill (Section 3.4.4.2), coupler (Section 3.4.4.3), primary collision posts (Section 3.4.4.5), secondary collision posts (Section 3.4.4.6), truck-to-car body connection (Section 3.4.4.14), or bolster anchor bracket (Section 3.4.4.15) loads shall be designed so that the ultimate strength of the connection exceeds the ultimate strength of the weakest member joined. All other structural connections shall be designed to withstand the worst-case normal loading specified in Section 3.4.4.

All load requirements over normal operating conditions shall be analyzed as specified and then reanalyzed with the load magnitude increased until calculations show structural member crushing has commenced.

No visible fastener heads shall be permitted. Visible resistance welds shall cause a minimum of surface indentation, shall not cause permanent discoloration, and shall be arranged in uniform patterns. Detailed weld procedures shall be submitted as required by Section 15.23.6.

All mechanically fastened connections shall be designed using a factor of safety of 1.5 based on 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 car body structure by welding subsequent to completion of primary car body structure manufacturing procedures. The exception is for hangers resistance spot welded to the web of a beam for attachment. Welding to the end of these hangers at a distance 0.8 inch (20 mm) or more from primary structure is permitted.

Intermittent fillet welds on tension members are prohibited. Plug or slot welds on tension members are prohibited. Intermittent groove welds are prohibited.

Stud welding to car body structure shall not be permitted. Stud welding to non-load carrying stiffeners and secondary structure is permitted.

Self tapping screws shall not be used for structural connections. With the exception of attachment points for floor panels, interior panels and trim, there shall be no tapped holes in car structure. Tapping plates may be used. Tapping plates 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. 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; see Section 15.2.2.2.

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

3.3.4 Finish and Flatness

All exterior surfaces of the car body shall be unpainted, brushed finish, stainless steel, unless otherwise specified. The brushed finish shall be approved by NYCT. All exterior non-corrugated surfaces shall be free of ripples and buckling. The surfaces of flanges and webs of all structural members shall be straight and flat, and free of ripples, buckling, dents, gashes and other surface imperfections. Maximum acceptable variation from a straight line for car body exterior surfaces and surfaces of flanges and webs of all structural members shall be:

- All exterior side and roof surfaces not hidden by covers or shrouds:
  - 3/32 inch (2.4 mm) peak to valley in 40 inches (1.02 m) over 95 percent of the area.
  - 1/8 inch (3.2 mm) peak to valley in 40 inches (1.02 m) over the remaining 5 percent of the area.
  - Areas within 8 inches (203 mm) of the side doors may have a gradual slope towards the door mask with a maximum deviation of 3/16 inch (4.8 mm) from the side sheet contour.

- Exterior surfaces hidden by covers and shrouds:
  - 5/16-inch (8 mm) peak to valley in 40 inches (1.02 m) measured in any direction.
These tolerances cover smooth flowing waves in flat sheets and shall not permit dents, gashes, deep spot weld dimples or other surface imperfections. The slope of any such deviation shall not exceed 1/8 inch in 1 foot (3.2 mm in 305 mm).

Exterior exposed spot welds, located in the unpainted surfaces of the stainless steel on the sides of the cars, shall be arranged in regularly-spaced patterns, and shall be treated as necessary so as to be nearly invisible at the completion of all manufacturing. Exterior exposed fusion welding shall be limited to the least amount practical, and, where permitted to be used, shall be finished to be unnoticeable except by close visual inspection. See Section 15.

### 3.3.5 Samples

Three samples of all exterior finishes shall be submitted for approval. Samples shall have a minimum surface area of 6 by 12 inches (152 mm by 305 mm). Samples of welding shall include a minimum of 6 welds. The following samples shall be included as a minimum:

- 2B (bright cold rolled) and scratch finishes
- Other mill finishes per ASTM A 480
- Exposed resistance welds illustrating each of the various metal-thickness configurations
- Each type of exposed butt joint and finished arc welds
- Each proposed method of fastening on exposed surfaces, i.e., non-welded connections

Fusion welded samples shall be notch-toughness tested; refer to Workmanship, Processes and Material Section 15.23.

After approval of the exterior finish specimens, one set will be returned to the Contractor. The second set will be used by NYCT inspection at the car body manufacturing site. The third set will be retained by NYCT as a permanent record.

### 3.4 Strength Requirements

The framing and sheathing of the car body shall form an integrated structure capable of resisting, without permanent deformation or fatigue, the buffing and other stresses inherent in the type of service for which the cars are intended.

The car body 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 shell shall meet the static and dynamic strength requirements stated in this section.
3.4.1 Structural Sketch

A structural sketch shall be prepared and submitted for approval. Approval of the structural sketch shall be a prerequisite for approval of the finite element model (FEM). As a minimum, the following views shall be included on the structural sketch: side elevation; top view of the roof and the underframe; and typical cross-sections of the car body at a window, side door, and full-height side-frame post. Cross-sections of the structural members with shape, dimensions, material and thickness shall be shown.

3.4.2 Energy Absorbing Structure

The car body shall be designed to maximize the energy-absorbing capability of the car body structure within the specified static strength parameters of this Section.

3.4.2.1 Structural Design for Energy Absorption

The car body structure shall be designed to crush in a controlled manner during end impacts where the forces generated exceed the elastic capability of the structure. Crushing shall commence at the ends of the structure and progress inward. During a crash, all of the end structural members shall retain their attachments to one another and to the roof and floor structures as specified in Section 3.3.3.

The underframe shall contain members designed specifically to crush at a controlled rate. These members shall provide the energy absorption required in Section 3.4.2.2, and their ability to absorb energy by crushing shall be tested in accordance with Section 17.3.3.15.14.

For the portion of the car body structure designed for controlled crushing and energy absorption, members other than those specifically designed to absorb energy by crushing, and undercar equipment (such as the coupler and its attachments, and trainline boxes and equipment groups) shall not provide any portion of the energy absorption required in Section 3.4.2.2, nor interfere with the controlled crushing of the energy-absorbing members.

3.4.2.2 Design Energy Absorption Values

The amount of energy absorbed during controlled crushing of the end of the car body structure as specified in Section 3.4.2.1 shall be the maximum possible within body strength requirements and the car interior arrangement. In no case shall the amount of energy absorbed by crush of the structure be less than 750,000 foot-pounds (1.02 M J).

3.4.2.3 Crashworthiness Analysis

In order to assess the energy absorbing properties of the structure, a crush energy absorption computer analysis and simulation of the vehicle shall be performed. The analysis shall be based on the assumption that one vehicle impacts a fixed barrier. The analysis shall include the following calculations:

- Compression load developed by the longitudinal frame members designed for crushing,
Buckling strength of the longitudinal members under the calculated compressive load,

The progressive buckling and crushing of the car body end structure, and

The accumulation of energy during crushing, i.e., force versus distance.

Furthermore, the analysis shall demonstrate:

- The vehicle structure inboard of the bolster does not fail while the end is crushing,
- Mounted equipment and structural members other than those designed for energy absorption shall not interfere with crushing of energy-absorbing members,
- Mounted equipment and structural members other than those designed for energy absorption do not provide any portion of the energy absorption required in Section 3.4.2.2, and
- The amount of energy required to shear or buckle members not specifically designed to absorb energy by crush, and car equipment located in crush zone.

A report of the analysis shall be prepared and submitted for approval, as required by Section 3.4.2.4. Tests shall be performed on the various structural elements to show the energy absorbed by the element during crushing, as required by Section 17.3.3.15.14. The report shall contain a comparison between analysis and test results. Test results shall be in substantial agreement with the analysis. Criteria for agreement shall be included in the test procedure.

### 3.4.2.4 Crashworthiness Plan, Analysis, Report, and Validation

This Section contains the requirements for crashworthiness analysis, a Crashworthiness Analysis and Test Plan, a Crashworthiness Analysis Report, and comparison of crashworthiness analytical and test results.

A Crashworthiness Analysis and Test Plan (Plan) shall be prepared in accordance with 3.4.2.3.1, and shall be submitted not later than 30 days after NTP.

A Crashworthiness Analysis (Analysis) shall be performed in accordance with 3.4.2.4.2.

A Crashworthiness Analysis Report (Report) shall be prepared in accordance with 3.4.2.4.3, and shall be submitted for review and approval not later than 60 calendar days prior to commencing manufacture of car body structural parts.

Structural tests shall be performed in accordance with Section 17.3.3.15 to verify the design and the accuracy of the analysis.
Approval of the Analysis shall be prerequisites for approval of the structural drawings and structural test procedures required by this Specification, and shall be used to assist in determining strain gage locations for use during the required tests.

3.4.2.4.1 Crashworthiness Analysis and Tests Plan

The Plan shall be discussed during the first design review meeting. Comments from the meeting and from formal review shall be incorporated, and the Plan resubmitted for review and approval. Approval shall be based on compliance with format, content and design requirements of the Specification as defined at the time of Plan submittal. Following that, the Plan shall be updated periodically as the body design develops. Updates of the Plan shall be identified by assignment of a new revision level, and shall be submitted for review and comment, but not more often than monthly.

The Plan shall include an outline of the procedure the Contractor will use to analyze and test the crashworthiness design of the car body. The outline shall include the following as a minimum:

- Listing of impact conditions to be used during each analysis and test, including force magnitudes, points of application, and energy absorption requirements,
- Description of the analysis to be performed,
- Diagrams of load applications and restraints,
- Table of material properties, and
- Criteria for agreement of analytical and test results.

Approval of the Plan and satisfactory resolution of NYCT comments on updates shall be required prior to approval of the Report required by Section 3.4.2.4.3. The latest version of the Plan shall be included in Report.

3.4.2.4.2 Crashworthiness Analysis

Crashworthiness analysis shall be performed using a time-dependent, large-deflection computer program. The Analysis including all of its sub-components, shall be used to design the car structure to meet the crashworthiness requirements of the Specification, and to assist in obtaining the lightest-weight design consistent with those requirements.

The energy absorbing elements shall be analyzed to determine their behavior and the amount of energy each will absorb. As necessary, non-energy absorption elements ("fuses") shall be analyzed to show they do not interfere with the functioning of the energy absorbing elements.

Once the element analyses have been verified and the elements tested, the results shall be used to define the performance of the absorbers and fuse in model used in the analysis of the complete car body.
During the design and manufacture of the cars, the Analysis shall be updated to conform to the production configuration. The final submitted and approved Analysis shall be consistent with the car in the as-built configuration.

For any portion of the proposed design which is based on a service-proven vehicle with energy absorption capabilities that are the same as specified and that have been verified by analysis and test, the Contractor may provide data from previous test and crashworthiness analyses as needed to satisfy equivalent portions of these requirements.

3.4.2.4.3 Crashworthiness Analysis Report

The Report shall show that all structural members and the car body satisfy the crashworthiness requirements of the Specification. The Report shall demonstrate that the crushing of the car body is stable.

The Report shall include animations of the time-dependant, large-deflection analysis compatible with one of the current commonly-available video formats, such as CD or VHS. The animation shall contain sufficient detail, view directions, and magnifications to review the behavior and stability of energy absorption elements, fuses, non-crushable structure inboard the crush zones, and the car body as a whole.

The report shall be organized and in sufficient detail so that the NYCT reviewer can readily follow the theory and its application to this car.

The report shall include a description of the model in sufficient detail to show that the model is appropriate for this application. This shall include, as a minimum, descriptions of the elements and restraints, and the conditions of the simulation. It shall also include the output of the simulation to show that relevant Specification requirements have been met, including force-displacement plots.

For non-crushable structure inboard the crush zones, locations where the MS is less than 0.20 shall be shown in a table with a discussion of the results. There shall be no permanent deformation in this area of the structure.

References for all formulas, calculation procedures, buckling coefficients, material strengths, and other physical and mechanical properties must be cited where these items appear in the report. If a cited reference is not readily available to NYCT, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages which show the cited formula or data, the pages which show the development and interpretation of the formula or data must be included. All references shall be in English. If an English reference cannot be found, an English translation shall be provided. Both the original and the translation shall be included in the report.

If tests are conducted to provide necessary data, the entire test report shall be submitted. Such reports shall include the test procedure, raw data as well as reduced data, and a summary.
At the discretion of NYCT, all models and results shall be reviewed during live interactive sessions three weeks after each submittal. At these sessions, NYCT shall have full access to the model input, output and use of the software on a computer. Access shall be provided to view the crushing simulation on the computer.

### 3.4.2.4.4 Comparison with Test Results

The Report shall contain the results of a comparison of analytical and test results. The analysis shall be in substantial agreement with the test results. Criteria for agreement shall be included in the Plan.

### 3.4.3 Stress Analysis

#### 3.4.3.1 General

The Contractor shall submit a stress analysis of the car body structure and equipment supports for equipment weighing over 200 lbs (90.72 kilograms). A Stress Analysis Plan shall be submitted not later than 30 days after NTP. The analysis shall be submitted not later than 60 calendar days prior to commencing manufacture of any car body structural parts. Stress analyses for supports for items weighing less than 200 lbs (90.72 kilograms) may be requested for review at the discretion of NYCT. The stress analysis shall be used to design the car structure to meet the requirements of this Specification and to obtain the lightest-weight car consistent with requirements. Structural tests shall be performed in accordance with Section 17.3.3.15 to confirm the adequacy of the design and the accuracy of the analysis.

The stress analysis shall show the calculated stresses, allowable stresses, and margins of safety for all elements for all specified loading conditions. The stress analysis shall include calculations of stresses in joints, joint elements, and other important elements.

The approved stress analysis 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 gage locations for use during the tests.

During the design and manufacture of the cars, the input to the stress analysis shall be updated to reflect the as-built structure's configuration.

The initial stress analysis will require temporary assumptions as to configuration and weights; also manufacturing and other considerations may require design changes. As these changes are made, the stress analysis shall be revised and submitted for review. The final submitted and approved stress analysis shall be for the car in the as-built configuration.

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 elastic stability of plates, webs and flanges shall be calculated for members subject to compression and shear. The variation in the stainless steel compression modulus with stress shall be considered in calculating compressive stability of stainless steel members.
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 skew to the beam's web, 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.

For any portion of the proposed design which is based on a service-proven vehicle, the Contractor may provide data from previous tests, historical data from operations, or stress analyses as required to satisfy the corresponding portion of these requirements.

3.4.3.2 Stress Analysis Definitions

3.4.3.2.1 Permanent Deformation

A member shall be considered as having developed permanent deformation if one of the following conditions is met:

- 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.
- The material has buckled or deformed and will not return to its original shape or position after the load is released.

For materials without a specific yield point, the 0.2 percent offset method shall be used to determine yield strength.

3.4.3.2.2 Ultimate Load Carrying Capacity

The ultimate load carrying capacity of a member is the maximum load which the member can support before it separates at its ultimate strength or completely fails as a column.

3.4.3.2.3 Margin of Safety

Margin of safety (MS) is defined as follows:

\[
MS = \frac{Allowable\ Stress}{Calculated\ Stress} - 1
\]

The calculated stress shall include the applicable load factors. MS shall be a minimum value, but a positive number.
3.4.3.2.4 Load Factor

Load factor is defined as 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.

3.4.3.3 Buckling Analysis

The buckling strength of major members shall be calculated. Any member in any of the analyses with a calculated compressive stress equal to, or greater than, 35 percent of its material's yield strength shall be included.

3.4.3.4 Stress Analysis Submittals

3.4.3.4.1 Car Body Stress Analyses and Tests Plan

A Car Body Stress Analyses and Tests Plan shall be submitted no later than 30 days after NTP. It shall be discussed during the first design review meeting. The Plan shall be a working document that will be updated as the body design develops. Whenever the Plan for the analysis and testing of the car body is revised, the Plan shall be updated with revision level indicated and resubmitted, but no more than monthly.

The Car Body Stress Analyses and Tests Plan shall include an outline of the procedure the car builder will use to analyze and test the design of the car body. It shall also include the following:

- Listing of load conditions to be used during analysis and test, including load magnitudes and points of application,
- Description of the analysis to be used for each load condition,
- Diagrams of load applications,
- Table of material properties, and
- Description of how analysis results will be correlated with test results, as required in Section 3.4.3.6.

The Car Body Stress Analyses and Tests Plan must be approved prior to approval of the Stress Analysis Report required by Section 3.4.3.4.2. The Plan shall be a volume of the Analysis Report.

The Plan shall follow the general requirements of the report in Section 3.4.3.4.2.

3.4.3.4.2 Stress Analysis Report

A stress analysis report shall be prepared and submitted for review and approval. This report shall show that all structural members satisfy the requirements of this Specification and good practice in the rail transit
industry. The report shall be organized and in sufficient detail so that the NYCT reviewer can readily follow the theory and its application to this car.

The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted to NYCT.

If a cited reference is not readily available to NYCT, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages which show the cited formula or data, the pages which show the development and interpretation of the formula or data must be included.

All references shall be in English. If an English reference can not be found, an English translation shall be provided. Both the original and the translation shall be included in the report.

All stress analysis sheets shall be signed and dated by the author and checked by a second stress analyst who shall also sign and date each sheet checked.

The stress analysis report shall include, at a minimum:

- Table of Contents.
- Wherever a formula or equation is used, it must first be stated algebraically with all terms defined, and the values and units to be applied to these terms stated, before calculations are performed.
- All quantities wherever given must have their units given with them.
- References for all formulas, calculation procedures, buckling coefficients, material strengths, fatigue strengths, and other physical and mechanical properties must be cited where these items appear in the stress analysis.
- Each page numbered, dated, and initialed by the analyst and the checker. In addition, in the event of a revision, the revision letter shall be included with revision date and initials of the analyst and checker.
- The approved structural sketch (see Section 3.4.1).
- Diagrams displaying, for each load case, loads applied externally to the car body and points of support.
- An analysis showing compliance with each design load and condition, as required by Section 3.4.4.
- Detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing, with a summary of the results. Locations where the MS is less than
0.20 shall be shown in a table along with the design or operating conditions (loads) which cause the stresses.

- Particular reference in the stress analysis shall be made to, but not limited to the following:
  - side sill
  - body sills (if used)
  - end sill
  - anti-climber
  - draft sills
  - coupler supports
  - side frame rails
  - side frame posts
  - transverse and longitudinal sections at doorways
  - body bolster
  - floor and floor beams
  - primary center collision posts
  - primary side collision posts
  - secondary collision posts
  - structural shelf
  - roof structure
  - equipment supports
  - connections between structural elements

- A tabulation or diagram of calculated deflections of the car body under full vertical loading and under combined vertical and compression loads specified in Section 3.4.4.

- Analysis of all critical and highly loaded connections showing the joint is stronger than the weakest member being joined.

- An analysis of the strength of the connection of the trucks to the car body, including calculated vertical and horizontal connection capacities.

- Analyses of the car body structure under the torsional loading resulting from diagonal jacking described in Section 3.4.4.11 and under torsional loadings resulting from anticipated normal operations.

- A tabulation of the Contractor's selection of allowable fatigue stresses, with sources, and assumed applied fatigue stress ranges for structural members which are critical in fatigue.

- A table showing the engineering properties of each grade and temper of each material used in the car structure. This table shall include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension, and compression and shear elastic moduli. 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 car body construction shall not be included in the tables.

- 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 car body. The source of the data shall be provided.

- 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.

3.4.3.5 Finite Element Analysis (FEA)

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The stress analysis shall include a linear-static finite element analysis (FEA) of the complete car body. The FEA shall be a recognized computer program such as NASTRAN, ANSYS, Algor, or approved equal.

The Contractor shall submit and receive approval of the finite element model prior to performing the analysis. The model shall be submitted not later than three months after NTP. The element grid, all assumptions, and a complete printed copy of the input file which includes input data, such as loads, boundary conditions, area properties and material properties, shall be included as part of the preliminary submittal and again as part of the complete analysis. Boundary reaction forces of the shell at AW0 shall be included.

Each load condition submittal thereafter shall include diagrams of grid areas of mesh refinement, all assumptions, all input data, reaction forces and a table to show static equilibrium.

Wherever required to be submitted, the 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 NYCT, FE models and results shall be reviewed during live interactive sessions three weeks after each submittal. At these sessions, NYCT shall have full access to the FE model input, output and use of the software on the computer used for the analysis.

Color plots shall be prepared showing the following:

- Deflections in all three axes.
- von Mises, or other approved combination stresses.
- Maximum and minimum principal stresses.
- Direction of maximum and minimum principal stresses (these may be monochrome plots, provided that readability is not affected).
- Strain-energy density, if available.
- Meshing accuracy index.

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 truck assembly
3.4.3.6 Comparison with Test Results

For each test required by Section 17.3.3.15, the car body structural test results shall be compared with the corresponding stress analysis results. This information shall be tabulated and submitted with the car body structural test reports for each test.

The tables shall compare stresses calculated from the test strain gauge readings with analytical stresses from the FEA. Comparison shall be made for the highest-reading strain gauges, which shall not be less than half of the total number of strain gauges used during the test. The tables shall include the test stress value, the analytical stress value, the percent difference between the two values, and a space for annotation.

The percent difference between the two values shall be within the following specified tolerance: for 75 percent of the compared values, test and analytical results shall agree within 15 percent.

If the analysis results do not agree with the test results within the above-specified tolerance, the builder shall revise the stress analyses, update the FE model, and re-run all FE analyses. This process shall be repeated until agreement of results is within the specified tolerance. All manual analyses using data from the FEA shall be recalculated using the corrected values. The stress analysis report shall be revised and re-submitted. All results from re-analysis shall meet specification requirements, and, if they do not, the design shall be corrected.

For any of the remaining 25 percent of the compared values where the analytical values disagree with the test value by more than 30 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 car body test report. This explanation may include supporting manual calculations.

Approval of the car body test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.

3.4.4 Structural Design Loads

The car body shall be designed to meet the load requirements in this Section.
3.4.4.1 Allowable Stress at Operating Loads

The completely equipped car body shall be designed, with a load factor of 1.6, to carry its AW0 car body weight (not including truck weight) plus uniformly distributed passenger load equal to the passenger portion of AW3, plus an allowance for vertical impact of 30 percent of AW3 car body weight, distributed uniformly along the vehicle. The stresses in the car body, except the car body bolster, shall not exceed the lesser of 80 percent of the guaranteed minimum material yield strength, and the buckling strength. The stresses in the car body bolster shall not exceed 64 percent of the yield strength of the material, and the buckling strength of the structure.

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

The allowable fatigue stress range is computed by multiplying the static stress at the AW3 load by the dynamic factor (fatigue load range). This stress range must 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 Authority. The bolster, its connections to the car body and truck, the side frame local to the bolster, and the draw bar anchor 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 but shall not be less than ±20 percent. The fatigue design shall be based on applied and allowable fatigue stress ranges at 10 million cycles.

3.4.4.2 End Sill Compression Load

Under an end compression load equal to a minimum of 240,000 lbs (1,067.5 kN) applied longitudinally at the end sills of a car body loaded to AW0, the following conditions shall be met:

- There shall be no permanent deformation in any structural member, including sheathing, the anti-climber, and its fasteners.
- Maximum stress in any material as a percent of the lesser of yield and critical buckling stress shall not exceed 80 percent.
- Margins of safety shall progressively increase from the ends of the car body to the center.
- 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 ±10 percent. The points to be measured shall be at the outer-bottom edge of the side sill.
3.4.4.3 Coupler Compression Load

Under an end compression load equal to 120 percent of the coupler automatic overload release force applied longitudinally to the coupler pivot of a car body loaded to AW0, there shall be no permanent deformation in any structural members, including sheathing. In addition:

- There shall be no permanent deformation in any structural member, including sheathing, the anti-climber, and its fasteners.
- Maximum stress in any material as a percent of the lesser of yield and critical buckling stress shall not exceed 80 percent.
- 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 ±10 percent. The points to be measured shall be at the outer-bottom edge of the side sill.

3.4.4.4 Combination Loads

3.4.4.4.1 General

Under the two combination loading conditions, the car body structure and equipment supports shall have stresses within the allowable stresses stated in Section 3.4.4.4.4.

3.4.4.4.2 Combination A, Operating Condition

1. Dead load of completely equipped car body, plus
2. A uniformly distributed passenger load, varying from 0 to the quantity (AW3-AW0), plus
3. An allowance for vertical impact of 30 percent of total static load consisting of loadings of (1) and (2) above, plus
4. A horizontal buff or draft of 50,000 pounds (222.4 kN) applied at the centerline of the coupler faces, plus
5. A force caused by the maximum acceleration or deceleration resulting from a 25 percent coefficient of friction, plus
6. A force caused by running on a sharp curve at a speed sufficient to throw the entire weight of the car including trucks and passengers on the four wheels on the outside rail.
7. Under this combination of conditions, the loading factors to be applied simultaneously to each car body mounted equipment unit shall be as follows:

- Vertical \(1.00 \pm 0.30\) g
- Lateral \(\pm 0.50\) g
- Longitudinal \(\pm 1.00\) g

8. Under this combination of conditions, a horizontal load of 200 pounds (890 N), acting in any direction, shall be applied to each stanchion at a level of 60 inches (1,524 mm) above the top of the floor.

3.4.4.4.3 Combination B, Buff or Draft Condition

1. A dead load of completely equipped car, plus

2. A uniformly distributed passenger load varying from 0 to the quantity (AW3-AW0), plus

3. A horizontal buff of 200,000 pounds (890 kN) applied at the centerline of the underframe and distributed over a 15-inch (380 mm) width of anti-climber, or a horizontal buff or draft of 150,000 pounds (667 kN) applied at the centerline of the coupler faces.

4. Under this combination of conditions, it may be assumed that the cars will not be running at high speeds and, therefore, the allowance for vertical impact can be omitted.

5. The forces caused by operation on curves will not apply in this combination.

6. Under this combination of conditions, the loading factors to be applied simultaneously to each equipment unit shall be as follows:

- Vertical \(1.00\) g
- Lateral \(0\)
- Longitudinal \(\pm 2.00\) g

3.4.4.4 Allowable Stresses for the Combination Loads

The maximum allowable stresses in the various car body structural members, their attachments, and supporting structures, under the combinations of design loads specified above, shall not exceed the following values:
In no case, except in bearing stress, shall the maximum allowable stress exceed 40 percent of the minimum ultimate tensile stress of the material.

The minimum factor of safety for buckling of the various portions of the car structure, under the design loads specified above, shall be 2.0.

The allowable stresses given above shall be reduced if necessary for structural elements or connections between structural elements which are critical in fatigue. Stress allowables for arc-welded structure shall not exceed the requirements of AWS D1.1, "Structural Welding Code", for New Bridges. Stress allowables for resistance-welded structure shall not exceed values selected by the Contractor and approved by the NYCT.

3.4.4.5 Primary Collision Post Loads

The strength of the car body end structures shall not be less than required by Sections 18 and 20 of AAR Standard S-034, unless otherwise specified.

3.4.4.5.1 Primary Center Collision Post Load 18 Inches Above Floor

The load carrying capacity of each primary center collision post when loaded in a horizontal plane at a point 18 inches (457 mm) above the top of the underframe and within 15” either side of the longitudinal axis of the vehicle shall be a minimum of 75,000 lbs (333.6 kN) without permanent deformation of any part of the car body.

The vehicle underframe structure and posts shall be designed so that for the conditions with one post overloaded, and with both posts overloaded, the initial failure shall begin as bending or buckling in the post(s) or in the end underframe. The ultimate failure shall occur in the post(s). If the ultimate load carrying capacity of the post is greater than specified above, the structure must be designed to support this increased capacity.
The ultimate failure shall not be in the underframe or roof, nor in the connection to the roof or underframe, nor shall the failure be by shearing or fracturing of any structural member.

The stress analysis of the stainless steel posts must consider the reduction in the modulus of elasticity of stainless steel with high compression loads.

### 3.4.4.5.2 Primary Center Collision Post Shear Load at Floor

The ultimate horizontal shear strength of each primary center collision stub post shall be 300,000 lbs (1,334.4 kN) 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 for the primary center 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, times the shear strength of the material. This shear strength shall be carried to the bottom of the end underframe.

### 3.4.4.5.3 Primary Side Collision Post Load 18 Inches Above Floor

The capacity of each primary side collision post, under an inward horizontal load applied 18 inches (457.2 mm) above the top of the end underframe, shall be not less than 26,000 lbs (115.6 kN) in the longitudinal direction, and not less than 50 percent of the actual longitudinal strength in the transverse direction. Under these loads there shall be no permanent deformation of any car body structure. The connections of the posts to the supporting structure, and the supporting structure itself, shall be strong enough to develop the ultimate load carrying capacity of the posts. If the posts are designed to support more than the specified capacity, then the supporting structure must be strong enough to support the increased capacity of the posts; the posts shall fail before the supporting structure fails.

### 3.4.4.5.4 Primary Side Collision Post Shear Load at Floor

The ultimate horizontal shear strength of each primary side collision post, in the longitudinal direction at the level of the top of the end underframe, shall be not less than 75,000 lbs (333.6 kN) at the cab end and at least 50,000 lbs (222.4 kN) at the non-cab end. The ultimate horizontal shear strength in the transverse direction shall be not less than 52,500 lbs (233.5 kN) at the cab end at least 35,000 lbs (155.7 kN) at the non cab end. This strength shall be carried to the bottom of the end underframe.

### 3.4.4.6 Secondary Collision Post Loads

### 3.4.4.6.1 Secondary Center Collision Post Load 18 Inches Above Floor

The load carrying capacity of each cab-end secondary center collision post when loaded in a horizontal plane at a point 18 inches (457.2 mm) above the top of the underframe and within 15° either side of the longitudinal axis of the vehicle shall be a minimum 38,000 lbs (169.0 kN) without permanent deformation of any part of the car body.
The vehicle underframe structure and posts shall be designed so that when the post is overloaded, the initial failure shall begin as bending or buckling in the post or in the end underframe. The ultimate failure shall occur in the post. If the ultimate load carrying capacity of the post is greater than specified above, the structure must be designed to support this increased capacity. The ultimate failure shall not be in the underframe or roof, nor in the connection to the roof or underframe, nor shall the failure be by shearing or fracturing of a structural member.

The stress analysis of the stainless steel posts must consider the reduction in the modulus of elasticity of stainless steel with high compression loads.

3.4.4.6.2 Secondary Center Collision Post Shear Load at Floor

The ultimate horizontal shear strength of each secondary center collision post shall be 200,000 lbs (889.6 kN) 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 for the secondary center collision post 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, times the shear strength of the material. This shear strength shall be carried to the bottom of the end underframe.

3.4.4.6.3 Secondary Side Collision Post Load 18 Inches Above Floor

The capacity of each secondary side collision post, under an inward horizontal load applied 18 inches (457.2 mm) above the top of the end underframe, shall be not less than 13,000 lbs (57.8 kN) in the longitudinal direction, and not less than 50 percent of the actual longitudinal strength in the transverse direction. Under these loads there shall be no permanent deformation of any car body structure. The connections of the posts to the supporting structure, and the supporting structure itself, shall be strong enough to develop the ultimate load-carrying capacity of the posts. If the posts are designed to support more than the specified capacity, then the supporting structure must be strong enough to support the increased capacity of the posts. The posts shall fail before the supporting structure fails, and failure shall not be by shearing or fracturing of the posts.

3.4.4.6.4 Secondary Side Collision Post Shear Load at Floor

The ultimate horizontal shear strength of each secondary side collision post stub, in the longitudinal direction at the level of the top of the end underframe, shall be at least 75,000 lbs (333.6 kN). The ultimate horizontal shear strength in the transverse direction shall be not less than 70 percent of the actual shear strength of the post in the longitudinal direction. This strength shall be carried to the bottom of the end underframe.

3.4.4.7 Structural Shelf Load

The structural shelf on the cab end shall support a longitudinal load of 15,000 lbs (66.7 kN) applied anywhere along the span between the primary center collision post and primary side collision post, without permanent deformation of any part of the car structure.
3.4.4.8 Anti-Climber Load

The anti-climber shall withstand a 80,000 lbs (355.8 kN) vertical load in either direction combined with a minimum of 200,000 lbs. (889.6 kN) longitudinal compression load applied at the car body centerline, without permanent deformation of any car body structure or failure of the means of attachment of the anti-climber to the end sill. One rib less than the total shall be used in computing and testing the vertical strength of the anti-climber.

3.4.4.9 Floor Load

With the vehicle floor loaded to simulate a uniformly distributed AW3 passenger load plus interior equipment, such as seats, interior liners, and equipment boxes, the following conditions shall be met:

- The floor panels shall not deflect more than 1/250 of the shortest span between supports, up to a maximum of 1/8 inch (3 mm).
- The floor panels shall sustain no permanent deformation during the design life of the car, and shall be designed to withstand the specified loading without exceeding 50 percent of the yield stress of the flooring material.
- The floor beams shall not deflect more than 1/250 of the span between supports.
- 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.

3.4.4.10 Roof Load

All parts of the roof structure and sheets, equipment covers, roof walkway, screens and other guards shall have sufficient strength to withstand, without permanent deformation, the following loads applied separately:

- The load imposed by a mechanical car washer, consisting of a pressure of 60 pounds per square foot (2873 Pa) over a 12-inch (305-mm) wide band extending transversely across the car body.
- The load imposed by maintenance personnel carrying tools and equipment while working on the roof, consisting of three concentrated loads of 250 lbs. (1,112 N) with a foot print of 6 in² (3870 mm²) spaced 30 inches (762 mm) apart.

The roof shall also support without yielding the loads imposed by normal operating conditions, including loads imposed by roof-mounted equipment, passenger-seat support stanchions and handholds, and specified collision and jacking loads.
3.4.4.11 Side Load

The car body structure shall be designed to resist an inward transverse load of 40,000 lbs (178 kN) applied anywhere along the side sill, and 10,000 lbs (44.5 kN) 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 considered to 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 will be allowed.

The car body shall be adequate to withstand, at any possible condition of passenger load, a lateral inertial load sufficient to cause overturning.

3.4.4.12 Jacking and Hoisting Loads

Each car body jack pad and its supporting structure shall have a load factor of two based upon supporting AW0 vehicle weight. The vertical load on each jack shall be combined with a horizontal load of 10 percent of the vertical load (including the load factor of two) applied in any horizontal direction. Under this loading condition, there shall be no permanent deformation of any car body structure.

The same load factors as above shall apply for lifting pads.

The car body at AW0, with trucks attached, shall be capable of being lifted with four jacks, one at each quadrant of the car body either under the primary side collision post or bolsters, in any combination, without permanent deformation of any car body structure.

The assembled car, with trucks attached, shall be capable of being lifted with two jacks at diagonally opposite corners of the shell without damage to the car body or any part of the assembled car.

3.4.4.13 Equipment Loads

The load factor for the design of all underfloor, side, end, roof, in-roof and interior equipment, any portion of the equipment, equipment boxes, equipment hangers, safety hangers, and the car body supporting structure shall be five in the longitudinal direction, three in the vertical direction, and two in the lateral direction. The load shall be equal to the weight of the item multiplied by the appropriate load factor. The specified tri-axial loadings shall be applied separately; such loading may develop the ultimate load-carrying capacity of the member being investigated.

With one less than the total number of supports, the remaining supports shall withstand not less than one-half of the required loadings without exceeding the ultimate load-carrying capacity of the members.

All supports shall be fatigue-resistant throughout the design life of the car.
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 load levels. The equipment box shall conform to these load criteria with the rearranged equipment \((i.e.,\text{ equipment that is presumed to have broken loose})\) in addition to its normal arrangement.

Structural connections in equipment supports shall be subject to the requirements of Section 3.3.3. In particular, equipment support fastenings shall be designed so that in no case shall either the strength of a fastener, or the shearing of the fasteners through the base material, be the limit of the carrying capacity of a member.

### 3.4.4.14 Truck Connection Strength

Trucks shall be locked to the car body. The strength of the means of locking the truck to the car body shall be sufficient to resist an ultimate load of 150,000 lbs \((667.2 \text{ kN})\) in any horizontal direction applied to any point on the truck. The bolster anchor rods shall not be used to provide any part of this strength. When the vehicle is raised off the track, the car body and the means of locking the truck to the car body shall resist a load equal to two times the full weight of the truck without permanent deformation.

### 3.4.4.15 Bolster Anchor Bracket Load

The strength of bolster anchor brackets, if used, and the attachments to the car body shall exceed that of the bolster anchor rods as described in Section 4.5.2.2. The bolster anchor brackets shall be designed such that, under extreme loading, the rods will fail without causing permanent deformation of the brackets, their attachment to the car body, or of the car body structure. When an installed bracket is loaded to failure from any horizontal direction anywhere in a zone from the lowest point on the bracket to one-half the distance from the lowest point to the centroid of the attaching fasteners, there shall be no permanent deformation of any part of the car body structure.

### 3.4.5 Natural Frequency

The natural frequency of the car body under a uniformly distributed AW3 passenger load and supported on its bolster suspension points \((\text{free-free beam})\) shall not be less than 2.5 times the natural frequency of the truck secondary suspension or 4.5 Hz, whichever is greater.

### 3.5 Car Body Shell Structure

#### 3.5.1 Underframe

#### 3.5.1.1 End Underframe

The A Car No. 1 End underframe unit shall consist of the draft sill, body bolster, end sill, anti-climber, post shear lugs, and stubs for connecting the posts to the underframe sills. The No. 2 End underframe shall be as identical as practicable to the No. 1 End underframe.
The end underframe shall be constructed of LAHT assembled by arc welding in accordance with Section 15 and AWS Structural Welding Code D1.1 using AWS pre-qualified 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. AWS pre-qualified 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 4.4.

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

In order to avoid the difficulties in attaching the light-gauge floor pans to the heavy underframe members, brackets or clips may be provided on the underframe for subsequent attachment of floor pans; see Section 3.3.

3.5.1.1.1 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.

3.5.1.1.2 Coupler Carrier

Where a coupler is applied, a coupler carrier shall be provided as part of each end underframe assembly. The coupler carrier element on which the coupler shank slides shall have a wear plate as approved by the NYCT. Reference Section 5.2.5.1 for additional details.

3.5.1.1.3 Body Bolster

The body bolster shall be designed to transmit loads between the truck and the car body, 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 de-trucking. Positive stops shall be provided on the car body and truck bolsters to limit the vertical and transverse movement of suspended trucks when the car body is lifted. (Reference Section 4.3.4.2.)

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. Fatigue-resistant design shall be a prime requirement of the body bolster structure.
3.5.1.1.4 End Sill

The end sill shall be designed to transmit the required anti-climber loadings into the draft sill without exceeding the yield strength of the end sill structure. The end sill shall also be capable of transmitting the loads from the primary center collision posts and primary side collision posts into the draft sill, without failure, when the posts are loaded to their ultimate strength.

3.5.1.1.5 Collision Post Shear Reinforcement

If reinforcement is used to provide the specified primary and secondary center and side collision post shear strength at the floor, it shall be designed to transmit the specified shear and other loads into the end underframe. Such reinforcement shall have shear strength not less that the corresponding collision post shear load from the bottom of the end underframe to a point 18 inches (457 mm) above the top of the end underframe, and then taper to a point not less that 30 inches (762 mm) above the top of the end sill.

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, except as otherwise required by Specification Section 3.5.3.2.

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 any one, two, or three adjacent primary 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 of 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 of the top connecting and supporting structural elements. The same requirement shall apply to the secondary collision posts at cab ends, considered as a separate load case, but without benefit of support from the structure outboard of the secondary collision posts.

Overload of collision post bottom connections shall result in buckling and crushing of the underframe structural members to which the collision posts and any collision post reinforcements are attached, rather than shearing or fracturing of the posts.

3.5.1.1.6 Anti-Climber

An anti-climber shall extend laterally over the full width of the car end frame at both ends, and shall be welded to the end sill. The anti-climber shall be designed to engage the anti-climber of an opposing car under the worst conditions of vertical and horizontal track curves and resist climbing forces between vehicles. The anti-climber shall be compatible with existing NYCT Division A equipment.
3.5.1.2 Side Sills and Body Sills

Side sills shall be provided to form the lower longitudinal corner of the car body structure, and shall form a structurally continuous bottom chord for the side frame. The side sills shall be securely connected to floor beams, cross-bearers, car body bolsters, end sills and underframe shear panels.

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 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 car body 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.

The side sills shall be designed to function as buffers to allow the car to withstand strikes against the station platform edging and edging fasteners without damage of any kind other than surface scratching.

Center sills are optional. If used, they shall consist of one piece, 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.

3.5.1.3 Sub-Floor Pans

A stainless steel sub-floor pan shall be provided throughout the length of the car. These floor pans may be an integral part of the floor structure, or they may be separately attached. The sub-floor pan shall contain the underfloor thermal insulation, and part of the fire protection system (Section 15). They shall be suitably stiffened to prevent resonance 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 weather entry into the sub-floor for the life of the vehicle.

3.5.1.4 Cross-bearers

Cross-bearers may be used to tie securely to the side sills to form the basic framing for support of the floor panels and the underfloor equipment units. Floor beams shall also be used as required for equipment support and to control floor deflection.

3.5.1.5 Underfloor Equipment Supports MOD 05

Underfloor equipment weighing more than 200 lbs (90.72 kg) shall be supported directly by the side sills, body sills, transverse floor beams or longitudinal supports between transverse floor beams. All equipment shall be mounted with at least four supports, unless otherwise approved by NYCT. Dissimilar metals shall not be allowed at connections.
Connection components shall not require disassembly for maintenance, or for removal and replacement of equipment. Equipment requiring removal and replacement for other than accident damage shall be supported so that both bolts and nuts are accessible.

Equipment supported on resilient mounts shall be provided with safety straps or other devices for support in case of mount failure.

All equipment weighing more than 25 lbs (11.34 kg) shall be safety hung (not supported by threaded fasteners in tension or shear). No equipment shall be supported by bolts in holes tapped in the car structure. However, it is permissible to use tapping plates in accordance with Section 3.3.3.

Equipment or equipment supports shall not contribute to nor detract from the controlled crushing of the structure as required by Section 3.4.2.1.

3.5.1.6 Corrosion Protection

A corrosion-resistant coating, as specified in Section 15, shall be applied to the entire underframe and the inside of side and end sheets. A corrosion resistant coating is not required on不锈钢 members except for sound deadening as may be necessary to meet the noise limits of Section 2.

3.5.1.7 Jacking and Hoisting Provisions

3.5.1.7.1 General

The lift and jack pads shall suit the construction of the car and the lifts, jacks, and stands in use in the NYCT.

The jacking and hoisting arrangement shall be designed so that:

- Cars can be jacked or hoisted individually and as a Unit.
- Individual cars can be jacked or hoisted at one end while supported at the truck pivot at the other end.

Diagonal jacking of a car with trucks attached as described in the diagonal jacking test in Section 17.3.3.15.11 shall not cause any structural or cosmetic damage, or cause degradation of the water tightness of any glazing.

Trucks shall be retained with the body during jacking or hoisting unless intentionally disconnected as described in Section 4.3.4.2.

3.5.1.7.2 Jacking Pads

There shall be a minimum of four jack pads on each side sill located at the same locations as those on the NYCT R110A cars. These jack pads shall be at least 6-inches (152.4-mm) long by 4-inches (101.6-mm) wide and project a minimum of ½ inch (12.7 mm) below the bottom of the side sill. Also, there shall be a minimum of 2-inch (50.8-mm) clearance to any obstruction around each
Jack pad. One jack pad shall be located under each primary side collision post. Another set of jack pads shall be located at the bolsters to permit jacking the car with NYCT standard floor jacks so that the truck can be rolled from under the car without removing any equipment or structure.

The bottom of all jack pads shall have a non-skid surface to provide frictional resistance against incidental horizontal loading between the jack pad and jack head.

The car shall be capable of being lifted with four jacks, one at each quadrant of the car body in any combination.

3.5.1.7.3 Lifting Pads MOD 04

There shall be lifting pads located at the bottom of the side sills between the bolsters. These pads shall be designed for lifting the car with both trucks attached using a NYCT overhead crane with lift hooks.

3.5.1.7.4 NYCT Drop Table Support CO 114

The car shall be capable of being supported at one end by lifting or jacking pads, without its’ truck attached, by the car body drop table support pads, while the other end is supported on its’ truck.

3.5.2 End Frame

3.5.2.1 General

The end frame shall be capable of resisting, without failure, normal operating loads and the specified collision and jacking loads. The front end frame shall also be designed to support the windshield assembly when tested in accordance with the requirements outlined in Section 17.

The end frame outer sheathing shall be 301LN stainless steel, fiberglass reinforced plastic, or a combination of 301LN stainless steel end sheet with a fiberglass reinforced plastic roof end cap. fiberglass reinforced plastic used for this purpose shall meet the requirements of Section 15, shall be non-structural, shall maintain a watertight seal with the car body, and shall not be damaged by any car body deflection including all deflections resulting from the structural tests of Section 17.3.

Fiberglass, if used, shall be fastened to the car structure in an approved manner. The following methods of fastening will be acceptable: recessed flat head bolts through areas of fiberglass shell that have been
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reinforced with steel strips not less than 1/8 by 2 by 3 inches (3 by 51 by 76 mm) molded within the shell with an
approved filler used to cover the bolt heads; cap screws with lockwashers under the head from inside the car into tap plates not less than 1/4 by 6 by 2 inches (6 by 152 by 51 mm) molded within the fiberglass.

The front end frame shall consist of two primary side collision posts, one each at the juncture of the front end and side frames, two primary center collision posts located at the approximate third points of the end frame width, but in any case not more than 40 inches (1.02 m) apart, a body end door, a structural shelf, and sheet metal sheathing connected to the structural framing members as necessary.

The non-cab end frame shall consist of two primary side collision posts, two primary center collision posts, framing posts, door posts, a header, and stainless steel sheathing. It shall be designed to resist the specified vertical, transverse and torsional loads. The door posts and header shall be designed to carry the body end door while maintaining weather tightness.

3.5.2.2 Primary Center Collision Posts

The center collision posts shall be a continuous closed section from the top of the end sill to the roof. They shall be welded to the shear reinforcement at the floor, stub posts, and to the roof to develop the full strength of the posts. The body end doors shall be mounted on the primary center collision posts.

3.5.2.3 Primary Side Collision Posts

The side collision posts shall be a continuous closed section from the top of the end sill to the roof. They 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.

3.5.2.4 Structural Shelf

The structural shelf is a horizontal transverse beam in the cab front end frame just below the windshield. It shall extend from primary side collision post to primary center collision post and be securely connected to both. The structural shelf shall be designed to provide additional resistance to penetration of the cab.

3.5.3 Side Frame

Side frames shall consist of vertical members such as window posts, door posts, secondary collision posts, and appropriate stub posts, and longitudinal members such as roof rails, side sills, window top rails and belt rails. It shall also consist of sheathing and internal skin stiffening members. All gussets shall be full height.

Structural posts shall be located at the sides of all door and window openings and elsewhere as required to limit deflection and fatigue stresses. Structural posts shall be continuous between the side sill and the roof rail. Where horizontal rails are interrupted by posts, gussets shall be used to reinforce connections to effectively make the rails continuous. The belt rail and its supports shall be designed to resist the specified side load. Adequate sideframe posts, or stub posts, extending between the side sills and the belt rails shall be provided to transmit vertical load from the body bolster ends, crossbearer ends and jacking pads into the side frame sheathing.
All posts shall be formed sections. Side post section moduli shall meet the requirements of AAR Standard S-034, Section 16. Side sheathing shall meet the requirements of AAR Standard S-034, Section 17 as a minimum.

Side sheathing shall be resistance spot welded to the outside of the side frame posts in the space 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.

Horizontal lap joints will be permitted where the flat side sheets are connected to corrugated side sheets provided the direction of the joint sheds water and the joint is seam welded.

Approved weatherstrips shall be applied at door openings.

3.5.3.1 Secondary Center Collision Posts

The cab-end of the car body shall have two secondary center collision posts, which shall be a continuous closed section from the top of the end sill to the roof. They shall be in line with the cab bulkhead and near the longitudinal center of the car, approximately in line with the primary center collision posts. They shall be welded to the shear reinforcement at the floor, and to the roof to develop the full strength of the posts.

3.5.3.2 Secondary Side Collision Posts

On the cab-end of the car there shall be two secondary side collision posts, one on each side, in line with the cab bulkhead. The secondary side collision posts shall be a continuous closed section from the top of the side sill to the roof. They shall be welded to the shear reinforcement at the floor, to intermediate side frame rails and sheathing, and to the roof rails to develop the full strength of the posts.

3.5.4 Roof

3.5.4.1 Roof Structure

The roof assembly shall be constructed of carlines, purlines, and roof sheathing covering the entire roof area. Equipment mounted under the roof suspended from the roof structure shall be bolted to the framing members. The framing members shall be reinforced in sub-assembly to accept the equipment load.

The roof sheathing and structure shall be designed to support the specified roof loads. The structure shall support all equipment with the equipment design loads as specified in Section 3. Both ends of the roof shall be designed to support the tops of all collision posts and distribute the specified collision post loads, including those from the primary center, primary side and secondary posts.

Splash guards shall be installed at the ends of roofs and gutters to prevent accumulated rain water from cascading over the cab ends of cars, and between coupled cars. If the roof is corrugated, the splash guards
shall be adequate for the purpose intended with water accumulation up to the maximum possible with the form of corrugation used.

The roof shall be framed and reinforced around openings. All reinforcement shall be welded stainless steel. Reinforcements on the roof shall be made watertight by welding or soldering. No through roof mechanical fastening is permitted.

Roof equipment arrangement design shall not permit accumulation of water. Drainage provisions shall be subject to NYCT approval.

3.6  Floor Construction

3.6.1  General

The floor shall be constructed so that all applicable noise, vibration, strength, and fire endurance rating requirements are met. Refer to Section 2.7 for noise and vibration requirements, Section 3.4.4.9 for panel deflection requirements, Section 15.25.4 for fire endurance rating requirements, and Section 15.10.4 for panel strength requirements. The floor design shall be tested to meet the fire endurance rating requirements prior to the Contractor's procurement of production material.

3.6.2  Construction

The floor shall be constructed of a minimum of 21/32-inch overall thickness plymetal which shall meet the requirements of Section 15.10.2. The panels shall be composed of exterior-type, grade B-B or better, five-ply plywood, using resin glued fir with solid and jointed cores and crossbands, faced on the entire top, bottom and edges with austenitic series stainless steel. The stainless steel shall be joined to itself by seam welding or crimping so that all edges of each sheet are sealed by the metal against water entry. The stainless steel skins shall be securely bonded to the plywood in accordance with MIL-P-8053 type III, paragraph 3.1.3.2.

The floor panels shall meet the fire resistance requirements of Section 15.25.

The panels shall be comprised of pieces as large as possible, and shall extend the full width of the vehicle with transverse joints which shall only be located over structural members. There shall be no joints in the top or bottom face skins of the panel. Lock seam joints, if required due to stainless steel width availability, may be used if a sample of the joint and a drawing depicting actual construction is provided by the Contractor and approved by the NYCT. A lock seam shall not be placed closer than 6 inches (152 mm) to floor fasteners, and shall be staggered by at least 6 inches (152 mm) so that a seam on the top of the panel is not directly over a seam on the bottom of the panel.

The panels shall be insulated from the metallic structure by elastomeric tape.

Floor panels shall be attached to the floor structure using approved flat head stainless steel fasteners in countersunk holes in the upper skin of the floor panels. The tops of the fasteners shall not be above the top surface of the floor panel skin. Reinforcements and steel tapping plates for above-floor attachments shall be
provided on the underside of, or within, the panels. The floor panels shall be attached to the floor beams, body sills, end sills, side sills and body bolsters. All joints between floor panels shall be atop floor structure and both edges shall be fastened to that structure.

3.6.3 Floor Beams

Transverse beams shall be provided to transmit vertical floor loads to the side sills.

3.7 Insulation

3.7.1 General

The floor, roof, sides, ends, and doors of the vehicle shall be thermally and acoustically insulated to the extent required to meet or exceed the environmental conditions specified in Appendix A, and the interior sound level requirements as specified in Section 2.7.3. In no case, however, shall the vehicle be thermally and acoustically insulated to a lesser extent than required by Sections 2.7.3 and 12.5.4.

The insulation and all material used for vibration damping shall meet the flammability and smoke emission requirements specified in Section 15.25.

3.7.2 Thermal

An approved insulation material shall be used throughout the roof, floor, side walls, and ends of the car bodies for thermal insulation. Heat transfer through the car body, using only the car body's own floor-level heaters, shall not exceed 12 BTU/Hr/°F per foot of car body length, under the environmental conditions specified in Appendix A while the car body is stationary. See Section 17.3.5.4 for climate room test requirements.

If fiberglass insulation is used it shall be manufactured from long, textile-type glass fibers which are drawn from a calcium borosilicate mixture to an average diameter of 9 microns. Fibers shall be bonded together with a thermosetting phenolic resin which shall not exceed 6 percent by weight. The fiberglass shall not mold, rot, or sustain vermin. It shall not corrode any metals or settle under car vibration. It shall not have an odor or be capable of absorbing odors. It shall be capable of performing to an upper temperature limit of 450°F (232°C).

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 car body skin and at any other location where it is necessary to interrupt an all-metal path between the interior of the car body and the outside of the car body skin.

3.7.3 Acoustical

A vibration and sound damping material shall be applied to inner surfaces of all areas of the structural shell, including sub-floor pans, ends, roof, and side frames, and one side of air duct splitters (if used). The thickness of the damping material shall be sufficient to provide 10 percent of critical damping for the treated surface. The damping material shall have a vibration decay rate of not less than 35 dB per second at a temperature of
70°F (21°C), as measured by the Geiger thick-plate, SAE Standard J671, or other equivalent approved test method. It shall be resistant to alkalis, greases, gasolines, aliphatic oils, vermin, and dilute acids, and shall meet the flammability and smoke emission requirements of Section 15.25. It shall be unaffected by sunlight or ozone, and shall not become brittle with age.

The damping material shall be a spray-applied, water base, non-asphaltic, silica-free filled polymer in an emulsion form. Application shall be according to the supplier's recommendations, and as follows:

- The inner surface of the car structural shell, except for the end underframe weldments, shall be coated with sound deadening compound. The inside surfaces of structural members shall be sprayed to the maximum extent possible. The compound shall be applied wet at the supplier's recommended thickness.

- The outside surfaces of the main air duct, any vertical underfloor equipment ventilation ducts which enter the car body interior through the floor panels, and all ventilation ducts shall be coated with sound deadening compound. The compound shall be applied wet at the supplier's recommended thickness.

- Duct splitters shall be coated on one side only.

- The ceiling below the main air duct shall not be coated.

A primer shall be applied in accordance with the recommendations of the manufacturer of the damping material.

3.7.4 Urethane Foam

Urethane foam insulation shall not be acceptable for use anywhere in the construction of this vehicle.

3.8 Floor Covering

3.8.1 General

CO 122

The floor covering shall be black with colored speckles, smooth rubber Noraplan Terrazzo tile flooring or approved equal. The floor covering shall be a minimum of 0.14 inches (3.5 mm) thick and of an approved size. Coloring shall be uniform and shall run completely through the material. The coefficient of friction of the floor covering shall not be less than 0.60 when tested in accordance with ASTM D 2047.

At all door openings, the floor covering shall connect properly and form a positively clamped, watertight seal with threshold plates or equivalent moldings. Where the floor covering reaches the walls of the car body, it shall follow the radiused cove to the bottom of the floor heat enclosure. The edge of the floor covering shall be mechanically retained.
3.8.2 Preparation

Before applying the floor covering, all voids, fastener heads, and cracks between floor panels shall be filled, and the floor made smooth and true within 1/16-inch (1.6 mm) in 3.3 feet (1 m) in any direction, with a fire retardant, leveling compound.

3.8.3 Adhesive

The type of adhesive used to bond the floor covering to the floor boards shall be as recommended by the manufacturer of the floor covering.

3.8.4 Application

CO 122

The back of the floor covering shall be sanded before laying, and then securely bonded to the floor panels. The floor covering in the aisle shall be applied so that it can be replaced without disturbing the covering under the seats. No more than three tiles shall be used for the full width of the car when laying the floor covering. Cold weld seaming of joints in the floor shall not be allowed.

The floor covering color shall conform with the approved color scheme and shall be subject to NYCT approval. The floor covering shall be laid in conformity with the manufacturer's recommended practices.

3.9 Thresholds

3.9.1 General

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Door thresholds shall be provided at all side and end doors. Door thresholds shall be designed and constructed to prevent the entry of water between the threshold and door, including entry of water when the vehicle is subject to the horizontal spray jets of the car washing facility.

The height of the side door threshold shall be 1/8-inch (3-mm) maximum above the top surface of the finished floor, with a maximum slope toward the outside of the car of 1 inch in 10 inches (25.4 mm in 254 mm).

The side and end door threshold shall incorporate guides for the sliding doors. Guideways shall be self-cleaning to remove debris. Thresholds shall be self-cleaning, and shall drain to the outside. The door thresholds shall extend sufficiently into the door pocket and align with the door pocket door guide to provide adequate support for the leading edge of the door when it is motion.

Side door thresholds and associated bottom tracks in door pockets, shall be electrically heated to preclude the accumulation of ice and faulty operation of door panels due to freezing conditions. These heaters shall be thermostatically controlled and powered from a 120 Vac, galvanically isolated source.

The configuration and depth of the door guide in the threshold shall be sufficient to provide for car body deflection as may occur between AW0 and AW3 loads, without resulting in door binding or escape from
guides. There shall be no less than 0.250-inch (6-mm) engagement between door and threshold and no less than 1/8-inch (3-mm) clearance between door and threshold under all conditions of passenger load.

3.9.2 Construction

Door thresholds shall be of wear-resistant cast iron, with an abrasive finish. Adhesive backed, non-skid "tape" or sheets are not be permitted.

3.10 Windows

3.10.1 General

All windows shall be of the single-glazed, fixed type, supported directly by the car structure with an approved fastener arrangement or by glazing strips. Car body end windows shall be maximized in size to provide clear viewing between cars. Where frames are specified the frames shall be designed to be vandal resistant. The ends of any glazing strip shall be joined together by the hot vulcanization process to form an endless glazing strip.

All sash frames, where used, and glazing strips shall be so arranged such that they are easily removable from the inside of the vehicle for repair or replacement. In all cases they shall have internally rounded corners, both inside and outside the vehicle, to facilitate cleaning. The glazing sections shall be designed specifically for this car considering both car body material thickness and configuration and window material thickness in order to make a watertight seal without the need for sealing compounds.

All Cab Car, No. 1 End windshields and their glazing strips shall meet the FRA Type I impact and ballistics requirements. All Cab Car, No. 2 End, and Non-Cab Car end facings windows, side facing windows and their attachments to the car body shall meet the FRA Type II impact and ballistics requirements. The glass shall also meet the requirements of Section 15.8.

3.10.2 Side and Door Windows

The side windows and door windows in the passenger section shall be clear, laminated safety glass constructed to meet the requirements of Section 3.10.1. The side passenger windows shall be the same length and height as the windows shown on the NYCT’s Drawing 301-7200 Sheet 454, Vent Window; Sheet 455, Fixed Bottom Window; and Sheet 457, Fixed Window. Drawing 301-7200 shall be used as a reference for size only. All other aspects of side windows shall comply with the requirements of this Section. The side door windows shall be the same height as the side passenger windows and as wide as practical.

The passenger compartment side windows located between side doors shall be full frame, split-vent style with a lower portion of glazing material glazed directly into the extruded aluminum frame and an upper portion of approved NYCT glazing material within an extruded aluminum frame inwardly hinged as a ventilating panel. Passenger window panels shall be secured in the frame through the use of an aluminum retainer strip. The retainer strip shall be inserted into a slot in the frame and shall be secured with a threaded fastener.
Window sash shall be retained in the window opening with integral removal seals, shall be readily removable and replaceable from inside without the use of a sealing compound.

All passenger compartment windows shall be made capable of resisting an outward force of two hundred pounds (90.72 kg).

All passenger compartment windows shall be supplied with an optically clear, distortion-free layer of polyester film on the interior facing surface. The polyester film shall be Vandal Shield or approved equal. The Vandal Shield shall be installed such that it can be removed and replaced without removing the glass from the window frame or glazing rubber.

Exterior glazing rubber shall be black neoprene rubber.

Individual side windows shall be interchangeable with windows of the same size. The window arrangement shall be approved by NYCT.

3.10.3 Windshields

A one-piece windshield for the right and left side of the No. 1 End of the Cab Car end shall be provided. The windshield laminate shall include a DuPont, Type 307, spall shield, or approved equal, on the interior facing surface. Windshields shall be constructed to meet the requirements of Section 3.10.1.

Windshields shall be retained in an endless elastomeric glazing section or aluminum frame. Windshield installation shall be watertight without the use of any sealants. Windshields shall be designed and installed to minimize external glare as well as reflections from inside the vehicle when the vehicle is operated at night or in the tunnel with the passenger interior lighting illuminated. The Contractor shall demonstrate that these requirements have been met through the use of the mock-up described in Section 17.2.

Windshield designs shall permit the required field of view as specified in Section 6.1.

Windshields shall be easily replaceable from outside the vehicle. Bonded-in-place windshields are not permitted.

The right side windshield shall have a metallic film type heater for demister-defogging purposes. The heater shall be capable of clearing 85 percent of the energized (covered by heating sets on wires) area of the windshield, through which the view is completely obscured by condensation, within 6.0 minutes. The heater shall have this capacity with the car in a normal operating condition that is the entire car (exterior and interior of the cab area) having been soaked for a maximum of eight hours or until the surfaces to be tested reach the equilibrium at 40°F (4°C).

The Cab End Door and the Cab Door are then closed for the duration of the humidification period and demisting period.

A simulated "one person heat load" of a minimum of 75W sensible and 59W latent shall be used to allow fog on 100% of the internal surface of the windshield.
The windshield heater is then energized while the cab heater is turned on and the HVAC system is also turned on (Auto Mode with the air diffuser oriented toward the windshield.

Heated windshield controls are detailed in Section 6.4.5.

### 3.10.4 Cab Side Window

The left and right side windows in the cab shall be a single glazed, counterbalanced, vertical sliding type and shall be constructed to meet the requirements of Section 3.10.1. The counterbalance design shall allow the operator to leave the window open in any position without the use of detents or latches. The opening shall provide sufficient clearance for the 5th percent female to the 95th percent male operator to lean out and observe the side of the train, operate yard switches, or operate route selectors. A stop shall be incorporated into the window frame which allows the window to be opened 16 inches from the top of the window frame. A latch, operable from the inside of the cab only, shall be provided on the window to hold the window closed. The windows shall be closable from the exterior. The windows shall be effectively weatherstripped, reinforced for hard usage, and designed to eliminate rattling.

The sliding portion of the window shall slide into a watertight stainless steel pocket in the car body side wall. The pocket shall be adequately weather stripped and shall contain a minimum of two, ½-inch (13 mm) diameter drain pipes to drain water through the floor to the outside of the car.

The window frame shall be satin finished anodized aluminum. The window latch and corresponding keeper shall be stainless steel. The side window glazing shall be clear, laminated safety glass which meets the requirements of Section 15.8, and Section 3.10.1.

The cab side window design shall be replaceable from the inside. It shall be reviewed and approved by the NYCT during the evaluation of the mock-up as described in Section 17.2.

### 3.10.5 End Door Windows

The end door windows shall be clear, laminated safety glass constructed to meet the requirements of Section 3.10.1 and the requirements of Section 15.8. The vertical dimension of the window shall match the vertical dimension of the end facing windows and the window shall be as wide as practical. The window shall be mounted directly into the door panel with an endless elastomeric glazing section.

Vandal Shield, or an approved equal, shall be provided on the interior facing surface of the end door window.

### 3.10.6 Cab Door Windows

The cab door shall each contain a single glazed, laminated safety glass window constructed to meet the requirements of Section 3.10.1 and the requirements of Section 15.8. The window shall contain a polarized, zero, black louvered, light control film with the louvers oriented vertically. The light control film shall prevent reflections on the cab windshield when the interior lights are illuminated and the car is either in a tunnel or outside at night.
Vandal Shield, or an approved equal, shall be provided on the interior facing surface of the cab door window.
3.11 Interior Linings

3.11.1 General

The interior of the vehicle shall be pleasing in appearance, modular in design, and shall be free of sharp corners or edges to eliminate the possibility of injury to passengers, and operating and maintenance personnel in either normal usage or emergencies. Design emphasis shall be placed on integration of components, maintainability, passenger safety, aesthetics, and cleanability. Surfaces requiring paint are not permitted. All melamine-on-aluminum constructed panels or sheets referenced in this Specification shall be constructed in accordance with the requirements of Section 15.10.6. Wherever "melamine faced plymetal" panels are called for in this section, the metal face of the plymetal panel shall be aluminum, unless otherwise specified as stainless steel, and the melamine shall be laminated to the aluminum or stainless steel in accordance with Section 15.10.6 prior to laminating the aluminum or stainless steel to the plywood core.

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 Section 15.

Interior linings shall be designed to comply with the following stiffness requirements:

- A centrally applied load of 50 pounds (222 N) on a contact area of not more than 4 square inches (2581 square mm) shall not deflect the panel more than 1 percent of the short span length.
- A uniform pressure of 30 pounds per square foot (146.5 kilograms per square meter) shall not deflect the panel more than 1 percent of the short span.
- The panel shall be capable of withstanding 20 foot-pounds (27 joules) of impact energy applied uniformly over an area of 2 square inches (1290 square mm) without permanent deformation or cracking.

3.11.2 Interior Lining Installation

Interior linings shall be applied and mechanically fastened to their supporting surfaces. The mounting shall be designed to accommodate the dynamics of vehicle movement without transmitting stress to the liners. Interior linings shall be designed to have a minimum 1 inch (25 mm) radius cove at intersecting adjacent surfaces to facilitate cleaning.

"Anti-squeak" tape shall be used between linings and any structure to which they are attached or with which they come in contact. Where linings cover 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 1/8-inch (3 mm) over 3.3 feet (1 m) in any direction.

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 will not be allowed, unless specified or approved for a specific application.

3.11.3 Interior Lining Finish

Samples of all colors and patterns used in the interior of the vehicle shall be approved by NYCT.

All exposed stainless steel, except for floor coverings, shall be given a 100-120 grit finish using a belt sander or equal. Grain direction shall be arranged to suit the decorative scheme.

The Contractor shall submit to NYCT at least three different samples of each of the finishes to be applied to interior trim and to interior sheets. The three samples shall demonstrate the range of surface finish of a worn, partially worn, and a new belt.

All melamine surfaces shall have a low-glare finish with a glossometer reading between 4 and 14, per ASTM D 523, machine direction, using a 60° glossometer. All composite surfaces shall have a high-gloss finish with a minimum glossometer reading of 85°, per ASTM D 523, machine direction, using a 60° glossometer with no appreciable orange peel or print-through. Color shall extend all the way through all lining materials except melamine.

3.11.4 Moldings

The use of moldings is to be minimized; 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.

3.11.5 Ceiling

The portion of the ceiling between air distributors shall be constructed of 3/8-inch (10 mm) thick, minimum, integrally colored, melamine-faced panels with an aluminum honeycomb core, or approved equal. Transverse joints shall be spaced no closer than 4 feet (1220 mm).

The sharply-curved portion of the ceiling outboard of the light fixtures and door transoms shall be constructed of integrally colored melamine-faced 0.081-inch (2 mm) minimum thickness aluminum, 1/8-inch (3 mm) thick molded fiberglass reinforced polyester, or approved equal. Alternatively, the curved portion of the ceiling may be formed by extensions of the window masks or door pocket panels. The curved portions of the ceiling shall be designed to retain NYCT standard rectangular advertising cards.

The low ceiling under the overhead HVAC units shall be composed of the minimum number of pieces consistent with the need for access to equipment. Longitudinal joints in this ceiling area are permissible only at light fixtures. Exposed, but inconspicuous, approved quick-acting fasteners shall be used for access. Panels or grilles under the overhead HVAC units, for access to and removal of the apparatus shall be hinged longitudinally and equipped with jacketed safety chains and spring clips. The spring clips shall allow the
access panels to open a minimum of 2 inches (50 mm) before the clips engage the frame of the access opening.
All ceiling panels shall be adequately supported to prevent sagging and drumming. The ceiling panels and air diffusers shall be supported by hangers welded to the roof structure. These hangers shall be located at a spacing no greater than 40 inches (1016 mm).

3.11.6 Side and End Walls

Side linings below the window masks and above the floor heat enclosures shall be melamine faced panels. End linings below the window masks shall be covered with 1/8-inch (3 mm) thick, minimum, integrally colored, unbalanced melamine, FR Grade. The number of joints in the wainscot panels shall be minimized. The joints in the wainscot panel shall be hidden by the seats from view. Edges and corners of linings and panels shall have 3-inch (76.2 mm) minimum radii to facilitate cleaning.

The interior side and end finish above the wainscot panels at all side and end windows including the end windshield shall be constructed of 1/8-inch (3 mm) minimum thickness, fiberglass reinforced composite panels or approved equal. The window masks shall be sloped to eliminate dirt collecting areas. All joints shall be supported and covered with moldings in accordance with Section 3.11.4.

The side linings at the door pockets shall be melamine faced panels with a plymetal, stainless steel honeycomb, or approved equal, core. Consideration will be given to a modular construction of the door pocket, window mask and curved ceiling panel if the Contractor can provide a panel with a surface that is cleanable, and resistant to marking and scratching.

The colors of moldings on all exposed surfaces shall be compatible with the colors of the other materials in the vehicle. Painting of any exposed interior lining surface shall not be acceptable.

3.11.6.1 Heater Grille Panels

Heater grille panels shall be fabricated of stainless steel, perforated in a suitable pattern and rigidly supported. Hole size and shape shall preclude insertion of ballpoint pen-size instruments. The panels shall be secured at all edges with accessible fasteners. Heater access shall determine the panel length and attachment method. The rigidized stainless steel shall be of sufficient thickness to resist denting as a result of kicking impacts. Heater grilles shall also conform to Section 12.3.3.5.

3.11.7 Cab Partition

A Train Operator's position in the cab shall be located at the No. 1 end of the Cab Car. The cab shall be full width and fully enclosed to prevent unauthorized access. The enclosure shall be designed so that the Train Operator's forward view is not obstructed. A door provided with a full-length stainless steel piano-type hinge shall provide access to the cab, as described in Section 3.12.1.4.

The cab partition shall be a panel constructed from a rigid, durable, mar-resistant material such as melamine faced plymetal, or stainless steel honeycomb. A window shall be provided in the partition door to permit a view back into the passenger area.
The partition shall be attached to the car structure, not to wall or ceiling panels. The cab partition shall include electric lockers, if required, and shall complement the appearance of the interior lining of the side walls. The cab partition shall include provision to mount an electric release for the cab door latch and shall include conduit or wireway to route future wiring to the electric release unit.

3.12 Doors

3.12.1 General Requirements

The door panels shall have a design life of 40 years.

The upper portion of each side door panel and end door shall contain a fixed, rectangular glass window as specified in Section 3.10. Window openings shall be blanked out of the inside and outside door skins with the edges formed inward. Window cutouts shall have proper radii for glazing and glazing strips.

Each side door panel shall contain a window installed into a reinforced opening provided in the panel.

Installed doors must be vibration and rattle-free while the train is underway and while doors are opening or closing.

3.12.1.1 Side Doors

Side doors shall be hung on the door operator's rolling carriage assemblies or on appropriate hanger tracks and guides depending on the type of door operator provided. (Reference Section 11.3 for hanger details.)

The side doors on other than their vertical closing edge shall be provided with weatherstripping to effectively keep out noise, weather, car wash, to prevent drafts and permit the car to be pressurized.

Door leading edges shall be faced with deep interlocking (tongue-and-groove) nose rubbers, that serve to detect small rigid objects, while protecting passengers from the impact effects of closing door panels. The durometer of the rubber shall be sufficient to preclude distortion around small objects. While doors shall not pre-load against each other, the door rubber edge interlocking shall, when closed, also effectively prevent water and/or inclement weather encroachment. Edges shall be mounted on stainless steel channels, for easy mounting and removal without need to disconnect the door panels.

Seals shall be configured in hardness and geometry to prevent the door panels from fully closing and locking on an object of the size stated in Section 11.5.

The side doors shall be tested as defined in Section 17.3.3.3.

3.12.1.2 Cab Car End Doors

Each Cab Car shall be equipped with a manually operated hinged door at the No. 1 End of the car to close off the space between the collision posts. The upper portion of each end door shall contain a fixed rectangular
window as specified in Section 3.10. The end door shall be hung on a continuous stainless steel piano hinge having a stainless steel hinge pin. The ends of the hinge shall be closed to preclude the hinge pin from sliding out of the hinge barrel.

The door at the No. 1 End shall be equipped with one wedge-type jam latch and one approved latch with an integral lock which shall sufficiently secure the door to provide a weather tight seal, in accordance with Section 3.12.5, at the head and tail end of a train. The lock and jam latch shall be operable from both sides of the door.

3.12.1.3 Other End Doors MOD 02

Each end of the Non-Cab cars, and the No. 2 end of the Cab cars shall be equipped with a manually operated, lockable, bi-parting, sliding door. The end doors shall be hung on steel ball bearing hangers. The design of the hanger shall be such that the operationally applied side loads or the static vertical loading of the door shall not act to spread the track. Dual hangers, bolted to the door panel, are acceptable.

Doors shall be readily removable. Lightweight hangers are not acceptable. Door hangers shall not require lubrication. Provision shall be made for vertical and transverse adjustment of the hanger.

A concealed, counter-balanced, closing device shall be provided for each sliding door leaf. The device shall exert sufficient force to hold the door leaves against the weatherstripping.

A manually operated door hold-open device shall also be provided for the sliding end door leaves. The device shall be concealed and accessible from inside the car. The holder shall be engaged by manually pushing a spring held lever and shall be disengaged by manually returning the lever to its original position.

The end door design shall include a near full close cushioning feature to prevent injury to an individual's hand caught between the closing door leaf nosing.

3.12.1.4 Cab Doors MOD 05

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A hinged door shall be provided in the cab partition, which shall be capable of swinging both into the passenger compartment, to permit rapid emergency egress from the cab, and into the cab. A stop shall be provided in each direction of door travel to prevent the door from striking other structures or equipment.

It shall be possible to latch and lock the door in a position in line with the cab partition, closing off the entire full-width cab from the passenger area. A latch shall also be furnished to hold the door in the open position. The door latch/lock shall be manufactured from nickel bronze of an approved configuration.
A fixed window shall be provided in the cab door as described in Section 3.10.6. The door shall be equipped with a full-length, stainless steel, piano-type hinge. The door shall automatically latch and lock in the closed position. The door lock shall be unlockable from the passenger side with the NYCT's Standard Car Key. The door latch/lock shall be manufactured from nickel bronze of approved configurations. Each cab door shall be equipped with a quick-release mechanism, operable only from within the cab, to enable the door to be opened without the use of a door key.

The cab door shall be equipped with a perforated grille in the lower portion for ventilation. The door shall be equipped with a 0.035-inch (0.9 mm) minimum thickness, stainless steel wall on the interior side, and should have a reinforcement beam within 8.0 inches (203 mm) from the bottom of the door.

3.12.2 Strength Requirements

The door panel skin, structure and mounting hardware shall sustain a concentrated load of 200 lbs (90.72 kg) applied perpendicularly to the plane of the door at the center of the front edge. The load bearing surface shall not exceed 16 square inches (10,323 square mm) for this requirement. The allowable maximum deflection under these conditions with the door simply supported at the top and bottom shall be limited to 3/8-inch (9.52 mm) maximum with no permanent deformation after the force is removed.

3.12.3 Construction Requirements

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Door panels shall be constructed so that all hardware, windows and glazing frames or strips are within the thickness of the door panel to allow the doors to operate freely without obstruction. Any fasteners used to attach hardware to the door panel shall be countersunk.

All end, cab, and side doors shall be constructed solely of stainless steel and joined into an integral welded unit. The exterior skin shall be welded to the frame. Internal reinforcement of the door panel shall be provided by a stainless steel honeycomb core bonded to the panel skin. All edges and joints shall be thoroughly sealed to prevent the infiltration of moisture. Interior cavities, where it is possible for condensation to form, shall be provided with appropriate drain holes.

The exterior and interior skins of the door panel shall have a finish identical to the adjacent exterior areas, and shall be free of all dimples, warping, welding depressions and other deformities. Stainless steel reinforcements shall be provided internally for the attachment of all door hardware. The reinforcements shall be mechanically attached to retain them when door hardware is being changed.

3.12.4 End Door Locks and Car Keys

MOD 02

CO 237

All end doors shall be secured with satin-finished nickel bronze locks. The locks shall be constructed so as to be draft proof. The locks shall be manually lockable, spring loaded to automatically latch, and be manually unlatchable when not locked.

The car end doors shall be unlockable through use of the NYCT Standard Car Key from the interior and exterior of the car.
NYCT specified car keys shall be utilized to operate all locks and controls on the cars. Two sets of each of the following type key shall be provided with each Cab Car:

- Master Controller Switch Key (Reference Section 6.6.7.1).
- Master Door Controller Key: This key will be used for the Master Door Control panel, overhead access panels for side doors, and access panels for cutout cocks inside the car, the PEHU reset, access panel for the Parking Brake Handle, outside and inside crew key switches, cab electric lockers and low voltage circuit breaker panels, and all other locking functions not explicitly identified herein.
- NYCT Standard Car Key: The standard car key will be used for all end door locks, the side door cutouts at the door posts, and the inter-car barrier storage compartment.
- Allen Head Tool: To open all ceiling panels and to activate TOD maintenance screens.

3.12.5 Weather Sealing Requirements

The door panel(s) and doorways shall be adequately weatherstripped for service speeds up to 60 mph (97 km/h) with the worst case possible combination of climatic conditions as described in Appendix A.

The forward edge of the side door where the panels meet in the closed position shall be sealed by an interlocking elastomeric nosing, preferably of a deeply interlocking tongue and groove configuration. This seal shall be of sufficient stiffness to enable the obstruction detection system specified in Section 11.5 to safely detect the specified obstructions. All elastomeric seals shall be applied in a manner which enables them to be easily replaced with the door panels in place. The back edge of each door shall be weatherstripped to form a seal with the front edge of the pocket when the door is in the closed position. The space between the door pocket and outside surface of the door shall be sealed to protect against stones or weather elements entering the door pockets. There shall be no detectable air drafts within the car at maximum speed. The maximum permissible gap shall be 1/32-inch (0.8 mm) in the weatherstrip to the door surface. The top of the side door panel shall be sealed to prevent weather elements from entering the passenger compartment or door header area. Protective stainless steel plates shall be installed over the interior and exterior side door pocket weather seals.

The end doors shall be equipped with an approved weather seal which shall be applied to all edges (top, bottom for the cab end door, and both sides) of the doors. The weather seal shall prevent air, rain, and noise from entering the car body at the interface of the end door and door frame of a lead car traveling at 60 mph (97 km/h). A secondary weatherseal shall be used at the interface of the bottom door edge to threshold plate if necessary to meet this requirement. The corners of the weatherseal which is applied to all four edges of the door shall be continuous to insure continuity of the seal. Below the threshold there shall be a watertight channel member that shall collect the run-off from the end door and drain it to the outside of the car. Once the door is closed and latched, the weather seal shall not inhibit end door drainage.
3.13 Electric Lockers

3.13.1 General
MOD 02

Electric lockers may be provided in the cab partition, accessible only from the cab area, if required. Locker depth shall be minimized and shall be approved by NYCT.

3.13.2 Construction

The locker panels shall be of the same construction as the cab partition. The lockers shall contain sufficient access doors to allow free access for monitoring and maintenance of the enclosed equipment. The access doors shall be hung on stainless steel, piano hinges and secured with Standard IRT Car Key operated door locks.

3.14 Seats

3.14.1 General

It is NYCT's intent to provide the maximum number of seating positions per car. Mobility impaired accommodations as described in Section 3.14.7 shall be provided. The seating arrangement shall be longitudinal. The seats shall be manufactured in groupings of three and, two and one passenger flip-up, as shown on "MTA-Car Plans", Drawing No. LTK 1-1, within Appendix D. Seats shall be interchangeable with like seats and shall meet the strength requirements of Section 3.14.4.

The minimum seating position width shall be 18.6 inches (472 mm). The seat contour shall be as shown on the Contract Drawings. The seat design shall be finalized during the review of the front end mock-up.

3.14.2 Construction

The seats and backs shall be one-piece, molded, glass fiber reinforced, composite shells meeting the requirements of Sections 15.25 and 15.13. The seat shell shape shall be as illustrated on "MTA-Car Plans", Drawing No. LTK 1-5, within Appendix D. The composite seat shall be reinforced by a structural frame. Seat shell attachment to the frame shall permit easy replacement.

Seats shall be cantilevered mounted to and supported by the car side walls.

3.14.3 Materials

Seat frames shall be of a welded steel painted steel construction. Seat frame tubing shall have the ends plugged where exposed.

3.14.4 Strength

CO 174

The following tests shall be performed in the presence of the NYCT on a sample seat to be selected by the NYCT. The seats shall be completely assembled and fastened to a rigid fixture simulating the car interface.
and attachment. The weight for the drop and swing impact tests shall consist of sand contained snugly in a tightly closed sturdy leather bag.

2 & 3 Passenger Seats:

- A longitudinal force (acting from front of seat to back) of 300 lbs (136 kg) per passenger (total 600 lbs (272 kg) for two passenger seat) with deflections everywhere less than 3/4-inch (19 mm) with no failure of the tubular frame or composite shell. A permanent set of 1/16-inch (1.6 mm) maximum will be permitted under these conditions.

- A downward vertical load applied uniformly along the front edge of each sitting position of 200 lbs (91 kg) [total 1400 lbs (635 kg) for seven passenger seat]. A permanent set of 1/16-inch (1.6 mm) maximum will be permitted under these conditions.

- A vertical drop test shall be applied to the seat with a 40 lbs. (18 kg) weight dropped from heights of 6 inches (152 mm), 8 inches (203 mm), 10 inches (254 mm), and 12 inches (305 mm), 10,000 drops from each height with no failures of the shell or frame.

- A swinging impact test shall be applied with an 40 lb. (18 kg) weight to the seat back from the front of the seat. The test shall include impacts from a distance of 6 inches (152 mm), 8 inches (203 mm), 10 inches (254 mm), and 12 inches (305 mm), 10,000 strokes for each distance with no failures of the shell or frame.

- A scratch resistance test of the glass fiber reinforced composite shell shall be conducted with a “Hoffman Scratch Tester”. An acceptable surface shall require a minimum of 1000 gram load on the tester to cause appreciable scratching.

- For each seat, a vertical downward load of 400 lbs (182 kg) shall be applied once to a 4 x 10 inches (102 x 254 mm) area at the front of the seat and once to an area of the same size in the middle of the set bottom with no failures.

Flip-Up Seat:

- A longitudinal force (acting from front of seat to back) of 300 lbs. (136 kg) with deflections everywhere less than 3/4-inch (19 mm) with no failure of the composite shell. A permanent set of 1/16-inch (1.6 mm) maximum will be permitted under these conditions.

- A vertical drop test shall be applied to seat bottom with a 150 lbs. weight dropped from a height of 9 inches, one time, with no failure of the shell, frame or mechanism. The seat shall return to the UP position.

- A swinging impact test shall be applied with a 40 lb. (18 kg) weight to the seat back from the front of the seat. The test shall include impacts from a distance of 6 inches (152 mm), 8 inches (203 mm), 10 inches (254 mm), and 12 inches (305 mm), 10,000 strokes for each distances with no failures of the shell or frame.
3.14.5 Sample Seat

Prior to placing a quantity order for seats, the Contractor shall furnish to NYCT one complete seat of each type, constructed in accordance with the design provisions specified above. The seat will be used by NYCT for evaluation of the comfort, interchangeability, and aesthetic aspects of the seat.

3.14.6 Flip-Up Seat

Two one-passenger flip-up seats shall be provided in the Cab end of the Cab car. The flip-up seat shall be designed to be similar in shape and contour to the fixed passenger seat. The flip-up seat shall be supported by a pedestal. The area beneath the seat shall be left open for easy cleaning.

The seat bottom assembly shall be a spring-loaded design which folds up to provide access for parking a wheelchair. The spring force shall be designed to eliminate the effect of the seat weight when the seat bottom is dropped to gain access to the seat. The seat shall remain in the up position until the seat is needed.

Flip-up seats shall be designated for priority seating with an ADA-compliant sign located on the side wall above the seat.

3.14.7 Accommodations for People with Disabilities

Accessibility to the vehicles for persons with disabilities, including persons who use wheelchairs shall be provided through the side doors. Two wheelchair parking designated areas shall be provided in the No. 1 End of the Cab Car.

The wheelchair parking designated area shall be placed adjacent to accessible entrance shall have a minimum clear floor area of 30 inches (762 mm) by 48 inches (1220 mm). Parking areas shall have flip-up seats, as described in Section 3.14.6, to accommodate other passengers when a wheelchair or mobility aid is not occupying the area, provided the seats, when stowed, do not obstruct the clear floor space required.

3.15 Stanchions, Grab Rails and Windscreens

3.15.1 Stanchions and Grab Rails

Stanchions and grab rails shall be provided for safe boarding, on-board circulation, and standing assistance as shown on "MTA-Car Plans, Drawing Nos. LTK 1-1, 1-2, and 1-3, within Appendix D. The stanchions and grab rail size and location shall conform to the requirements of the ADA. The final stanchion arrangement shall be determined during the design review process and approved on the Carbuilder's mock-up.

Vertical stanchions shall be located on the inboard edge of each windscreen and attached to the passenger seats. Two vertical stanchions shall also be provided, one in each low ceiling area. The location of these stanchions shall be determined during the design review process and approved on the Carbuilder's mock-up. Longitudinal grab rails, mounted to the ceiling, shall be provided over the seating area and along the longitudinal centerline of the car. The height of the grab rails above the finished floor shall be approved by the NYCT.
The stanchions shall be made of stainless steel, and shall have a cross-sectional diameter between 1.25 and 1.50 inches (32 mm and 38 mm). Stanchion fittings shall be stainless steel with a grit circumferential finish. The grab rails shall be of the same material construction and finish as that of stanchions and shall be designed without the need for any lateral supports. All surfaces shall be smooth and free of sharp edges which might injure passengers. Knuckle clearance shall be 1.50 inches (38 mm) minimum. All fasteners shall be tamper-resistant, stainless steel.

Each vertical stanchion shall withstand, without permanent deformation, a horizontal load of 330 lbs (150 kg) applied in any direction at the midpoint of the stanchion’s free span. Each horizontal and diagonal grab rail shall withstand, without permanent deformation, a distributed load of 10 pounds per inch (1.75 kN/m) applied at any angle within a 45 degree cone from vertical downward.

3.15.2 Windscreens

Windscreens shall be provided adjacent to all side doorways except at the designated wheelchair areas.

The windscren lower panel shall be constructed of 0.500-inch (13 mm) minimum thickness melamine-faced plymetal, having the same color and texture as the other interior linings below the belt lines. The windscreens and horizontal grab rails shall be secured to the vertical stanchion, and interior wall, in an approved manner. The windscreen configuration shall be as depicted on the NYCT mock-up. The final windscreen design shall be determined during the design review process and approved on the Carbuilder's mock-up.

3.16 Interior Accessories

3.16.1 Advertising Card Frames

Each vehicle shall be designed with provisions for mounting of advertising cards 11 inches (280 mm) high on curved ceiling panels above the side. The frames shall be designed to be an integral feature of the curved ceiling panels.

Each vehicle shall be designed with provisions for mounting a minimum of two, 23 x 28 inches (584 x 711 mm), system maps. Locations of the system maps shall be such that they are not obscured by seated passengers. System map frames shall be designed to be an integral feature of the panel on which they are located.

Each vehicle shall be provided with vandal-resistant advertising card frames to hold standard 22 x 21 inches (559 x 533 mm) advertising cards. Advertising card frames shall be provided on eight door pockets in the B car and seven in the A car. Advertising card frames and system map frames shall contain a protective, clear polycarbonate cover secured by an approved NYCT fixation device. All hardware used for access of all frames shall be captive. All frames (system map frame, advertising card frame and art poster frame) shall be hinged on one side as approved by NYCT.

Each vehicle shall be provided with a vandal-resistant advertising/artwork frame, identical in design to that used for the system map, on each side destination sign cover. The frame shall be designed to accommodate an advertising card or artwork of dimension 9 x 44 inches (229 x 1118 mm) paper with a polycarbonate cover.
3.16.2 Convenience Outlet

Convenience outlets shall be provided as described in Section 9.11.

3.16.3 Ventilation Ducts

The necessary ducting and piping shall be as described in Section 12.2.3. The Contractor shall satisfy these requirements when sizing and shaping walls, and ceilings.

3.16.4 Passenger Emergency Intercom

Two passenger emergency intercom stations shall be provided per non-cab car, and three on the Cab Car. The intercom stations shall be located at diagonally opposite sides of the cars on the door pocket panels of the Number L2 and R5 doors. The third intercom for the Cab Car shall be flush mounted in the wheelchair area and shall be located within ADA height requirements.

Reference Section 13.2.1.3 for passenger intercom detail requirements.

3.16.5 Tamperproof Fasteners

All tamperproof fasteners shall be of a single style as approved by the NYCT.

3.17 Graphics

3.17.1 General

All graphics applied to the vehicle interior shall be in accordance with NYCT Specification No. 3061-MATL-87, latest revision, entitled "Interior Rail Self-Adhesive Stickers". Exterior graphics shall be constructed from an approved adhesive backed, Tedlar film, applied and edge sealed, if required, in accordance with the manufacturer's instructions. The location, size, text, color and application shall be approved by NYCT. Text shall be Helvetica medium and in accordance with 49 CFR Part 38.55. All graphics layouts shall be submitted to NYCT for approval. All warning or safety signs shall meet the requirements of ISO 3864 and shall be distinguished by using the word “warning” for personal safety and “caution” for damage to equipment.

3.17.1.1 Exterior Graphics

Graphics shall be provided as follows:

- Car Number Plate - Each car shall be provided with four car number plates located at the same height and near the ends of the outside of the car as shown on NYCT drawing Body Number Plate Details, Dwg. No. 604-5001, within Appendix D. The plates shall be applied to the car as approved by the NYCT.

The plates shall be manufactured from 18 gauge steel, Grade III, ingot iron, or 0.090-inch (2.3 mm) thick fiberglass reinforced composite material. If steel plates are provided the
CAR BODY

Contract No. R34142A NYCT Division A

Finish shall be an acid and alkaline-resistant, smooth, porcelain, vitreous enamel fused to the plates by an approved process and free from cracks, chips, scales, flaws, bubbles, holes, pits and other imperfections.
The numerals shall be white, standard, medium type face, spaced in accordance with the NYCT’s graphic standards, on a black background. The car numbers will be assigned by the NYCT.

Logo type - A logo type design shall be applied to the car exterior in areas to be selected by the NYCT. Logo design shall be furnished by the NYCT.

Truck serial numbers shall be applied to both sides of each truck at the center of the side frame in figures 0.75-inch (19 mm) high, with the bottom on the figures 0.25-inch (6 mm) from the tangent point of the bottom of the member and shall be distinctly stamped into the frame with steel dies. The starting serial number for trucks will be assigned by NYCT.

MTA Ownership Plates: A small cast aluminum ownership plate shall be attached to the body side sill, right side, "A" side, No. 2 end of the car over the center of the bolster; and to each truck at the corner toward the center of the car, left side. The ownership plate shall include the words, "Property of NYCTA" and the serial number as stated below.

Serial numbers shall be stamped on body and truck ownership plates to agree with the body and truck numbers, respectively, given above.

The following items of undercar equipment shall be stenciled. Color as noted with high visibility paint:

- MR in 4-inch letters on both sides of the main reservoir - red.
- S in 4-inch letters on both sides of the supply reservoir - yellow.
- V in 4-inch letters on both sides of the volume reservoir - yellow.

Miscellaneous Signs. Underfloor apparatus shall be marked by means of engraved metal plates, welded or mechanically fastened to the apparatus being identified and with the background and lettering in a contrasting color.

- Each air brake reservoir and all cutout cocks, parking brake isolation valves, switches, fuses and junction boxes shall be as previously stated. The cover of each apparatus box shall list each major item of apparatus contained therein. The application status of the PBIV, BCO and SBCO is to be clearly identified by mechanically fastened labels as follows:

  PBIV – Air On, Air Off
  BCO – Cut In, Cut Out
  SBCO – Cut In, Cut Out

- Warning advice, including the normal maximum voltage of circuits therein, shall be provided on the outside of boxes containing electrical apparatus energized at greater-than-battery potential. Identifying labels with white characters on a black background.
background shall be provided for switches, circuit breakers, terminal strips and indicating lamps.

- The car number shall be clearly displayed on the car roof, as approved by NYCT.
- The exterior graphic decal shall be furnished and installed in accordance with the requirements of the Exterior Decal Specification dated October 7, 1998.

Except as otherwise specified, exterior signs and numbers shall be as approved by the NYCT. Where logotype is applied to Tedlar film, it shall be protected by a final lamination of clear Tedlar film. Edges of film shall be sealed in accordance with supplier recommendations.

### 3.17.1.2 Interior Graphics

**CO 176**

Passenger assistance and general information graphics shall be furnished. Graphics shall be ADA compliant. The following passenger assistance and general information signs shall be applied to the interior of the car; others may be required:

- Decals on certain seats indicating priority for the disabled as directed by the NYCT.
- On the cover of the PEHU, the label shall read:
  
  "Emergency Brake
  Open this cover
  Alarm will sound
  Pull handle down"

arranged horizontally in four rows.

- Door numbers in figures shall be applied at the top of the inside door post nearest the door panel. The door panels shall be numbered starting from the No. 1 end in consecutive order toward the No. 2 end of the car; as R1-2-3-4, etc., L1, 2, 3, 4, etc.
- Car ends shall be numbered "1" and "2". The cab end shall be marked "1" and the non-cab end shall be marked "2". The number 1 end of the car shall be defined by the location of the truck equipped with the parking brake.
- A star shall be placed at an approved location under which is located the brake cutout cock handle. The star shall be black on a clear film.
- A triangle shall be placed at an approved location under which is located a selector cock handle. The triangle shall be black on a clear film.
- On the cab bulkhead and inside the Train Operator’s cab: The car number, which is in agreement with the exterior mounted car number. The contract number shall also be placed inside the Train Operator's cab.
On the switch panel for the converter circuit breaker: "Wait 5 seconds before resetting" with an arrow pointing toward the circuit breaker.

Name plates, trade mark insignias or other identifying markings will not be permitted on any equipment inside the car, which is visible to the public, except that an NYCT-approved builder’s plate may be furnished by the Contractor and attached to the inside of the car in an approved location. These plates shall remain unpainted and have a finish to match other interior hardware.

### 3.18 Information Signs

The Contractor shall furnish an information sign system. The system shall consist of side destination signs viewed from the outside, interior information signs, interior electronic strip maps, and end route signs.

#### 3.18.1 Side Destination Signs

Two side destination signs, viewed from the exterior, shall be furnished per car. They shall be located in the car interior, one per side, generally in the center of the car side wall, against the split-vent portion of the side window. The sign display shall not be obscured by the frame of the split-vent.

A cover shall be provided over the destination sign which shall hide the sign from passenger view. The cover shall be manufactured from the same material as the side lining surrounding the window. The cover shall contain an advertising card frame as specified in section 3.16.1.

Detailed sign requirements are in Section 13.5.2.

#### 3.18.2 Interior Information Signs

Two information display signs shall be furnished per car. They shall be located in the low ceiling panel at each end of the car, mounted transverse to the car centerline. The sign shall not reflect off the car ceiling and detract from the ability to read the message.

Detailed display requirements are in Section 13.5.3.

#### 3.18.3 End Route Sign

One end route sign shall be furnished per No. 1 End of each Cab Car. It shall be located on the interior of the car's front end, above the end door, and shall be readable from the outside of the car. The sign shall be easily accessible from inside the car.

Detailed sign requirements are in Section 13.5.5.

#### 3.18.4 Electronic Strip Maps

Two electronic strip maps and two paper route maps shall be furnished per car. They shall be located in the advertisement card area between the side passenger doors.
Detailed map requirements are in Section 13.5.4.

3.18.5  *Intentionally Blank*

3.19  **Equipment Boxes**

3.19.1  **General Requirements**

**MOD 05**

**CO 239**

All equipment enclosures, unless specifically stated otherwise within this Specification, shall be mounted underfloor. Installation of equipment under passenger seats is strictly prohibited.

Exterior equipment enclosures, except the battery box, shall be constructed of stainless steel, LAHT, mild carbon steel or, where approved, fiberglass reinforced plastic (FRP). Enclosures constructed of steel shall have continuous welds or approved spot welds along all seams. The battery box shall comply with the requirements of this Section and the special design requirements in Section 9.9.3.

Materials used in exterior equipment box assemblies and the workmanship involved in the assembly and finish of exterior equipment boxes shall conform to the applicable requirements of Section 15. When FRP or other potentially combustible materials are proposed and approved, they shall conform to the flammability and smoke emission requirements defined in Section 15.25. Flame-retardant additives shall not in any way detract from the strength of, or contribute to the brittleness of the boxes.

Undercar equipment with a direct line of sight to a wheel for any possible truck orientation shall be protected from water splash, flying rock ballast, or other objects thrown by the wheel. If separately-mounted, solid-metal shields are used to provide such protection, they shall not hinder the flow of heated air from the underfloor to a degree which might allow overheating of wiring or apparatus.

Exterior mounted equipment enclosures shall be hung in accordance with the requirement in Section 3.5.1.5. The enclosures shall contain drain holes fitted with cotter keys or other approved, simple drain clearing mechanisms for discharge of condensation and leakage due to damaged or deteriorated seals.

All equipment, equipment enclosures and its contents shall conform to the structural requirements of Section 3.

Equipment shall be arranged for the maximum ventilation of parts. Equipment enclosures that are provided with air from the forced air ventilation system shall be equipped with a manometer test fitting in an accessible location on the box to allow for easy measurement of box pressurization.

All underfloor and roof equipment shall be arranged to allow ready access from the side of the Unit, from the maintenance pits or scaffolding, and when the Unit is on lifts. Labels and warning indicators shall be applied as required by Section 3.17.

Equipment installed in boxes shall not be attached directly to the box by bolts or other fasteners through the enclosure walls, top or bottom sheets, unless otherwise approved. They shall be attached to standoffs or subplates which are in turn welded to the box. In addition, sufficient clearance (1/2-inch [12.7-mm] minimum)
shall be provided between the exposed sides and covers of the equipment enclosure and the internal equipment to protect the internal equipment from damage due to minor impacts.

All underfloor enclosures, with the exception of the battery box, shall be grounded to the car body, as specified in Section 9.4.
3.19.2 Hardware Requirements

All hardware, including hinges, used to secure access covers or access plates on equipment enclosures shall be made of stainless steel. All mounting hardware for access covers shall have captive nuts or bolts.

3.19.3 Access Cover and Maintenance Access Requirements

MOD 02

Equipment box access covers shall not be removable. They shall be constructed of stainless steel, LAHT, or mild carbon steel. Interior surfaces of covers shall be coated with an arc-protecting, high-dielectric powder coating. FRP covers where approved for use, shall meet all requirements in Section 15.13.

All access covers shall be provided with quick-release, spring-loaded, stainless steel, or approved equal, latches which operate with a toggling-type action. The latches and latch catches shall be arranged so that they do not protrude beyond the bottom of the box or cover in the latched position, except as approved. The latches shall not violate the Unit dynamic clearance outline if not engaged.

The latches shall be adjustable to compensate for seal relaxation considering the worst case condition of hard contact between the cover and box, except as approved. In this extreme case, the latch adjustment must be sufficient to hold the cover firmly to the box without rattling. The latch and all its components shall be fabricated from stainless steel. Prior to delivery, cover latches shall be adjusted to compress the cover seals no more than 50 percent of the compressible height of the seal and watertightness tested. The latches shall not have separable or non-retained parts.

A spring-loaded safety catch shall be provided at the center of each underfloor box cover. The safety catch shall be designed to retain the cover within the Unit dynamic clearance envelope at all operating speeds without the cover latches engaged.

Underfloor equipment enclosures shall be provided with top-hinged access covers on the outboard side and, if required, the inboard side. Outboard covers shall swing open a minimum of 90° for quick examination of the interior without removing the covers. Inboard covers shall swing open to the maximum extent possible, but in no case less than 60°.

Openings provided upon opening of covers shall be of sufficient size to permit removal and replacement of any component in the box and easy access to equipment in the box for inspection and maintenance.

All outward facing covers shall have an internal "hold open" feature unless otherwise approved. The "hold open" feature shall in no way interfere with or impede the easy opening of the cover, nor shall the "hold open" mechanism present the possibility of shorting or grounding internal electrical parts when the cover is opened or closed.

The covers shall be arranged so that only one person is required to easily open, close, and latch any cover, regardless of size. Adequate clearances for all handholds, latches, and other appurtenances, shall be provided so that a person wearing gloves is not hindered.
3.19.4 Environmental Sealing

Environmental sealing shall be equivalent to a NEMA Standard No. 250, Type 4 enclosure. Seals shall be of a material that will insure watertightness and remain resilient for a period of at least 10 years, with proper maintenance.

Only one common type of hollow, closed-cell foam tube or similar design shall be used for all cover seals. The seals shall have a minimum free compression range (hollow tube inside diameter) of 3/8 inch (9.5 mm). Flat foam strips or glue-on attachments will not be permitted. The design shall allow for ease of seal replacement.

3.19.5 Electrical Interface

The arrangement for conduit, cable, wire routing, connections to equipment enclosures, and equipment contained in enclosures shall be configured so that structural, electrical and environmental integrity is maintained, and so that the removal and replacement of the equipment enclosure is facilitated. Each arrangement employed shall be approved.

All control and power cable terminations shall be made internal to the enclosures or in waterproof, gasketed junction boxes meeting NEMA 4-type requirements or using connectors as specified in Section 15.CAPut!'.6. Cable entry shall be by means of watertight sealing glands. Glands and cable terminations shall provide for cable replacement without removal of lugs, terminals, or connectors from the wires.

Conduit shall be connected to underfloor equipment groups using watertight connectors as specified in Section 15.21. The entrance of conduit or cables in the top and bottom of equipment boxes will not be permitted.

3.19.6 Interior Equipment Enclosures

All electric or electronic equipment located inside the cars, where approved by NYCT, shall be mounted in approved, dust-proof, equipment enclosures. Enclosures shall be consistent with interior construction methods and materials. All interior enclosures shall be readily accessible.

3.20 Exterior Accessories

3.20.1 Windshield Wiper

Windshield wipers shall be provided for the Cab Car, cab end right side windshield. At least 80 percent of the width and 60 percent of the height of the total windshield area shall be swept. The windshield wipers shall be functional at all car speeds.
The drive units shall provide two speeds of synchronized operation and the wiper blades shall return to a PARK position at extreme ends of their sweep in the OFF position. The PARK position shall be at the left edge of the windshield. There shall also be a fixed intermittent, five-second delayed mode of operation. Drive units shall be electrically operated and drive motor shall be rated to sustain stalled conditions. Wiper operating mechanisms and drive units shall be accessible for repair and replacement from inside the cab. The operating mechanisms shall be enclosed. The wipers shall be mounted at the top of the windshield glass. The wiper control switch shall be located on the cab console. Switch positions shall be OFF, INTERMITTENT, LOW, and HIGH.
3.20.2 Windshield Washer
MOD 05

A windshield washer shall be supplied for each operator’s end windshield. The spray head shall uniformly distribute the fluid over the windshield and shall be mounted on the car body. Translucent reservoirs with 2-gallon (7.6 L) capacity, minimum, shall be provided. The reservoirs shall be located so as to permit filling from inside the cab. The reservoir fill tube shall be located behind a latched access panel and shall be configured to prevent any fluid from contacting any equipment in the area. The reservoir access cover shall be gasketed to prevent leaks into the vehicle.

3.20.3 Horn

A pneumatic horn shall be mounted underfloor at the cab end of each Cab Car. Reference Section 10.3.3.5 for details.

3.20.4 Rain Gutters
MOD 05

Rain gutters shall be continuous and shall be located above the doors, cab windows, passenger windows and destination signs at the roof. Drain slots shall be utilized in the rain gutters only in the area of the side passenger windows. The rain gutters may be separately formed and attached, or may be integral with the roof structure.

3.20.5 Between Car Safety Chains and Barriers

3.20.5.1 General
CO 237

Removable safety chains shall be provided at the ends of all cars. ADA-compliant inter-car barriers shall be provided at the outer ends of all cars. The safety chains and barriers shall be so designed to permit coupled cars to negotiate the most extreme conditions of vertical and horizontal curvature (reference Appendix A).

3.20.5.2 Safety Chains
CO 03

Removable safety chains, as approved by the NYCT, shall be provided at the end of each car which shall effectively enclose the sides of the passageway between cars. The safety chains shall be secured to the end of the coupled car and shall be designed to withstand all conditions of curvature, turnouts, and crossovers encountered in normal passenger operation.

Three safety chains shall be provided, attached to one end door post at the end of each car. The chains shall be connected with a center vertical rod and shall have a sufficient length to extend from car to car and to be easily unhooked while the cars are standing on a minimum radius curve (see Appendix A).

The fixed ends of the chains shall be permanently attached to the end door post and the free ends of the chains shall be fitted to a steel rod. The steel rod shall be arranged to insert into sockets, permanently
attached on the adjacent car to form the sides of the passageway between cars. At each end of a train, the rod is to be inserted in the sockets on the facing collision post to block the end walkway.

A socket shall also be provided adjacent to the fixed ends of the chains to allow for insertion and storage of the steel rod when walkway blockage is not desired.

3.20.5.3 Between Car Barriers

The outer ends of all cars shall be equipped with an ADA-compliant barrier on both sides to prevent passengers from inadvertently walking off the platform and falling between the cars, and to discourage intentional end car access.

The end barrier assembly between cars shall be the NYCT standard "bologna spring" arrangement. When cab cars are uncoupled, the end barrier device of one cab car shall be returned to a stored and secured position within an approved enclosure on the No. 1 end. The storage method shall prevent the barrier device from contacting the No. 1 end during normal car movement. The securement points of the barrier devices shall be reinforced.

3.21 Safety Appliances

3.21.1 Climbing Steps

Stainless steel, 2-step climbing steps with an anti-slip tread, having a minimum flat of 10 inches (254 mm) wide shall be provided at each end of the car to enable entry to the car through the end doors from the roadbed. The steps shall have a 8-inch (203 mm) clear depth and height and shall support the load of a 300 lbs (136 kg) crew member with a safety factor of 1.5 against yield. The steps shall be within the clearances specified in Appendix A.

3.21.2 Grab Handles

Three stainless steel grab handles shall be fastened to the outer face of each end of each car. The grab handles shall be designed so as to not detract from the cosmetic appeal of the ends of the car. The grab handles shall be within the specified clearances.

Grab handles shall be a minimum of 0.625 inches (16 mm) in diameter. A minimum clearance of 2 inches (51 mm) shall be provided between each grab handle and any part of the car body, including doors and latch handles.

3.22 Automatic Vehicle Identification System

The NYCT, through separate contract, is procuring an Automatic Vehicle Identification System (AVI). This system will include "Tags" to be mounted to the R142A cars. The Contractor shall provide a surface to which the "Tag", a self-contained device anticipated to be approximately 5 inches x 10 inches x 3 inches (127 mm x 254 mm x 76.2 mm) may be attached. The designated surface shall be located underfloor in approximately the middle of each car.
# SECTION 4

## TRUCKS AND SUSPENSION

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SECTION 4

4.0 TRUCKS AND SUSPENSION

4.1 General

The design shall provide the NYCT with a truck that is lighter in weight, requires less maintenance and is more reliable than the present trucks operated by the NYCT. Improved ride quality, low noise and vibration generation, reduced wheel flange and rail wear and good rail adhesion are also important features sought by the NYCT. The truck design shall be free of sliding metal-to-metal surfaces and shall not have lost motion or free play in any area.

Truck frames shall be designed to maintain stresses within the endurance limits for the specified operational environment over the 40-year design life of the car. The design life goal for elastomeric components shall be no less than 7 years.

4.1.1 Configuration

The trucks and suspension subsystem shall be formed by all truck components from the rail up to the body bolster, including any suspension subsystem components rigidly mounted to the car body. It does not include gears, motors, wiring, brake system or current collectors. Any mechanical interface requiring welding or drilling on the truck shall also be considered part of the truck. The Contractor shall ensure that all truck-mounted equipment can be accommodated without physical interference. On each motor truck shall be mounted two traction motors, reduction gears and third rail power collectors. On each trailer truck shall be mounted third rail power collectors.

Each truck shall be equipped with an air spring secondary suspension. The truck frame and bolster shall be an outboard bearing design of fabricated steel. Fabricated truck elements shall be heat treated if required by the supplier of the material, for stress relief or strength attainment. Cast components of the truck frame and bolster assembly may be considered for use on a case-by-case basis with prior NYCT approval. Longitudinal forces from traction and braking, between truck bolster and truck frame shall be transmitted through long life elastomeric elements. The truck wheel base shall comply with Section 2.2.4. Clamps for piping, cables, etc. shall be attached to tapping plates or raised bosses.

4.1.2 Interchangeability

Trucks shall be interchangeable between ends of the cars, with no modifications to the truck except for installation and removal of parking brake rigging and leveling valves, and accounting for the different equipment between motor and trailer trucks. No welding, drilling, tapping, riveting, or cutting shall be necessary for conversion from a non-parking brake truck to a parking brake truck or from a trailer truck to a motor truck. Any parking brake or leveling valve to be installed or removed from a truck shall be attached with bolted connections.

Trailer trucks shall be identical to the motor trucks but shall not include traction motors, or reduction gears and may use a primary suspension of modified stiffness. Truck frames, bolsters, wheels, axles, bearings, gear units, and motor assemblies shall be interchangeable.
4.1.3 Truck Weight

Reduction of truck weight is desirable to achieve an optimum life cycle cost. The truck manufacturer shall coordinate the design with the car manufacturer in order to achieve a completely equipped, motor truck weight of less than 15,250 lbs. (6932 kg). The complete motor truck includes the gears, motors, wiring, brake system components, current collectors in addition to the truck components from the rail up to the body bolster, the parking brake and the leveling valves with their component.

4.1.4 Truck Stress Analysis

4.1.4.1 General

The Contractor shall submit a stress analysis of the truck, including the truck bolster. The analysis shall be submitted not later than 60 calendar days prior to commencing manufacture of any truck assembly structural parts. The stress analysis shall be used to design the truck structure to obtain the lightest-weight truck possible meeting the requirements of this Specification. Structural tests shall be performed in accordance with Section 17.3.3.12 to confirm the adequacy of the design and the accuracy of the analysis.

The stress analysis shall show the calculated stresses, allowable stresses, and margins of safety for all elements for all specified loading conditions. The stress analysis shall include calculations of stresses in all joints, joint elements, and other important elements.

The approved stress analysis shall be a prerequisite for approval of the static and dynamic truck test procedures required by this Specification, and shall be used as an aid in determining strain gauge locations for use during the tests.

During the design and manufacture of the truck, stress analysis shall be updated to reflect the as-built configuration. The initial stress analysis will require temporary assumptions as to configuration and weights; also manufacturing and other considerations may require design changes. As these changes are made, the stress analysis shall be revised and submitted for review. The final submitted and approved stress analysis shall be for the truck in the as-built configuration.

Critical connections which cannot be adequately analyzed shall be prototyped and tested to demonstrate compliance with the requirements of the design and the Specification.

For any portion of the proposed design which is based on a service-proven truck, the Contractor may provide data from previous tests, historical data from operations, or stress analyses as required to satisfy the corresponding portion of these requirements.

4.1.4.2 Stress Analysis Definitions

Refer to Section 3.4.3.2.
4.1.4.3 Truck Stress Analysis Report

A stress analysis report shall be prepared and submitted for review and approval. This report shall show that the structure satisfies the requirements of this Specification and good practice in the rail transit industry. The report shall be presented in sufficient detail and organized so that the NYCT reviewer can readily follow the theory and its application to this truck.

The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted to NYCT.

If a cited reference is not readily available to NYCT, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages which show the cited formula or data, the pages which show the development and interpretation of the formula or data must be included.

All references shall be in English. If an English reference cannot be found, an English translation shall be provided. Both the original and the translation shall be included in the report.

All stress analysis sheets shall be signed and dated by the author and checked by a second stress analyst who shall also sign and date each sheet checked.

The stress analysis report shall include, at a minimum:

- Table of Contents.
- Wherever a formula or equation is used, it must first be stated algebraically with all terms defined and the values of these terms with units stated, before calculations are performed.
- All quantities wherever given must have their units given with them.
- References for all formulas, calculation procedures, material strengths, fatigue strengths, and other physical and mechanical properties must be cited where these items appear in the stress analysis.
- Each page numbered, dated, and initialed by the analyst and checker. In the event of an revision, the revision letter shall be included with revision date and initial of the analyst and checker.
- The truck structural drawings.
- Diagrams displaying, for each load case, loads applied externally to the truck assembly and points of support.
- An analysis showing compliance with each design and test load and condition.
Detailed calculations of stresses with Margins of Safety (MS) in all structures with a summary of the results. Locations where the MS is less than 0.20 shall be shown in a table along with the design or operating conditions (loads) which cause the stresses.

A tabulation, or diagram, of calculated deflections of the truck assembly under full loading specified in Section 4.1.5.

Analysis of all critical and highly loaded connections.

An analysis of the strength of the truck frame-to-truck bolster, and truck bolster-to-car body bolster connections, including calculated vertical and horizontal connection capacities.

A tabulation of the Contractor's selection of allowable fatigue stresses, with sources, and assumed applied fatigue stress ranges for structural members which are critical in fatigue.

A table showing the engineering properties of each grade and temper of each material used in the truck structure. This table shall include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension, and compression and shear elastic moduli. 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 truck assembly construction shall not be included in the tables.

Table(s) showing the minimum static and fatigue strengths of all welds. Values shall be given for each material, temper, weld size, and thickness combination used in the truck assembly. The source of the data shall be provided.

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.

4.1.4.4 Finite Element Analysis (FEA)

The stress analysis shall include a linear-static finite element analysis (FEA) of the complete truck assembly. The FEA shall be a recognized computer program such as NASTRAN, ANSYS, Algor, or approved equal.

The Contractor shall submit and receive approval of the finite element model prior to performing the analysis. The initial model report shall be submitted not later than five months after NTP. The element grid, all assumptions, and a complete printed copy of the input file which includes input data, such as loads, boundary conditions, area properties and material properties, shall be included as part of this preliminary submittal and again as part of the complete analysis. Boundary reaction forces due to a gravity loading shall be included in the report.
Wherever required to be submitted, the 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 NYCT, FE models and results shall be reviewed during live interactive sessions three weeks after each submittal. At these sessions, NYCT shall have full access to the FE model input, output and software on the computer used for the analysis.

Color plots shall be prepared showing the following:

- Deflections in all three axes.
- von Mises, or other approved combination stresses.
- Maximum and minimum principal stresses.
- Direction of maximum and minimum principal stresses.
- Strain-energy density, if available.
- Meshing accuracy index.

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 truck assembly (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 FEA input and output data shall also be submitted on electronic media as approved by the NYCT. Submittal of the input file is required with the model, and at any time the file is changed, but not more often than monthly. Criteria for final approval of the stress analysis shall include the Contractor's submittal of the fully configured input data files as required by this paragraph.

Upon completion of the final design, the FE model and analysis report shall be updated to represent the final configuration of the structure.

4.1.4.5 Comparison with Test Results

The stress results from the truck static load test required by Section 17.3.3.12.1 shall be compared with the corresponding stress analysis results. This information shall be tabulated and submitted with the truck structural test report.

The tables shall compare stresses calculated from the test strain gauge readings with analytical stresses from the FEA. Comparison shall be made for the highest-reading strain gauges, which shall not be less than half of the total number of strain gauges used during the test. The tables shall include the test stress value, the analytical stress value, the percent difference between the two values, and a space for annotation.

The percent difference between the two values shall be within the following specified tolerance: for 75 percent of the compared values, test and analytical results shall agree within 15 percent.
If the analysis results do not agree with the test results within the above-specified tolerance, the builder shall revise the stress analyses, update the FE model, and re-run all FE analyses. This process shall be repeated until agreement of results is within the specified tolerance. All manual analyses using data from the FEA shall be recalculated using the corrected values. The stress analysis report shall be revised and re-submitted. All results from re-analysis shall meet specification requirements, and, if they do not, the design shall be corrected.

For any of the remaining 25 percent of the compared values where the analytical values disagree with the test value by more than 30 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 truck test report. This explanation may include supporting manual calculations.

Approval of the truck test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.

### 4.1.5 Truck Design Load Requirements

The Contractor is responsible for selecting truck design loads and design stresses. The truck design loads shall be selected to meet the truck test requirements of Section 17.3.3.12. Design loads and stresses shall be submitted to NYCT for approval.

The truck shall be capable of withstanding the maximum load imposed by the forces acting on the frame, including forces resulting from track shocks, motor torques, friction brakes, and any combination of these forces without developing stresses which are greater than the allowable stress.

Design allowable stresses shall not exceed 50 percent of the yield strength of the material and 60 percent of the endurance limit (either or both) for the specified materials. The fatigue allowables shall not exceed the requirements of AWS D1.1 for non-redundant structures.

### 4.2 Ride Quality

#### 4.2.1 General

The truck shall be supportive of the car ride quality requirements of Section 2.7.8.

#### 4.2.2 Truck Vibration

The truck shall be free of oscillations at all operating speeds with new or worn wheel profiles.

NYCT will provide the Contractor with the approved reports of previous tests, and the criteria used in these tests shall be met or exceeded.
4.2.3 Wayside Vibration

To minimize low frequency ground-borne vibration and noise, unsprung weight should be minimized and truck frame on axle-wheel assembly resonance frequency shall not exceed the value in Section 4.5.1.

The trucks shall not produce any greater amplitudes of low frequency range ground-borne vibration than the previously purchased R110A cars or expose persons near the right-of-way to a vibration spectrum which compares unfavorably to the previously purchased R110A cars under identical test conditions. Data relative to the R110A cars will be available to the Contractor.

4.3 Truck Assembly

4.3.1 Performance

Since the design of the truck is used as a trailer truck, it shall accommodate a mismatch of two wheel sets up to 3/4 inches (19 mm) diameter.

4.3.1.1 Lifting Provisions

The truck shall also be provided with 4 built-in lifting eyes located at the far ends of the truck frame and capable of supporting the entire truck weight. The lifting eyes shall have an internal diameter of at least 1.5 inches (38 mm). The truck shall be capable of being "lifted" with standard lift chains in use on the NYCT, and shall be capable of being wheel-trued with use of standard tie-downs in use on the NYCT.

Each truck side frame shall be fitted with two diamond pattern or similar slip-resistant jacking surfaces approximately 6 inches (152 mm) long by 4 inches (102 mm) wide to support the truck with wheels clear of the rails. Alternatively, jacking pads may be located beneath the axle boxes.

The truck frame shall be provided with interface pads to accommodate the progressor used in wheel truing.

4.3.1.2 Service Conditions

The truck shall meet the requirements under the track and operating conditions specified in Section 2 and Appendix A. Assume the annual mileage will have an average of two station stops per mile.

4.3.1.3 Motion Restriction

- Motion - The suspension subsystem shall not permit car body motion to exceed, under all conditions, the dynamic outline referenced in Section 2.1.3.

- Clearance - All truck parts, except wheels, power collector shoes, trip cocks, and axle-mounted equipment, shall clear the plane of the top of the rails by not less than 2.5 inches (64 mm) under all conditions referenced in the final sentence of Section 2.1.3.
Maximum wear is that condition in which a piece of equipment can be retained in service but beyond which it must be removed from service.

The Contractor shall provide for the clearances between the trucks and the car body and all its parts under all operating and loading conditions, including wheel and other wear. Clearances shall be provided for operation, body-truck cabling and piping, inspection, maintenance and repair.

The completely assembled truck with motors and other equipment shall not exceed the clearance limits required between truck parts with maximum wear and load, primary or secondary suspension deflection and/or rubber creep, in accordance with the track requirements of Appendix A.

4.3.1.4 Car Body Height Adjustment

Provisions shall be made for vertical adjustment to compensate for wheel wear to maintain the top-of-rail to floor height within the vertical tolerance. A minimum of four 3/8" steps for wheel wear adjustment shall be furnished. The design shall be subject to approval and shall permit adjustment with standard maintenance equipment and shall not impair the operation of the truck. Such adjustment shall not affect the leveling valve calibration and shall not be accomplished with loose shims. Wheel wear shall not be compensated at the primary suspension.

4.3.2 Testing

The testing required for the truck is specified in Section 17.3.3.12. The Contractor shall provide all testing instruments, materials and labor necessary to perform the testing. The cost of all such testing shall be borne by the Contractor.

4.3.3 Construction

4.3.3.1 General

Where pockets or partially enclosed spaces exist, provision for adequate drainage shall be assured. Moving contact surfaces shall be permitted. Low friction elements shall not require lubrication. The frame shall be provided with attachments for the application of brake system parts, motors, gear units, primary and secondary suspension elements, and dampers. All drilled or tapped holes in any part of the truck structure shall have deburred edges. Any drilled or tapped holes shall occur in an area of increased thickness for lower stress. Sharp edges on machined surfaces shall be deburred. The Contractor shall provide a working procedure for the attachment of accelerometers for truck testing. Frame attachments for accelerometers shall be provided as necessary according to the attachment procedure.

Truck parts adjacent to or above current-collector devices and uninsulated power connections shall be shielded against arc damage by dielectric, non-combustible barriers and protective shielding of adequate mechanical strength. All threaded fasteners shall be SAE Grade 5 minimum, but threaded fasteners connecting parts essential to operating safety shall be Grade 8. All nuts and cap screws shall be retained by locking devices as specified in Section 15.2.2.2.
4.3.3.2 Materials

Truck frames and bolsters shall be fabricated welded steel.

The trucks shall be free from sharp corners, sharp edges or burrs which may cause injury to maintenance personnel. All machined, ferrous surfaces shall be free from surface defects and shall be coated with a strippable rust preventive paint.

All truck surfaces, except those listed in Section 15.24.5, shall be painted as specified in Section 15.24.10.

Straightening of truck fabrications by cold-pressing is not permissible unless subsequently stress-relieved or unless the fatigue test sample has been cold pressed in the same manner to the maximum limit subsequent to stress-relief and before the fatigue test.

4.3.3.3 Inspection

Inspections shall be as specified in Section 18.1.2.

4.3.3.4 Welding

All welding on the truck including application of brackets, pads and other attachments shall be entirely completed prior to stress relieving. Drilling, tapping and machining of finished surfaces shall be accomplished only after stress relief.

4.3.4 Truck Frame and Bolster

4.3.4.1 General Requirements

MOD 02

Truck frames and bolsters shall be of a service-proven outboard bearing design fabricated by welding. Small cast parts may be permitted as approved by NYCT. Materials shall be according to Section 15.4. All welding shall be in accordance with welding and brazing requirements specified in Section 15.23. Steel plate welds shall be inspected to AWS D1.1, Section IX requirements. Inspection non-destructive sampling provisions of Section 15.23 shall be applied to plate steel weldments.

Pedestal tie bars, if used, shall be attached to the truck frame pedestals in a manner which provides a positive, metal-in-bearing path for loads which may be taken through the tie bars. A pedestal tie bar attachment design which depends solely on clamping friction to transmit loads between it and the pedestals shall not be acceptable.

There shall be no sliding surfaces involved in the method of retaining the journal bearings in their proper positions. The design of the truck shall allow compensation for normal creep or settlement of the primary suspension springs.

Where pockets or partially enclosed spaces exist, adequate drainage shall be provided so that no moisture collects anywhere within the frame and bolster.
TRUCKS AND SUSPENSION

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If any part of the truck structure is required to function as an air reservoir, that part of the structure shall be designed and tested to 1½ times the maximum main reservoir pressure. Stresses associated with the pressure-vessel function shall be combined with service stresses for calculations and testing. If separate pressure vessels, external to the truck structure, are used for air suspension system reservoirs, they shall meet the requirements of Section 15.16.

Threaded fasteners, adjustment points, and structurally-critical locations shall be accessible for inspection and work using conventional means and tools.

4.3.4.2 Car Body Connections

- Configurations - Positive mechanical connections shall be provided between the car body and trucks, such that the trucks shall be raised with the car body, without causing any part of the suspension system to disengage or be displaced. This feature shall provide protection against inadvertent vertical separation of truck and car body. The connection shall be readily separable with ordinary hand tools.

The truck shall be capable of rotating about a vertical axis with respect to the car body and shall operate freely over all curves and turnouts specified in Appendix A.

Truck rotational stops shall be provided.

Positive stops shall be provided on the car body and truck bolsters to limit the vertical and transverse movement of suspended trucks.

- Strength - The strength of the connection shall provide a factor of safety of not less than two times the yield strength of the material when lifting a fully assembled truck. These connections shall be designed and located in a manner which shall minimize car body damage during derailments. See also Section 3.4.4.13.

Truck lifting hooks and/or other members used to attach the truck to the car body shall be capable of resisting a vertical load of 50,000 lbs. (222.4 kN) without permanent deformation. The lifting hooks and/or members used to attach the truck to the car body shall be designed and located in a manner which shall minimize the possibility of damage during derailments. The ultimate strength of the truck-to-car body connection shall be sufficient to secure the entire truck to the car body under conditions in which a horizontal load of 150,000 lbs. (667.2 kN) is applied in any direction at any point on the truck, without separation of the truck and car body. The ability of the truck-to-car body connection to sustain this load shall be independent of the presence of vertical load. The horizontal load may be transmitted from the truck to the car body through structural members, positive stops, or other rigid, mechanical safety devices. Bolster anchor rods shall not be used to provide any portion of this strength.

The truck center plate design, if utilized, and each side bearing shall each be capable of carrying the maximum car to truck loads.
4.3.4.3 Components

All shock-susceptible components shall be suitably shock mounted. Safety support members shall be provided for emergency support of major components, including traction motors and gear units, so that they shall remain clear of the track in the event of primary mount failure. Safety support members shall not support any weight until a failure has occurred. Equipment mounting bolts shall be as specified in Section 15.2.2.

4.3.5 Maintenance Access

The truck shall provide unobstructed access to all parts which require periodic inspection, lubrication, and/or removal and replacement without requiring removal of any other apparatus or detrucking of the car. Detrucking is permitted for replacement of traction motors, gear units, air bags, wheels, axles, primary suspension and wheel bearings. All other items requiring detrucking shall require NYCT approval. Inspection covers on equipment, when removed, shall provide visibility of all apparatus requiring lubrication and fittings on the truck shall be readily accessible for servicing either from a pit or from carside.

Trucks are removed after suitable release of the locking device by jacking the end of the car until the engaging members clear the truck. The truck is then rolled out and in this condition must clear the car body including coupler draft gear. Neither the truck being removed nor the truck remaining shall suffer any distress or damage during this operation.

All major bolted, threaded, keyed or pinned connections shall be readily accessible for visual inspection. Threaded fasteners shall be standard, readily accessible without removal of truck components or the truck from the car, and located to permit removal by standard hand tools. The motors shall have suitable truck clearances to permit each motor to be removed from above the car truck without interference with members of the truck frame.

4.3.6 Wiring

All cables and conduits shall be supported on each truck in an accepted manner. Wiring supports shall withstand the expected levels of vibration without failure.

Truck ground connections shall be as specified in Section 9.4. The axle ground ring assembly shall be as specified in Section 10.2.11 and 9.4.4.

4.3.7 Piping

The air piping on the truck for the brakes, trip cocks and secondary air bag suspension shall conform to the following:

- Air lines shall be black iron per ASTM A53, Schedule 80, or approved equal.
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Piping shall be clamped to prevent vibrating, rubbing, and chafing. Clamps shall be installed to prevent noise generation. Insulation shall be provided to protect piping in close proximity to electrical installations.

Hoses shall conform to the latest revision of NYCT Specification 2086-PROD-96 and except as that requires otherwise, to AAR Specification M-618 with AAR-approved reusable fittings, AAR Specification M-927. Air hose applications shall not be permitted in locations where adequate visual inspection cannot be assured.

Piping shall be installed with a minimum number of fittings. Unions shall be used where necessary to permit replacement of apparatus and hoses. All other connection shall be brazed or welded.

All piping, fittings, and valves shall be protected from damage caused by flying ballast and other foreign material which might be encountered in rapid rail operations.

No water pockets (traps) shall be permitted and materials shall be as specified in Section 15.

4.3.8 Power Collection

Power collection equipment shall be mounted on each side of each truck to be compatible with the third rail of both Divisions "A" and "B" of NYCT. The installed equipment must not exceed the car clearance envelope illustrated on Clearance Diagram 51'-4" Car, "A" Division, Dwg. No. 205-3004, Rev. A, within Appendix D. The power collector assembly shall meet the requirements specified in Section 9.2.

Truck parts adjacent to or above current-collector devices and uninsulated power connections shall be shielded against arc damage by approved, dielectric, noncombustible barriers and protective shielding of adequate mechanical strength.

4.3.9 Trip Cocks

A trip cock shall be mounted on one journal box of each truck in diagonally opposite corners of each car. Reference Drawing entitled, "Trip Device Application, Record Dwg. R-62-934, within Appendix D. See Section 10.3.2.7 for details. The truck shall also have mounting provisions for a B Division trip cock. There shall be a capped pipe connection near the coupler, for attachment of trip cock hose.

4.3.10 Motor Mount

If a WN type drive is used, the motor mount shall be in accord with the NYCT’s latest design trucks, with widely spaced lower supports.
4.3.11 **Tread Brake Unit Mounting**

Each truck shall have supports for the mounting of four tread brake units. The tread brake units shall be removable without the need to detruck. See Section 10.3.2.2 for further information.

4.4 **Wheels and Axles**

4.4.1 **Wheels**

Wheels shall conform to the referenced documents and this Section.

4.4.1.1 **Requirements**

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Wheels shall be a light-weight (corrugated), ring-damped, wrought-steel wheel per Drawing KURUMA-5500, as furnished by Sumitomo Corporation of America of a diameter in accordance with the overall dimensions within Section 2.2.4, (-4 tapes, +6 tapes). The wheels shall conform to NYCT Specification 2091 PROD 97, Drawing No. 704-3035, latest revision, with the exception of the following dimensions and tolerances:

- Concentricity of tread relative to rough bore: 3/64”, per NYCT Drawing 704-3035, note 8.
- Tolerance on flange height: ±1/16”, per NYCT Drawing 704-3035.
- Back rim face to back hub face: 1-9/16” ±1/16”, per Sumitomo KURUMA-5500.
- Hub outside diameter: 10-5/16” +3/4”, -0, per Sumitomo KURUMA-5500.
- Damping ring groove depth: 0.30” ±.03”, per Sumitomo KURUMA-5500.
- Wheel plate blending radii: 5/8” hub, rim, per Sumitomo KURUMA-5500.
- The fracture toughness test specified by Item 4.3 shall be performed as per the Specification. However, the test results to be submitted shall not be used for the purpose of determining acceptability of the wheels.
- The back plate paint stenciling required by the first paragraph of Item 3.7.2 shall be in accordance with Note 3 of Sumitomo drawing KURUMA 6116, latest revision.
- The front plate stenciling is not required.

Wheels shall meet the noise test requirements of Sumitomo document RINGI 98-003 dated January 8, 1998.
The Contractor shall furnish accurate gauges and templates for inspecting the assembly of wheels and axles.

4.4.1.2  Marking

Wheels shall be stamped in conformance with the requirements in the above referenced documents.
The Contractor shall furnish the NYCT with a record of these numbers together with the numbers of the axles to which each wheel is mounted and the numbers of the trucks on which they are installed.

4.4.2 Axles

4.4.2.1 Requirements

Motor axles shall be manufactured in accordance with NYCT Drawing 704-3001, within Appendix D. Trailer axles shall be identical to motor axles, in the areas of the axle end, wheel seats, journal, general practices, and such areas as are relevant to a trailer axle. Axles shall be ultrasonically inspected in accordance with AAR Specification M-101A.

Axle design shall be in accordance with applicable AAR requirements, except as otherwise required in this Specification.

Axles shall have an exterior finish in accordance with AAR Specification M-101 as a minimum, and shall have been subjected to a magnetic particle inspection following machining.

4.4.2.2 Inspection

Requirements for inspection shall be based on AAR standards. All axles when finished shall be free from cracks, flaws, seams or other injurious imperfections. The interpretation of injurious imperfections shall be made in accordance with the Appendix to ASTM Specification A-21. Test reports in triplicate shall be forwarded to the NYCT.

Axles shall be rejected that are galled or otherwise scarred when pressing on wheels or gear components. In the absence of visible evidence of such galling or scarring, the use of excessive force shall be taken as cause for rejection of the assembly.

4.4.2.3 Marking

Each axle shall be marked in accordance with the "Motor Axle", Drawing No. 704-3001, in Appendix D, and shall be assigned a unique serial number which shall be legibly and permanently stamped on the gear seat end of each axle with characters not less than 0.25 inch (6.35 mm) high. The serial numbering shall be as directed by the NYCT. The Contractor shall furnish the NYCT with a record of the manufacturer's serial and heat numbers listed together with the appropriate serial numbers of the cars and trucks on which they have been installed.

4.4.3 Bearings

4.4.3.1 Journal

Journal bearings shall be 5 inch bore, roller-type, NFL-type (no field lubrication), and sealed by contact seals. The bearings shall be of approved design and manufacturer. Bearings shall be designed for a ANSI/AFBMA
L_{10} of 1,000,000 miles (1,609,000 km) of service at the AW3 passenger load, as specified in Section 2.2.5. An average speed based on the requirements of this Specification shall be used.
Bearings shall not require inspection more than once every 500,000 miles (804,500 km). Bearings shall be lubricated with an AAR M-942 grease or NYCT Commodity No. 69-10-3161. Each assembly shall have a maximum capacity of two (2) pounds (0.9 kg).

The bearings shall be adequately protected against the passage of electric current.

4.4.3.2 Truck Rotation Bearings

The Contractor shall provide a truck assembly that will resist hunting (nosing) at all speeds and be sufficiently free to swivel such that wheels do not exhibit double-groove type wear patterns or flange wear below the condemning thickness (thin flange) before reaching condemnable high flange condition. High speed stability shall remain acceptable for all normal wheel wear and truck assembly wear or aging. Truck stability, turning stiffness and longitudinal stiffness shall not cause wheel wear requiring wheel truing more frequently than every 60,000 miles (96,540 km).

The Contractor shall furnish for NYCT review, calculations of the truck swiveling index. The Contractor shall provide for a truck swiveling index, as described below, within the band of 0.040 to 0.074. Service-proven trucks may vary from this band. (Refer to Koffman’s formula from the Rail Engineering International publication, September 1973 edition.

\[
\text{Truck Swiveling Index (TSI)} = \frac{T}{2 \times Q \times d}
\]

where:
- \( T \) = Truck Turning Torque in foot-pounds
- \( Q \) = Wheel Load in pounds
- \( d \) = Truck Wheel Base in feet

The TSI shall be calculated for the following conditions:

- New vehicle, AW0 wheel load;
- New vehicle, AW3 wheel load;
- Fully worn truck attachment, AW0 wheel load; and
- Fully worn truck attachment, AW3 wheel load.

Truck attachment as used above means the device or devices which attach the truck to the car body and permit the truck to swivel under the vehicle in curves.

4.4.4 Assembly

The wheels, axles, gears, roller bearing journals, etc., shall be mounted using pressure and fit recommended by the manufacturer except as noted below and approved by the NYCT. All wheel and axle assembly work shall be performed in an approved AAR certified wheel shop.
TRUCKS AND SUSPENSION

4.4.4.1 Wheel and Axle Sets

Wheel sets shall be concentric within 0.005 inch (0.127 mm) total indicated run-out when rotated on their bearings. Mounted wheels shall not exceed 0.015 inch (0.38 mm) out of paralleled to a plane perpendicular to the centerline of the axle (wobble), nor 0.030 inch (0.76 mm) out of parallel with each other.

Wheel gauge shall be 55-11/16 +0, -1/16 inches (1414.5 +0, -1.6 mm).

Wheel-axle sets shall be mounted in pairs matched in diameter within one-half tape size. Wheels shall be pressed on axles by suitable and approved apparatus at a load of from 68 to 105 tons (605 to 934 kN) and shall be measured and recorded by means of an approved recording gauge which shall be frequently checked with a standard gauge. Prior to the start of pressing wheels on axles, the pressure gauge shall be calibrated in the presence of the NYCT. Periodic recalibration in the presence of NYCT shall be performed by an agreed upon schedule. Pressure diagrams shall be provided with each set of wheels to permit monitoring of the pressing operation. Only those pressings showing a uniform buildup of force with displacement shall be accepted.

Two wheels mated to the same outside diameter shall be pressed on an axle and upon completion of this operation the axle shall be revolved on its centers, in the presence of the NYCT’s inspector, to determine that the wheels are concentric with the axle, are of the same diameter and that the inner faces of rims are true and parallel within allowed tolerances.

4.4.4.2 Journal Box

The journal box shall be mounted outboard of the wheels and guided in the truck frame by the primary suspension. The journal box shall contain a roller bearing as described in Section 4.4.3.1 and provide sufficient clearance to prevent seizure of the bearing within the journal box.

The journal boxes shall be readily removable from the axle. Bearings and boxes shall permit easy insertion into axle centers of the centering spindles of wheel truing machines manufactured by Simmons Stanray. This arrangement shall include a 2 ½ inch IPS square head pipe plug in the journal box front face or cover. The head of the pipe plug shall be drilled for safety wiring. Trucks shall incorporate a lip on the outside top of the journal box for support of the axle tie down cables of the wheel truing machine. Alternatives may be submitted for approval.

Each journal box shall have provision for support of the trip cock of Section 4.3.9.

4.5 Suspension Details

Each truck shall have a primary and secondary suspension system. Designs having lost motion in any axis will not be accepted.

The suspension system, except for components otherwise specified, shall be designed to provide satisfactory service for 12 years under the operating conditions specified.

Vertical adjustment to compensate for wheel wear and/or wear of other truck parts shall be provided as described in Section 4.3.1.4.
The air spring travel from the light car, AW0 passenger load, to the solid air spring height shall be adequate to prevent contact with the safety secondary suspension element during operation on the NYCT with all conditions of passenger loading specified in Section 2.2.5.

4.5.1 Primary Suspension

The primary suspension shall be of elastomeric elements or combination of elastomeric and coil springs arranged in such a manner as to preclude rotation of the journal box with changing vertical load.

The Contractor shall propose appropriate spring rates for each of the three axes. The vertical natural frequency of the primary suspension system shall not exceed 7.5 Hz. The longitudinal spring rate shall permit the axles to align in curves of 1000 feet (305 m) radius or greater and shall in no case exceed 90,000 lbs. per inch (15,760 N per mm) when measured under AW3 load.

The truck configuration together with the primary suspension elements shall allow movement of each wheel for load equalization. Lifting or dropping any wheel of a truck 2 inches (50.8 mm) shall not change the load on any wheel of that truck more than 50 percent at AW0. The raising or lowering of any wheel 2½ inches (63.5 mm) shall not result in loss of contact between any other wheels and the rail.

The springs shall be specifically designed for this car to provide the maximum passenger comfort within the criteria provided by this Specification.

The year of manufacture, the car contract identification, and the manufacturer's identifying mark shall be stenciled on each elastomeric spring in a manner that will not be detrimental to the service of the spring.

The Contractor shall obtain from the spring manufacturer and furnish to the NYCT, a certified guarantee against failure of the springs caused by defective material and/or workmanship.

4.5.2 Secondary Suspension

The secondary suspension shall be provided by air springs (air bags) between car body and the truck bolster or between the truck bolster and truck frame. The truck bolster shall also serve as the suspension reservoir unless otherwise approved. The secondary suspension subsystem shall have a natural bounce frequency in the vertical direction not to exceed 1.5 Hz under any load condition. Shielding or other means shall be provided to protect the air springs (air bags) from damage by electrical arcing. The air springs (air bags) shall comply with the smoke and flammability requirements within Section 15.25, or be enclosed within a compliant material.

4.5.2.1 Dampers

Whatever vertical and lateral damping of spring action is required to meet ride quality requirements, and is not provided by the air spring suspension shall be provided by hydraulic dampers. The design life goal of hydraulic dampers shall be 7 years.
4.5.2.2  Truck Connection

The truck connections to the car body shall include a safety connection as specified in Section 4.3.6.

If the trucks are restrained longitudinally by bolster anchor rods or similar devices, each bolster anchor rod shall withstand a longitudinal load equal to a minimum of 100 percent and a maximum of 135 percent of the required design load, without permanent deformation. The design load for each bolster anchor rod shall be two times the weight of a complete truck, including motors, gear units, brake equipment and all other truck-mounted apparatus, but excluding the truck bolster assembly. Any bracket by which a bolster anchor rod is attached to the truck or the truck bolster, the member to which the bracket is attached, and any intermediate connection shall, as a minimum, withstand a longitudinal load equal to 150 percent of the required design load without permanent deformation. The brackets or the connections shall fail (deform permanently or break) before the members to which the connections are made fail.

Clearance shall be provided between the bolster anchor rods and all parts of the car body and apparatus under all operating conditions.

Propulsion and braking forces shall be transmitted between the truck and the truck bolster in a manner which minimizes weight transfer between axles of a truck, and therefore maximizes adhesion and minimizes stress levels, wear, and displacements in the truck. To this end, bolster anchor rods, if used, shall be positioned as low as allowed by clearance, and shall be elastomerically cushioned at both ends.

4.5.2.3  Stops

Rigid stops required to restrict lateral car body motions shall be provided with elastomeric cushions, as specified in Section 15.7.6, providing not less than 0.5 inch (13 mm) of compression and spring characteristic appropriate to attainment of the required ride quality.

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.

Positive mechanical stops shall be provided on the truck to prevent the secondary air springs from going solid. Each air spring shall have an elastomeric safety spring built in to provide some suspension capability in the event of a failed air spring or leveling valve. The solid height of the air springs shall be less than the height of the spring pocket after the mechanical stops have contacted for all conditions of tolerance and relative truck motions.

4.5.2.4  Springs

The secondary suspension shall consist of air bags. The suspension system shall limit the roll of the car just prior to and during unloading, so that the car floor on the side adjacent to the station platform shall not be lower than the station platform as shown in Appendix A. Safe operation of the car shall be assured at all speeds when any or all air springs are inoperative. If air reservoirs external to the truck structure are used, they shall meet the requirements of Section 15.16 and shall have manual drain cocks. Connections between air springs and external pressure vessels (if used) shall be sufficiently large to prevent such connections from becoming dampers to the air flow.
Cutout cocks (one per truck), of approved type and design, shall be provided in the air supply line to the air springs of each truck to vent both springs and close the air supply to the springs. The cut-out cocks shall be located adjacent to each truck and shall be readily accessible from both sides of the car without going under the car. Their location shall be identified by the letters “ASC” applied to the side sill immediately adjacent to the cut-out cocks. Cut-out cocks shall be lock wired in their normal operating position.

4.5.2.5 Leveling Valves

The leveling valves shall be of a design having provided previous successful transit service. Hysteresis of the design shall be sufficiently low to maintain floor height within the vertical tolerance of ±1/2 inch. Adjustment shall be readily accessible from the side of the car and shall be of the type where a jam nut can be loosened and an appropriate number of turns taken and the jam nut re-tightened. Trucks with a single leveling valve shall sense car body height on the longitudinal centerline of the car. The No. 2 truck shall have a single leveling valve.

Sudden loss of air spring pressure on either side of the truck shall initiate rapid venting of the opposite spring. Air pressure shall reflect the supported weight by each truck with an accuracy of ±5 percent or better, as required by the overall systems design.

The leveling valves shall have a minimum life of 7 years before overhaul.

4.5.2.5.1 Load Weigh

The No. 2 truck of each car shall have a load weigh transducer meeting the requirements of Section 10.2.2.1.

4.5.3 Suspension Components

4.5.3.1 Car Body Roll Stabilization

The suspension of each truck shall be designed to minimize car body roll. The method of controlling roll to keep the car body within the dynamic clearance outline shall be torsion bars or other service-proven method approved by the NYCT.

4.5.3.2 Noise Isolation

The trucks shall be equipped with shock insulating materials to minimize audio noise transmissions into both the passenger and wayside areas. The noise levels shall conform to the standards listed in Section 2.7.

4.6 Tram

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The truck frame assembly, when centrally loaded through normal load paths shall maintain the axles parallel to within 0.09 inch (2.29 mm) at the journal centers, and shall limit the difference between diagonally opposed bearing locations to 0.20 inches (5.1 mm). These limits shall apply both at the AWO load and the AW3 load condition.
The Contractor shall submit for approval a test procedure for verifying the above requirements and one truck shall be tested. An analysis showing the adequacy of the design in this respect shall be included in the FEA deflection analysis required by Section 4.1.4.4, fifth paragraph, first bullet. All frames shall have tram marks above and below (where applicable) each journal bearing housing, located within 0.005 inches (0.13 mm) of the true position.

4.7 Parking Brake

Provision shall be made for the installation of a parking brake as defined in Section 10.3.6.
SECTION 5

COUPLERS, DRAWBARS AND DRAFT GEAR

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SECTION 5

5.0 COUPLERS, DRAWBARS AND DRAFT GEAR

5.1 General

A fully automatic, coupler shall be provided at the No. 1 end of each A Car. The brake pipe pneumatic connection shall be trainlined and form an integral part of each mechanical portion. Electrical connections, shall be through an electrical head attached to the bottom of the mechanical portion.

A simplified link bar arrangement shall be provided at each end of the Non-Cab Cars and at the No. 2 end of the A Cars. Electrical connections shall be through electrical cables terminated with multipin circular-type connectors.

5.2 Mechanical Coupler

The coupler head assembly shall be a Tomlinson style, flat faced, hook-type coupler of approved design and manufacture.

5.2.1 General Requirements

A device shall be provided within the mechanical coupler to lock the couplers automatically in close mating contact. It shall not be necessary to remove the drawbar to replace the coupler.

The coupler and draft gear length, from the anchor pivot to pulling face, shall be established by the supplier with NYCT review. Drainage shall be provided for rain and car wash water.

Draft gear shall absorb shock in both buff and draft and shall be self-leveling from a 5 degree rotational displacement to either side of the vertical centerline around the longitudinal axis.

As part of the reduction of noise program of the NYCT, metal-to-metal wearing surfaces shall not be permitted.

All surfaces subject to frictional wear shall be provided with rolled manganese steel or NYCT-approved wear plates.

5.2.1.1 Emergency Operations

The drawbar-coupler draft gear assembly shall be designed to provide satisfactory service in emergency operations with trains consisting of twice the normal maximum number of cars with one half of the motor cars powered, the other half of the motor cars dead.

5.2.1.2 Compatibility

The coupler equipment shall be mechanically compatible with the NYCT's R44, R46 and R110B cars, which utilize Tomlinson-style, flat face, hook-type couplers. The couplers shall also mechanically couple with the
NYCT's "A" Division (IRT) H-2-C couplers through the use of an adapter. Reference Specification Section 5.7.

5.2.2 Geometric Requirements

5.2.2.1 Curving

The drawbar, coupler and radial drawbar carrier shall be designed and constructed to permit coupled cars to negotiate all horizontal and vertical curves specified in Appendix A, including operations with maximum mismatch between cars due to spring deflection, wheel wear and track irregularities. Under no conditions shall the drawbars or couplers interfere with truck parts, wheels, cables or other equipment.

5.2.2.2 Gathering Range

The operation of the mechanical and electrical couplers shall be completely automatic within a gathering range of such proportions that they will couple when the vertical distance between the center lines of coupler does not exceed 3 inches (76 mm); or the horizontal distance between the center lines of the couplers does not exceed 3-3/8 inches (86 mm) and the drawbar yokes have twisted a maximum of 5 degrees to each side of the vertical center line varying a total of a maximum of 10 degrees from each other. The coupler configuration shall provide the maximum practical gathering range when both vertical and horizontal misalignments exist in combination with the limits stated above.

5.2.2.3 Drawbar Stops

Mechanical drawbar stops shall be provided on each side of the adjacent truck end transom to prevent interference between the truck and the drawbar, if necessitated by specific truck design. Either the truck or the drawbar shall have elastomeric stop cushions with integral wear plates at the point of contact with the other member. Other techniques accomplishing this objective may be offered for approval.

5.2.2.4 Lateral Force

When uncoupled, the drawbar and coupler assemblies shall move laterally when a force of not more than 75 lbs. (333.6 N) is applied laterally to the face of the coupler head.

5.2.3 Coupler Head Assembly

5.2.3.1 General

The coupler head shall be as required under Sections 5.2 and 5.3, mechanical coupler. The equipment shall meet the following requirements.

5.2.3.2 Coupler Head MOD 02 C

The coupler head shall have a compatible length from pulling face to pivot and shall be provided with a hinge lug for vertical centering.
Lubrication requirements shall not be necessary on coupler head pivots.

Means shall be provided in the coupler to permit manual uncoupling from track level in the event of loss of air pressure. The force required for uncoupling shall not exceed 75 lbs. (333.5 N) applied at the center of the hand grip surface.

A locking device is to be provided for the mechanical coupler head in order to prevent inadvertent uncoupling of the coupler hooks during a rescue operation. If an external device is used, it shall be stored with the coupler adapter.

Integral brackets shall be provided on the coupler housing to support the electrical couplers. The mating surfaces on the coupler housing shall be machined to interface properly with the electrical coupler. Registration pins shall be provided for electric head alignment. The mounting bolts shall be used only for retaining the electric head.

5.2.4 Strength Requirements

The various components of the drawbar and coupler structure shall withstand the following static loads without yielding or buckling:

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For any horizontal position of the coupler, the coupler, its carrier and the car structure shall withstand, without yielding, a vertical load (both directions) 50,000 lbs. (222 kN) applied at the coupler face.

The drawbar housing shall sustain an ultimate test load of 400,000 lbs. (1780 kN) in draft and buff.

Radiographic inspection of coupler system castings shall be conducted in accordance with Section 15.5.3.2.

For each fabricated weldment, if used, the supplier shall perform a design qualification test on the first component. The test shall be subject to the approval of the NYCT. Quality control procedures shall be subject to approval by the NYCT.
5.2.4.1 Mating Surfaces

All surfaces mating to car body attachments shall be machined.

5.2.5 Carrier and Centering

5.2.5.1 Coupler Carrier

The drawbar shall be supported at its normal height by a radial drawbar carrier which will support the weight of the drawbar and the mechanical and electric (cab car #1 end) couplers. The carrier must be so designed that the coupler head is permitted the required range of movement in a vertical plane. The carrier shall be designed to allow a sufficient range of movement in the transverse direction to enable the coupler head to move in a horizontal plane to the required extent to negotiate curves. Provision shall be made for coupler vertical height adjustment and wear compensation without removing the drawbar. A stop shall be provided at each end of the radial drawbar carrier bar or on the underside of the car to prevent excessive transverse movement. It shall not be necessary to remove the drawbar carrier to remove the drawbar.

The drawbar carrier shall be forged, fabricated or cast steel with additional requirements as specified in Sections 15.4 and 15.5. It (the drawbar carrier) shall be machined and either it, or the drawbar jaws, or both, shall be provided with wear plates of Nylatron, or approved equal.

The bolts fastening the carrier to the car underframe shall be grade 5 or ASTM A-325.

5.2.5.2 Wearing Surfaces

All wearing surfaces shall have ample area and hardness to perform the functions required for a minimum of 12 years. Readily replaceable wear plates shall be provided. Mechanical coupler head guide as well as hook pins and bushings shall be renewable.

5.2.5.3 Coupler Centering

CO 56

5.2.6 Draft Gear

5.2.6.1 General

Draft gear shall be provided at each end of each car to carry coupler loads to the car body via the draft stop and drawbar housing and its attachment to the draft sill.

At a load of 100,000 lbs. (445 kN), the travel shall be 1-1/4 inches, +1/8-inch, -0 inch (32 mm, +3 mm, -0 mm). Upon appropriate justification, other values may be approved by the NYCT.
5.2.6.2 Drawbar Housing

The drawbar housing casting shall be cast steel conforming to the requirements of Section 15.5. It shall be provided with approved long-wearing wear plates and bushings meeting the requirements of Section 5.2.1 on all surfaces subject to frictional wear.

The drawbar housing casting shall have an approved removable member to permit removal of the draft gear. In order to place full responsibility for specific performance of the draft gear on the manufacturer, the drawbar shall be furnished assembled, complete with draft gear and yoke installed in the housing. The yoke must have clearance inside the housing casting to rotate as described in Section 5.2.6.3. Carrier jaws shall be provided with approved long-wearing wear plates meeting the requirements of Section 5.2.1.

These castings shall be inspected and gauged by means of special templates and jigs supplied by the manufacturer.

5.2.6.3 Yoke

The yoke in which the draft gear functions shall be cast steel, conforming to the requirements of ASTM A-148, grade 90-60 with additional requirements specified in Section 15.5. It shall be designed to allow a twisting motion of 5 degrees to each side of the vertical center line, permitting the respective vertical centerlines of two coupled cars to vary a total of 10 degrees from each other. Upon removal of such loading, the yoke shall return to its normal position.

The assembly shall be provided with a helical spring or springs held by a special head bolt and washer in a pocket and also the spring supporting the coupler head hinge lug. The jaw of the yoke shall neatly fit the coupler hinge.

Attention is directed to the importance of the soundness of the yoke castings and the machining required. These castings shall be inspected by the Contractor on an approved sampling basis, using radiographic procedures in accordance with ASTM Specification E-94 (2 percent sensitivity) and with indications judged in accordance with ASTM E-446 with criteria as approved. Magnaflux methods per ASTM Specification E-109 or E-138 with approved criteria shall also be employed. The yoke shall be gauged by the Contractor by means of approved templates and jigs supplied by the manufacturer.

5.2.6.4 Yoke Pin

The yoke shall be provided with a steel yoke pin of ASTM A 576 Grade C-1045 or equivalent. The yoke pin shall be designed to allow for ease of assembly and removal for maintenance.

5.2.6.5 Anchorage

An anchorage assembly shall be provided for the attachment of the coupler-draft gear assembly to the car underframe. The anchorage shall be high strength steel and shall comply with the strength requirements of Section 5.2.4.
If a casting is used, the steel shall conform to the requirements of ASTM A-148 grade 90-60, with additional requirements specified in Section 15.5. If a weldment is used, the steel shall conform to ASTM 572 Grade 50.

The anchorage assembly shall be secured to the car underframe with bolts made of ASTM A-490 or ASTM A-325.

Sufficient clearance shall be provided in the anchor casting to permit the removal of the drawbar housing from the car without the necessity of removing the drawbar carrier.

The drawbar pin shall fit with sufficient interference to prevent relative motion. An access plate shall be provided in the car floor for access to the drawbar pin. The pin shall be removable without the need to remove or lift the car relative to the adjacent truck. Holes for jacking bolts shall be provided to assist in pin removal.

A positive, approved means of securing the drawbar pin shall be provided.

The drawbar pin shall be top mounted and made of ASTM A-576 Grade 1045 steel machined all over.

5.2.6.6 Drawbar Connections

Drawbar connections shall be designed so that uncoupling between the drawbar and the coupler head or the anchor can be accomplished with the use of hand tools.

5.2.7 Energy Absorption

The draft gear shall be provided with an automatic shear release mechanism to provide emergency release in the event of severe end impacts.

The shear pins shall shear upon a buff load of 150,000 lbs. (667.2 kN) [with a tolerance established by testing a sample of 10 shear mechanisms, but not to exceed +15,000 lbs. (+66.7 kN)/-5,000 lbs (-22.2 kN)], permitting the transfer of excess buff loads to the car's underframe. This shall allow the coupler and drawbar yoke to travel an additional distance before contacting the rear of the drawbar where the yoke shall be further cushioned by the elastomer in the draft gear.

The design of the emergency release feature shall be such as to require no special tools and a minimum of hand labor to restore the mechanical coupler to a normal operating condition. It shall not be necessary to remove or disassemble the yoke or drawbar housing to replace the shear pins. The shear pin assembly shall be designed to facilitate pin removal in the event of partial shear.

Positive indication shall be provided on the exterior of the drawbar housing casting for inspection purposes to determine the position of the shear mechanism and whether or not a full or partial shear has taken place.
5.3 Electrical Inter-Car Connections

5.3.1 No. 1 End

5.3.1.1 Electric Coupler Head

An electric coupler head shall be mounted under the mechanical coupler at the No. 1 end (cab end) of each cab car. A multi-pin arrangement in a fixed pin block shall be used.

The electric head shall be capable of automatically making the required number of electrical connections between cars. Creepage surface between adjacent contacts shall be adequate for the applied voltages including surges.

Electric connectors shall maintain effective continuity under all car operating, lay-up and storage conditions.

Electric coupler head shall contain multipin contacts to provide electrical connection for critical trainline signals between cars. The proper number of back contacts shall be included to perform all necessary functions. Four spare contacts shall be furnished. These contact pins shall be wired back to the junction box; two with 16 AWG wires and two with a shielded twisted pair.

Each electric coupler head shall be provided with not more than two receptacles to interface with car wiring cables. Each connection shall be designed to receive conductors in an approved manner.

All contacts shall be of the conventional type, spring-loaded, butt-type of an approved material, the heads of which shall be completely silvered with coined tips 0.030-inch (0.76-mm) thick. The contacts shall have ample surface capacity, suitable shape and positive action to prevent fouling in coupling. Contacts shall be designed to transmit not less than 40 amperes for one hour and 30 amperes continuously. Contacts shall not stick or bind under any environmental condition. Contacts shall not freeze under any condition including due to snow, ice, rain and other environmental factors. The electrical coupler sub-assemblies shall be heated by thermostatically controlled heaters of adequate capacity to prevent freeze-ups in inclement weather.

Electric coupler contacts and train lines shall be symmetrically arranged about the vertical centerline so that they may be reversed with respect to any other car and the specified functions will not be affected. The electric coupler head shall be mounted on the mechanical coupler in an approved manner that they shall provide for easy removal and replacement of the entire assembly without the removal of any other adjacent equipment.

Multiple sets of contacts shall be provided to meet the impedance, shielding and balance requirements of the various data busses required elsewhere in this Specification.

The individual parts and the assembled electric coupler head shall be sufficiently rugged to withstand the coupling impacts and repeated stresses to which they will be subjected in service. The electric coupler heads shall maintain positive contact under the impacts to which the car couplers will be subjected in service. The coupler pins shall have sufficient diameter and travel to exceed the requirements under worst case conditions for condemning limits of the mechanical coupler.
A manual retraction handle shall be provided for the electric portion of the coupler to advance and retract the multi-pin contacts. In addition, a locking mechanism shall be provided for the manual retraction handle to lock the manual retraction handle in place when the contact pins are in the advanced position.

All parts shall be accurately finished to dimensions that insure proper fit and functioning, both of the individual parts and the coupler as a whole.

The maximum diameter for any multiple conductor cable shall be 1.50 inches (38.1 mm).

The electric coupler contacts shall be arranged so that the operator's signal indication circuit can be obtained only when the cars are coupled.

### 5.3.1.2 Trainline Circuits

Contacts circuit assignments shall be approved by the NYCT.

### 5.3.1.3 Requirements

Electrical contact pins shall be designed to maintain positive contact with an adequate force between coupled contact interfaces. The disconnect operation shall be rapid to avoid damage by arcing. The uncoupling circuit shall preclude unwanted uncouplings and shall be considered a safety critical circuit according to Section 18.4.

Contacts shall be of the two piece design so that the active portion of the pin is replaceable from the front of the coupler without disassembly of the coupler or its internal wiring harness.

The contacts and associated hardware shall be constructed of corrosion-resistant metal alloy and shall be mounted in a block of insulating material.

The design of the insulating block, contacts and edge seals shall preclude the entry of water and debris of any kind into the electrical housing, shall be non-absorbing and shall neither embrittle nor soften in extreme heat or cold.

### 5.3.1.4 Current Interruption Protection

To prevent front contacts from arcing during uncoupling, a separate set of switching functions shall be included for the automatic disconnect of all circuits which might cause arcing damage, prior to separation of the current carrying contacts.

### 5.3.1.5 Connections

**MOD 06**

Connections to the back of the electric coupler contacts shall be either by means of compression-type terminals integral with the contact or eye-type terminals bolted thereto and accessible for maintenance, except as otherwise approved.
Each contact, except spares, shall be marked to identify its actual circuit designation by engraving its identification on the contact block directly beneath the contacts and filling the engraved lettering with an approved non-conductive white paint as specified in Section 15.24. However, spares shall be identified with decals only, designating "Spare" and its number.

Connections from electric couplers to the trainline junction box shall be by means of multiple-conductor cables wired to the approved connectors.

Contacts for loop circuits shall be provided in the isolation switch described in Section 5.3.3.

Back connections shall be provided for a minimum of four circuits; one to the Train Operator's indication signal light, one to the taillights, one to the end door locks and one spare. These first three circuits and one spare circuit shall be opened when the switch is in the coupled position and shall be closed when the switch is in the uncoupled position. Alternate means of control achieving comparable functions may be proposed.

Provisions shall be made for firmly tie wrapping all the leads connected to the various contacts within the electric coupler.

Suitable clamping shall be provided for the multiple-conductor cables between the electric coupler housings and along the cables' entire length to the trainline junction box.

Between the coupler housing and trainline junction box, the cable shall be protected, in an approved manner, against chafing, pinching, kinking or fouling.

5.3.1.6 Housing

The housing of the electric coupler head shall be a high-grade steel casting or may be fabricated of mild steel or stainless steel. The interior of the housing shall be painted with an approved insulating paint or enamel, as specified in Section 15.24 if it is a casting or mild steel fabrication. If it is of stainless steel, the interior paint may be omitted provided the supplier can demonstrate to NYCT's satisfaction that air gap and creepage distances are adequate. It shall be provided with an opening on the bottom, covered with a removable plate of sufficient size to make connections and to inspect and repair the terminals, cross connections and other internal parts of the coupler. All parts within the coupler housing shall be made of non-corroding materials. Cable entry shall be through watertight bushings.

5.3.1.7 Contact Holder

The holder or block containing the contacts shall be molded or fabricated in one piece of non-absorbing insulating material which is tough, fibrous and dense but not brittle or soft under cold or heat. The holder may have brass sleeves molded into each contact hole for a bearing or a spring container. The creepage surface between adjacent contacts on the outside face of the holder shall be ample. The holder shall be removable from the front.
5.3.1.8 Contact Springs

The contact springs shall be made of beryllium copper or stainless steel. They must not be subject to a permanent set due to compression in service and shall provide the design pre-load force at the contact pin faces. A bonded, braided shunt shall carry all current away from the spring.
5.3.1.9 Electric Coupler Cover

CO 198

Each cab end electric coupler shall be provided with a weather-resistant cover which shall protect the coupler contacts from dirt, dust, water and ice when it is closed in the uncoupled position. The cover shall be spring-closed and shall automatically open as the vehicles are buffed together during coupling. The electric coupler cover shall be provided with a hold-open feature, such that the hold-open feature can be properly secured when not in use. The cover shall be easily replaced. The cover shall not be damaged when used by maintenance personnel to move the coupler assembly.

5.3.2 Non-Cab Ends

The non-cab ends include the number No. 2 Ends of the A Cars and both ends of the Non-Cab Cars.

5.3.2.1 Electrical Connections MOD 02

Intercar electrical connections shall utilize jumper cables with connectors at each end, connected to car junction boxes. Electrical connections shall meet the requirements of Section 15.19. Semi-permanent jumper cables or an alternate connector arrangement may be submitted for NYCT approval. Such an arrangement must include provision for protecting loose end of cable when car is uncoupled.

The details for wiring the inter-car connectors are listed in Section 15.19.6. The connectors shall be of the threaded type, the inserts and sealing shall meet the standards of MIL-C-5015, and they shall be approved by the NYCT.

5.3.2.2 Current Interruption Protection

Since the disconnection of the inter-car connectors is a manual process, the Contractor shall provide means to remove all circuits capable of carrying more than 50 volts and/or currents in excess of 10 amps prior to such disconnect.

5.3.3 Electrical Isolation MOD 06

Provision shall be made to automatically isolate the electrical circuits as needed through an electro-pneumatically operated switch. Provision shall be made to operate the isolation switch manually from the side of the car if either the electrical or pneumatic system malfunctions.

High current contacts shall be included to allow electrical interruptions. Parallel connections of switch contacts to provide increased current carrying capacity shall not be permitted. Loop circuits shall be made through the isolation switch. All vital door control circuits wiring and door position indication circuits wiring shall be isolated from B+ and other circuits by approved terminal separation, wire arrangement, and wire dressing. A manual isolation switch shall isolate all other circuits or selected circuits as approved.
5.4 Pneumatic Coupler

5.4.1 Cab Ends

Unit-to-Unit brake pipe connections shall be made automatically when couplers are fully engaged mechanically and locked. Connections shall be provided in the coupler for brake pipe and any other connections necessary for the automatic coupling and uncoupling of the Units. Manually operated self-locking, non-vented cut-out cock shall be provided at each cab-end of main reservoir pipe and brake pipe.

A readily replaceable, self-closing valve shall be provided which shall automatically close off the brake pipe when Units are uncoupled and open between coupled Units. The design of the coupler and controls shall ensure that during intentional uncoupling the emergency brakes shall apply on the Unit being parked. The uncoupling operation shall not cause an emergency brake application on the controlling Unit and shall not result in the loss of brake pipe air. Unintentional uncoupling, break apart, shall cause emergency brakes to be applied to both Units.

Provisions shall be made to prevent undesired buildup of air pressure in the uncoupling cylinder due to uncoupling valve leakage.

The air connections at the rear of the coupler head shall be tapped for standard iron pipe size connections. All piping and fittings on or about the coupler shall be of approved materials. The air line at the face of the coupler shall be free-flow connected by means of spring loaded rubber gasketed bushings or approved equal. These gaskets shall be retained to prevent their becoming dislodged during uncoupling.

All piping and fittings on or about the coupler shall be of approved materials.

5.4.2 Non-Cab Ends

Manual uncoupling at the non-cab ends of A Cars and both ends of the Non-Cab Cars shall be provided by the link bar as specified in Section 5.1. The link bar shall not require support to couple or after uncoupling. Pipe union connectors shall be provided for the main reservoir and brake pipe trainlines. Manually operated self-locking, non-vented cut-out cock shall be provided at each carbody end of main reservoir pipe and brake pipe.

5.5 Control

5.5.1 General

Coupler design shall permit automatic coupling by bringing cars together.

The coupler hooks shall be of suitable design and the operating mechanism of ample capacity to produce a positive uncoupling by the operation of the coupler uncoupling valve and shall make further manual effort unnecessary.
COUPLERS, DRAWBARS AND DRAFT GEAR

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Coupler control shall be arranged so that the complete uncoupling operation can be performed only from the active cab (operating cab with active master controller). The trainline isolation function will still be available in any cab. If the displacement of the couplers is within the gathering range specified, coupling shall be effected when the couplers come into full contact.

The uncoupling control shall provide reliable, fail safe operation, requiring completion of an uncoupling cycle before train operation is possible. Single point failures in the uncoupling control shall not produce uncoupling.

5.5.2 Coupler Control

MOD 06

The electric and pneumatic control system shall provide the functional features to permit automatic coupling and uncoupling of basic train Units from within adjacent cab and undercar locations. Manual, electric and pneumatic coupling and uncoupling features shall also be provided.

5.5.3 Cab Ends

MOD 06

During uncoupling, the emergency brakes shall be automatically applied on the cars to be parked and released on the cars to be moved.

In the event of an inadvertent uncoupling, an emergency brake application to all sections of the train shall be caused by exhausting the brake pipe.

Auxiliary equipment shall be supplied as part of the coupler equipment to energize in both cars the activating relays and magnet valves performing the following functions:

- sense the uncoupled state and open the drum switch or equivalent. Close the looping circuits and open all other switched trainline circuits; close the air trainlines and open the coupler hook;
- sense the coupled state and close the drum switch or equivalent. Open the looping circuits, restore continuity of trainlines and open the air trainlines. Manual means must also be provided by which specified air and electric trainlines can be opened or closed; and
- provide manual means by which specified trainlines can be broken.

This equipment may consist of the following: an electrically-thrown or magnetically latched contactor, an air-operated rotary or a manually operated disconnect switch and electrical protective equipment. The sensing is to be done by positive means of trainline control. Sensing by proximity switches is not permitted.

5.5.4 Non-Cab Ends

MOD 02,06

All operations at the non-cab ends are to be performed manually.
In the event of an inadvertent uncoupling, an emergency brake application shall be caused by exhausting the brake pipe.
5.6 Checking Gauges

The Contractor shall supply three sets of special templates and jigs as defined in Sections 5.2.6.2 and 5.2.6.3. The Contractor shall supply twelve sets of “GO”-“NO GO” gauges to check every critical surface of the coupler for proper dimension to assure continued proper operation.

5.7 Coupler Adapters

Lightweight coupler adapters as listed below shall be furnished and delivered with the cars.

The adapter will be required for pulling or pushing in the event of an emergency, up to a maximum length train, each car loaded to AW3. The adapter shall be NYCT Standard Commodity No. 16-46-1077 (Dresser No. RTP 1326 HTS), or approved equal.

One adapter for each Cab Car shall be furnished to permit coupling of the specified hook type coupler to the NYCT’s H-2-C type coupler. The adapter shall be provided with an approved carrier to be mounted at an approved location on each cab car.

5.8 Trainline Portable Test Equipment

Portable test equipment shall be provided to check the integrity of the trainline wiring from the contacts in the coupler electric heads at one end of the basic train Unit to the contacts in the coupler electric head at the other end. The test equipment shall be designed for use by one person, shall be microprocessor-based and shall utilize the vehicle's battery for power. The test equipment shall identify problems without the use of a code and subsequent need to refer to a table. The test equipment shall be accompanied by diagrams, schematics, maintenance procedures, calibration instructions and troubleshooting procedures. General requirements and quantities for portable test equipment are provided in Section 20.
# SECTION 6

## CAB AND CAB CONTROLS

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SECTION 6

6.0        CAB AND CAB CONTROLS

6.1        General

MOD 05

A full width cab shall be provided at the No. 1 End of each Cab Car. The cab shall contain all appurtenances necessary for operation of a train. Each cab shall contain as a minimum, the following appurtenances:

- Seat;
- Console and controls, including Master Controller and Train Operator’s Display (TOD);
- Master Door Control panel (MDC) (one set on each side of the cab);
- Bypass and Cutout Panel;
- Two conductor's emergency brake activating devices and handles;
- Heaters;
- Circuit breaker panels;
- Auxiliary control and indicator panel;
- Cab air conditioning outlets;
- Overhead lights;
- Radio and associated auxiliaries;
- Train schedule holder, located for good visibility;
- 120-volt electrical receptacle;
- Rack to store five contact shoe slippers (see Section 9.2.2);
- Coat hook;
- Provisions for CCTV flat screen monitor on left hand end face of cab console (see Section 13.6); and

The cab layout shall maximize the use of available space and shall employ sound human factors and industrial design principles in its development. The Train Operator's space and equipment shall be properly designed to ensure safe and optimal Train Operator performance for Train Operators in the range of the 5th percentile female to the 95th percentile male of the general population. All cab details shall be shown in the mock-up specified in Section 17.2.1.

The cab shall be free of sharp edges, protruding objects, safety hazards and floor obstructions. The cab design shall not allow hidden areas in which paper and other debris can accumulate.

6.2        Arrangement

6.2.1        General

The cab shall be arranged to permit train operation by a Train Operator seated or standing before the console. It shall permit the Train Operator conveniently to stand up and move to the side window on either side to operate doors, without interference from the console, the seat, or other cab fittings. The cab shall be fully enclosed to prevent unauthorized access.
6.2.2 Construction

6.2.2.1 Cab Partition

The cab partition is described in Section 3.11.7.

6.2.2.2 Cab Door

The cab door is described in Section 3.12.1.4.

6.2.2.3 Flooring

The cab finished flooring shall be the same as provided in the passenger section. Refer to Section 3.8 for details of construction and application.

6.2.2.4 Side Linings

Refer to Section 3.11.6 for details of construction of the side and end linings.

6.2.2.5 Ceiling

The cab ceiling shall be constructed of 0.375-inch (10 mm) thick minimum, integrally colored, melamine on aluminum faced panel, with an aluminum honeycomb core or approved equal.

The cab ceiling shall be arranged to facilitate maintenance access to equipment located above the ceiling. Equipment requiring scheduled attention more often than every two years shall be readily accessible through hinged access panels sized and located for convenient opening. Equipment requiring less-frequent attention shall be accessible through larger access panels arranged for complete removal with only hand tools. All access panels shall be equipped with safety cables to prevent sudden dropping. The number of access panels shall be as small as possible, consistent with functional requirements.

Ceiling panels shall be adequately supported to prevent sagging and drumming. Ceiling panels shall be supported by hangers welded to the roof structure and located at a spacing no greater than 40 inches (1,016 mm).

6.3 Cab Side Window

The cab shall be equipped with vertical sliding windows (drop sash) on both sides of the cab to allow the Train Operator to monitor the loading and unloading of passengers. Refer to Section 3.10.4 for details of side window construction.
6.4 Cab Equipment

6.4.1 Cab Seat

6.4.1.1 General

A contoured, adjustable seat shall be provided in the cab. The cab seat shall be located to maximize the Train Operator’s forward visibility. The seat shall be a folding type, and shall be supported from the bulkhead wall behind the Train Operator's position. When not in use the seat shall fold against the bulkhead wall.

The design of the seat shall address ergonomic considerations for Train Operators from the 5th to the 95th percentile in such a way as to minimize Train Operator fatigue and discomfort. The seat shall be vertically and horizontally adjustable to accommodate Train Operators from the 5th percentile female to the 95th percentile male of the general population. The seat shall rotate approximately 25° to the left of center and 18° to the right of center. The cab seat design and location shall be reviewed during the cab mock-up review.

The operating levers for the seat adjustment shall be designed to prevent unauthorized removal of knobs. Seat adjustment controls shall be operable from the seated position. All locking mechanisms shall have positive engagements.

6.4.1.2 Seat Construction

Seat framing shall be corrosion resistant tubing with an approved black finish. The frame members shall be joined together using proper welding techniques. All seat frame tubing shall have the ends closed. A locking mechanism shall be added to hold the seat in the up position. Where applicable, rubber shock absorbers shall be added to the train operator seat to cushion the vertical motion of the seated operator upon release of the locked seat.

The back rest shall be positioned at an angle of 95 degrees to 97 degrees from the horizontal.

The seat cushion shall consist of a minimum of 3 inches (76 mm) of low smoke, flexible foam meeting the requirement of Sections 15.11 and 15.25. The back cushion shall consist of a minimum of 2 inches (51 mm) of low smoke, flexible foam meeting the testing requirements for seat cushions listed in Section 15.11 and 15.25.

Cushion shape shall be accomplished by either fabrication or molding of the cushion material.

The front edge of the seat cushion shall be properly supported to prevent collapse of the front edge when the Train Operator is sitting on the seat.
The seat upholstery material shall be made of black woven, transportation-grade fabrics of 90 percent wool and 10 percent nylon blend, with a minimum weight of 840 grams per linear meter (27 ounces per linear yard) or approved equal. The material shall meet the physical property requirements of Section 15.12 and the flammability and smoke emissions requirements of Section 15.25.

In all positions, the seat and its attachment to the floor shall meet, without permanent deformation or disengagement, the following loads:

- A vertical, uniformly distributed load of 330 pounds (1,468 N) applied at the forward edge of the seat.
- A horizontal, uniformly distributed load of 250 pounds (1,112 N) applied to the forward edge of the seat along every direction in the horizontal (but one direction at a time).

6.4.2 Coat Hook

A folding, flush, nickel-bronze coat hook shall be provided in each cab on the cab rear partition.

6.4.3 Air Comfort

Two adjustable forced-air diffusers, as described in Section 12.2.4.2, shall be provided in each cab ceiling. Floor heaters, one on each side of the cab, shall be provided as described in Section 12.3.3.2.

6.4.4 Windshield Wipers and Washers

Windshield wipers and washers shall be provided as described in Section 3.20.1 and 3.20.2 respectively.

6.4.5 Heated Windshield

A heated windshield as described in Section 3.10.3 shall be provided in each cab. An on-off control shall be provided on the console, reference Section 6.6.5. The heated windshield shall be enabled only in an active cab, and visual indication provided on the console. If required, a resettable high limit thermostat or timing device to remove power from the windshield heating element shall be provided to prevent excessive temperatures. The device shall be designed to protect the windshield from overheating at any ambient temperature.

6.4.6 Visor

An adjustable translucent visor shall be provided in each cab for the windshield and right side cab window such that the Train Operator can limit sunlight coming through the windshield and side window.

Visors shall be the Rosco 927FX sun visor, or approved equal, which shall cover the width of each windshield and the separate side window. The visors shall be positionable over the full height. Vibration and normal car motions shall not cause the visor's adjusted position to change. The visor color shall be grey No. 2074.
6.4.7 Cab Lights

Reading lights, as described in Section 14.2.4, shall be provided in the ceiling of the cab.

A fluorescent light, as described in Section 14.2.4, shall also be provided in the ceiling of the cab.

6.4.8 Convenience Outlet

There shall be a 120-volt, 60-Hertz, 20-ampere heavy duty duplex convenience outlet in each car, as described in Section 9.11.

6.4.9 Monitoring and Diagnostic System Connectors

Each cab shall include conveniently located connectors to permit access to the Monitoring and Diagnostic System (MDS) as specified in Section 8.3.1. These connectors shall include the standard PTE connector and any connectors required for use of the System Level Dynamics Tester (SLDT) as described in Section 8.3.1. If the PTE connector in the cab is other than a type without significant wear-out modes, it shall be furnished with a semi-permanently-installed sacrificial adapter that shall absorb wear due to repeated connection and disconnection of the laptop computer and shall resist loosening due to vibration and use. The sacrificial adapter shall be of a type readily available as a commercial product and shall be replaceable with only standard hand tools. Absence of the sacrificial adapter shall not preclude use of the connector.

6.4.10 Cab Door Window Light Control Film

A polarized, light-control film as described in Section 3.10.6 shall be provided on the window in the cab partition door.

6.4.11 Intentionally Blank

6.4.12 Instrumentation Through Floor Access Port

A through-the-floor access port shall be provided within each A Car cab. The access port shall consist of two, one-inch diameter conduits located in the cab wall or cab partition, to be used for NYCT’s running of instrumentation wiring. These conduits shall have removable caps and meet the floor fire resistance requirements of Section 15.25.4.

6.4.13 Intentionally Blank
6.5 Cab Controls and Indications

6.5.1 General

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Each cab shall be provided with the control and indicator panels specified in Sections 6.6 through 6.9. For reference, these include:

- A console, including one Train Operator’s Display (TOD) and a Master Controller (MC),
- Two Master Door Control panels,
- A Bypass and Cutout panel, and
- Two circuit breaker panels.

Each cab shall be capable of taking control of the train regardless of its position in the train. Mid-cab operation may be accomplished by using bypass switches for trainline interlock functions.

All controls and indicators shall be located and identified in a logical and orderly manner. Each control or indicator that is associated with a particular side of the train shall be positioned on the corresponding side of its panel. Controls shall be located such that they are conveniently reached, based on their importance or frequency of use.

The Contractor shall submit layouts of the cab and panels for approval by NYCT. Upon approval, the approved design shall be incorporated in the cab mock-up for final approval.

6.5.2 Identification

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All controls and indicators not implemented on the TOD shall be identified by raised lettering and/or raised graphics and/or engraved lettering with a depth of 0.012” to 0.015” on the panel. The panel shall be black with the raised lettering remaining in a polished natural metal color or the engraved lettering filled with white paint. Multi-position controls shall have all positions identified. Continuously variable controls shall have all salient positions identified.

6.5.3 Panel Construction

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All controls and indicators shall mount to aluminum panels fastened to the panel cabinet or enclosure. Wall-mounted panels shall match the wall color scheme.

The console and all other panels not in a vertical position shall be designed so that liquid spilled on the surface will not damage or interfere with operation of controls, indicators, or wiring. All panels shall have a finish that can be cleaned with a soap solution in water.

6.5.4 Control and Indicator Devices

Switches and pushbuttons, where used, shall be of the heavy-duty type, shall be arranged to prevent entrance of dirt or dust, and shall comply with the requirements of Section 15.30. Switches and controls shall be
designed to prevent inadvertent actuation. Pushbuttons shall be flush with the top of the bezel in the undepressed state, unless otherwise approved. Clearance between each pushbutton and its housing shall be as tight as practicable to prevent unauthorized insertion of devices, such as pins, to hold buttons down. Switch guards may be applied where approved.

Indicators, where provided, shall be illuminated from the low-voltage power supply by a minimum of two LEDs in parallel. Indicators shall be capable of being replaced from the rear of the panel; lenses shall not be removable from the front of the panel.

All cab controls and indicators shall be arranged to withstand, without damage, intermittent exposure to water and car washing fluids such as may occur when the cab window is inadvertently left open.

6.5.5 Indicator Test Function

An indicator test function shall be provided in the console. It shall provide a test of all indicators located within the cab. It shall be active only when the train is not in motion. All indicators and associated circuitry shall be arranged in such a way that a fault in the indicator test function shall not interfere with the function of any other car system, function, or interlock.

6.6 Console

6.6.1 General

The console shall be located in the right side of the cab, behind and centered on the windshield.

The console shall include controls and indications for train activation, train supervision, and train operation, as specified in Sections 6.6.4 through 6.6.11. These include:

- Individual switches, pushbuttons, and indicators,
- Integrated controls and indicators implemented via the Train Operator’s Display (TOD), and
- A Master Controller (MC).

Console control and indication functions shall be implemented either as conventional switches, pushbuttons, indicators, and the like, or as “soft” controls and indicators presented via the Train Operator’s Display. Except as specified below, the assignment of controls and indicators to these two alternatives shall be conducted as part of the design development process, shall reflect the policies and practices of NYCT, and shall be approved by NYCT. Note, however, that control and indicator functions shall be assigned such that full operational capability is available with an inoperative TOD.

The design of controls, indicators, and displays shall include space provisions to support future operation under the CBTC system described in Section 7.5.
6.6.2 Arrangement

The console operating face angle and operating face height shall be properly positioned to accommodate a seated Train Operator. The console top surface shall be sloped towards the Train Operator. Console indicators shall be positioned to be in the line of sight of the Train Operator when the Train Operator is in the normal driving position. In addition, those controls that must be manipulated while coupling cars shall be arranged for safe and convenient operation by a Train Operator standing up next to the console looking at the coupler through the open end door.

The Master Controller handle shall have a central location in the console. Console equipment shall be arranged for convenient operation of the Master Controller handle by either the right hand or the left hand, at the Train Operator's option.

6.6.3 Construction

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The console operating face shall be constructed of corrosion-resistant, cigarette-burn-resistant, flat black, non-reflective, anodized aluminum. The MC, the TOD, and other distinct, functionally integrated subassemblies shall be installed as connectorized modules to facilitate their rapid removal and replacement, shall be replaceable from the front of the console and shall be secured by not more than four mounting screws each. The remaining portion(s) of the console face panel shall be secured by not more than four mounting screws.

6.6.4 Train Operator’s Displays

6.6.4.1 General

Each cab console shall be provided with one Train Operator’s Display (TOD), which shall act as a combined display and manual input device for the Train Operator and other authorized NYCT personnel. The location and orientation of the TOD shall be suitable for continual reference to and actuation of the TOD by the Train Operator, without discomfort or fatigue beyond that which would be experienced with conventional controls and indicators.

The TOD shall be arranged to be clearly visible to the Train Operator under all lighting conditions encountered in normal operation, ranging from bright sunshine to darkness, without at any time developing a brightness level that interferes with the Train Operator’s vision. Fixed shields, display dimming, and similar methods shall be employed as required. Display dimming, if employed, shall be automatic, requiring no action on the part of the Train Operator.

The assignment of controls and indicators to the TOD shall be such that normal train operation may continue indefinitely with loss of the TOD. Controls and indicators necessary for normal operation shall not be integrated into the TOD, but shall be provided as discrete devices.
6.6.4.2 Construction

The TOD shall be a high contrast, color, touch screen display of the infrared type or other approved type, with associated processor(s) and logic, suitably rugged for the application, and requiring no adjustment or maintenance except that which is consistent with NYCT current practice for cab-mounted equipment. If the TOD is not inherently rugged, it shall be provided with a rugged, transparent protective cover. It shall support both text and graphic presentation of information. The touch screen function shall be suitable for easy manual actuation, including actuation by a Train Operator wearing driving-type gloves. The human interface for the TOD shall comply with Section 5.6.2 of MIL-STD-1472.

The TOD shall be self-contained, requiring no external controls, other than clearly indicated touch screen interface buttons, and/or menus to allow the crew and maintenance personnel to communicate with the Monitoring and Diagnostics System and other vehicle systems.

The TOD shall perform logical processing related only to the presentation of information on its screen, to the interpretation of Train Operator inputs from its screen, and to communication with other processors and devices on the car. No other control or monitoring function shall be implemented within the TOD. Processors embedded in or associated with the TOD shall comply with the requirements of Section 16.

6.6.4.3 Screens

The TOD shall provide four primary screen displays for interface with the train crew and maintenance personnel. These shall be the Operating Screen, the Control Screens, the Trouble Screen and the Maintenance Screens. The default display shall be the Operating Screen as described in Section 6.6.4.4.

Each screen except the Operating Screen may employ one or more levels of subsidiary screens which present more extensive information and control choices. No subsidiary screen shall be employed unless the complexity and scope of the information to be presented preclude its inclusion directly on a higher level screen. Subsidiary screens shall be arranged hierarchically, with a consistent interface to facilitate moving up and down the hierarchy. Where the same information is provided on several different screens, it shall be presented the same way (text, graphics, color) and in the same location, but not necessarily the same size. Screen areas designated for touch activation shall be arranged for convenient, reliable use by a Train Operator wearing gloves, under the dynamic conditions encountered in a transit vehicle cab. Activation of a touch area shall be acknowledged by highlighting of the area, such as by reverse video. The interface for screen selection shall be consistent among all of the screens.

Information shall be divided among and presented on screens in a logical and orderly manner. Information shall be displayed textually and/or graphically, depending on the clearest and most efficient way to present each item of information. No information shall be displayed in any code that is not immediately understandable by human beings, such as hexadecimal numbers or arbitrary alphanumeric designators. Abbreviations, reference designators, and mnemonic codes already conventional in NYCT operations may be employed with NYCT approval.
Each of the TOD screens shall be the same in content and layout regardless of where it is displayed, but selected control functions may be locked out where not appropriate to the particular display location, as indicated by a “graying-out” of the affected screen areas, or comparable techniques.
6.6.4.3.1 Operating Screen

The Operating Screen shall present information and control functions useful to the Train Operator when the train is in motion or during a normal station stop. Information displayed on the Operating Screen shall be arranged according to relevance to operation of the train. Items of greater importance shall be largest and most centrally located. Items of less importance to the Train Operator shall be given smaller or more peripheral display. Items with urgency shall flash to catch the Train Operator’s attention. Flashing of such items shall be canceled by the user's activation of a Fault Acknowledge control provided on the console.

6.6.4.3.2 Control Screens

The Control Screens shall present information and control functions relevant to set up, configuration, or preparation of the train for service but which are not needed often enough to warrant their inclusion in the Operating Screen. Setup functions accessed from the TOD shall be limited to monitoring and diagnostics, signs and announcements.

6.6.4.3.3 Trouble Screen

The Trouble Screen shall provide pertinent information to the Train Operator or Road Car Inspector concerning conditions which affect the immediate operation of the train. The Trouble Screen is described in Section 8.2.2.1.

6.6.4.3.4 Maintenance Screens

The Maintenance Screens shall provide pertinent information to maintenance forces to assist in maintenance, troubleshooting, and repair of the equipment in the shop environment. The Maintenance Screens are described in Section 8.2.2.2.

6.6.4.4 Screen Operating Modes

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The TOD in a cab shall be activated:

- When the Master Controller Key Switch in the same cab is placed in an active position; or
- When the Master Door Controller in the same cab is activated.

In addition, means shall be provided for maintenance personnel to activate the TOD in any cab.

The allocation of controls and indicators to the TOD shall provide for full operating capability with an inoperative TOD.

In normal operation, the TOD shall, when first activated, display the Operating Screen.
It shall be possible to select the other screens by manual action(s).

The TOD shall have a “sleep” timer, which can be adjusted or disabled by maintenance personnel through use of the PTU. It shall also have a “sleep” mode to blank the screen when the train is keyed up but stopped for a certain interval with no user interaction and to blank the screen after an interval of no user interaction in a cab which is not keyed up.

Display and menu activity shall occur concurrently with normal data collection and processing activities, without impacting any of the functions.

6.6.5 Console Individual Controls

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As a minimum, the following individual controls, with the type of switch indicated, shall be included on each console. Refer to the indicated Section for functional details. All pushbuttons shall be resistant to damage including that due to twisting, unless otherwise approved.

- Horn Pushbutton (yellow) (see Section 10.3.3.5);
- Indicator Test: Momentary "On" for all indicators (see Section 6.5.5);
- Master Key Switch for left side door operation (see Section 11.6.3);
- Left Door Open Pushbutton (see Section 11.6.3);
- Cab Light Controls (see Section 14.2.4);
- Master Controller Key Switch (see Section 6.6.7.1);
- Provision for a Left Door Close Pushbutton (see Section 11.6.3);
- Master Controller (see Section 6.6.7);
- Buzzer Pushbutton (see Section 13.3.3);
- Communication Controls (see Section 13.1.4);
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- Forward or Reverse Direction Control;
- Power Interlock Bypass (see Sections 11.10.2 and 7.3.2);
- Friction Brake Running Test Control (dynamic brake cutout); Circuit Breaker on auxiliary panel (see Section 10.2.2.8);
- Snow Brake On/Off Control (see Section 10.2.13.2);
- Communications Controls, including Public Address, Passenger Emergency Intercom, Cab Intercom, and Radio; on console and MDC (see Section 13.1.4);
- Coupler Control: Couple keyswitch, Uncouple, Isolate, Advance (see Section 5.5);
- Windshield Wiper Control (see Section 3.20.1);
- Windshield Washer Control (see Section 3.20.2);
- Cab Heated Windshield Control, with integral indicator (see Section 6.4.5);
- Cab Heater Off/Low/High Control (see Section 12.3.3.2);
- HVAC On/Off Control (see Sections 12.5.1);
- Interior Lights On/Off Control (see Section 14.2.3); and
- Left Door Enable Control with integral enable indicator (see Section 11.6.5).
- Right Door Enable Control with integral enable indicator (see Section 11.6.5).

6.6.6 Console Control and Indicator Functions

6.6.6.1 Control Functions

As a minimum, the following control functions shall be provided as part of the cab console TOD.

- Fault Acknowledge; Operating Screen (see Sections 2.5.5.3 and 6.6.4.3.1);
- Route and Destination Set-Up; Control Screen (see Sections 13.2.1.1.1 and 13.5);
6.6.6.2 Visible Indications

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As a minimum, the following visible indications shall be provided as part of the cab console (either as individual indicators or on the TOD). Indication colors shall conform to the convention established in Section 2.5.4, unless otherwise approved. Individual indicators shall be provided except where the indicator is explicitly assigned to the TOD.

- Train Speed Indication (digital) (see Section 6.10);
- No-Motion; Trouble Screen (see Section 10.2.2.3);
- Door Enable Indications (see Section 11.6.3.9);
- Doors Closed and Locked in Train Indication (see Section 11.10.2);
- Snow Brake On/Off Indication; Operating Screen (see Section 10.2.13.2);
- Next Stop (as displayed on interior message displays); Operating Screen (see Section 13.5.1);
- Fault Indication (flashing); Operating Screen (see Section 2.5.5.3);
- Passenger Emergency Signal (PEHU) Indication (with exact location); Trouble Screen (see Section 10.3.3.6);
- Communications Mode and Status Indicators, including Public Address, Passenger Emergency Intercom, Cab Intercom, and Radio (see Section 13.1.4); on the console;
- Consist Indication (cars in train, with car numbers shown in order and lead car indicated); Trouble Screen;
- Brake System Status Indications:
  - Friction/Parking Brake Released (see Section 10.2.13.2 and 10.3.6) with green indicator;
CAB AND CAB CONTROLS

♦ Location of applied friction brake/parking brake (Trouble Screen);
♦ Brake Cylinder Pressure (Duplex Air Gauge) (see Section 10.2.13.2, 10.3.3.4); and
♦ Brake Pipe Pressure (Duplex Air Gauge) (see Section 10.3.3.4).

In addition, Brake Cylinder, Brake Pipe and Main Reservoir pressure indications shall be provided on the TOD (Trouble Screen).

- Route and Destination; Control Screen (see Sections 13.2.1.1.1 and 13.5);
- Door Interlock Bypassed; Control Screen (see Section 6.8.2);
- No-Motion Bypassed; Control Screen (see Section 6.8.2);
- Regenerative Brake Cutout; Control Screen (see Section 6.8.3);
- Time and Date Indication (hh:mm in the 24-hour system and MM-DD-YY); Operating Screen;
- Cab heated windshield, integral to the control switch (see Section 6.4.5); and
- C/R indication; Operating Screen.

6.6.6.3 Audible Indications

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Audible indications shall be provided in the cab for at least the following events. Each indicator shall have a distinctly different sound and shall be no louder than required for audibility over the ambient sound levels in the cab.

- Passenger Emergency Intercom (see Section 13.2.1.3);
- Buzzer (see Section 13.3.2);
- Parking Brake Applied with Train in Motion (see Section 10.3.6);
- Direction set to Reverse;
- Passenger Emergency Signal (PEHU) (see Section 10.3.3.6); and
- Radio Transmit Timeout (see Section 13.4.2.1).
6.6.7 Master Controller Group

The console shall include a master controller and related equipment for propulsion and braking control, as specified in Sections 6.6.7.1 through 6.6.7.3. For reference, this equipment group shall include:

- A Master Controller Key Switch, and
- A Master Controller (MC).

6.6.7.1 Master Controller Key Switch

Each console shall be provided with a key-locked, two-position key switch to select the cab status. The key lock may be integral with the switch or may be a separate assembly mechanically interlocked with it, and shall accept the standard Master Controller Key. The positions of the switch shall be as follows:

- KEY OUT. This shall be a maintained position. When the switch has been moved to this position and the train has come to a stop, cab controls shall be inactive unless activated via the Master Door Controller, the propulsion system shall not be energized, and train operation shall not be possible.
- RUN. This shall be a maintained position. In this switch position, all systems shall be energized and train operation shall be possible. Cab controls shall be active.

The term "active cab" used elsewhere in the Specification indicates a cab in which the Master Controller Key Switch is in the RUN position. When all Master Controller Key Switches in a train have been moved to the KEY OUT position, systems other than propulsion shall remain in the previously commanded state. Provision shall be made for implementation of a “sleep” mode in which these systems shall shut down after a pre-determined period of time.

6.6.7.2 Master Controller

Control of both propulsion and braking shall be obtained through an all-electric, single-handle Master Controller (MC) designed for left-hand or right-hand operation with equal comfort. The MC shall operate longitudinally with maximum power in the forward-most position, coast in the middle position and emergency brake in the rear-most position.

The handle design shall minimize strain and fatigue on the Train Operator. Data specific to the magnitude of the spring load, force required to overcome detents, handle travel between detents, force required to forestall deadman feature, and other ergonomic aspects shall be provided and approved during the design reviews.

The MC shall use cam-operated switches of modular construction to carry out its digital controlling functions. As a minimum, separate switches shall be provided for power/brake mode, deadman, and emergency brake functions. Cam-operated switches shall be of transit-propulsion-equipment quality to and shall be designed to provide a life of at least $3 \times 10^7$ cycles in this application. Analog functions shall be generated by directly-
driven absolute Gray-coded encoders. Encoder resolution shall be such as to provide a minimum of sixteen steps of modulation in the power mode and sixteen steps of modulation in the brake mode.

The MC shall incorporate duplicate and independent sets of internal electrical and electronic components, including switches and encoders and their associated mechanical actuators, arranged in such a manner that possible single points of failure shall be limited to major mechanical components of the MC, such as main shaft bearings. Each set of components shall constitute a separate logical and physical node on the Car Network described in Section 7.3.4 and shall communicate by means of the Car Network with the Trainline Controller(s) associated with the same cab.

All MC parts shall be replaceable with common hand tools. The MC as a whole shall be arranged as a modular, connectorized unit, shall be secured with a minimum number of fasteners to facilitate replacement in the field in the event of failure, and shall not weigh more than twenty pounds unless approved by NYCT. The MC shall incorporate diagnostic capability with built-in indicator(s) visible by opening the console and shall report its condition to the Monitoring and Diagnostic System. Alternate means of achieving comparable diagnostic function may be proposed.

The Master Controller handle positions with positive detents shall be as follows:

- **MAXIMUM POWER**
  - Maximum acceleration rate as stated in Section 2.4.2.1;
- **MINIMUM POWER**
  - Minimum acceleration rate as stated in Section 2.4.2.1;
- **COAST**
  - Nominal zero acceleration and zero deceleration;
- **MINIMUM BRAKE**
  - Minimum service brake deceleration rate as stated as acceleration rate as stated in Section 2.4.3.1;
- **FULL SERVICE BRAKE**
  - Maximum acceleration rate as stated in Section 2.4.2.1;
- **EMERGENCY BRAKE**
  - Emergency brake application; and
- **SHUT DOWN**
  - Storage position permitting Master Controller Key Switch to be moved to KEY OUT position.

The MC shall provide continuously variable handle positions between the MAX POWER and MIN POWER positions, and between the MIN BRAKE and FULL SERVICE BRAKE positions. There shall be a detent between the MIN POWER and COAST positions and a detent between MIN BRAKE and COAST. There shall be a detent between the FULL SERVICE BRAKE and EMERGENCY BRAKE positions, which shall require a greater force to overcome than the detents at the COAST position. The "feel" of the controller is extremely important, and a sample controller shall be presented for approval.
The MC handle shall have a twist-type deadman feature that shall be highly resistant to deliberate attempts to defeat its operation. The design shall incorporate hysteresis in the deadman detection and reset points. The deadman feature shall be rendered ineffective when the MC handle is in the FULL SERVICE BRAKE or the EMERGENCY BRAKE position, or when the Master Controller Key Switch is in other than the RUN position. The deadman feature shall function as part of the Deadman Control specified in Section 6.6.8. The twist feature shall not require any awkward or uncomfortable position or motion of the hand when initially grasping the handle.

### 6.6.7.3 Interlocking

Interlocking between the Reverser, the Master Controller Key Switch and the Master Controller handle in each cab shall be by direct mechanical means, robust enough to withstand attempts at out-of-sequence operation. The following interlocks shall be provided:

- It shall be possible to move the Master Controller handle out of the SHUT DOWN position only when the Master Controller Key Switch is in the RUN position.
- It shall be possible to move the Master Controller Key Switch to a position other than the RUN position only when the Master Controller handle is in the SHUT DOWN position.
- It shall be possible to remove the Master Controller Key from the switch only when the switch is in the KEY OUT position.
- Interlocking with the reverser switch shall be such that the reverser cannot be moved unless the Master Controller Key Switch is in RUN and the Master Controller is in the FULL SERVICE BRAKE, EMERGENCY BRAKE, SHUTDOWN or COAST positions.

Control circuits shall be arranged such that brakes will not release when more than one Master Controller Key Switch in the train is in other than the KEY OUT position.

It shall be possible to operate the train from any cab, including those in intermediate positions, without any limitation in control capabilities.

### 6.6.7.4 Master Controller Operating Modes

The Master Controller and associated circuits shall be designed to operate in conjunction with the Trainline Controller specified in Section 7.2.

### 6.6.8 Deadman Control

A deadman control shall be provided that determines incapacitation of the Train Operator. The deadman control shall comprise of the master controller handle deadman feature specified in Section 6.6.7.2.
Actuation of the master controller handle deadman feature shall result in immediate initiation of an emergency brake application. Recovery from the emergency brake application shall be as specified in Section 6.6.11.

6.6.9 \textit{Intentionally Blank}

6.6.10 Car Servicing Function

A car servicing function shall be provided to enable the train to be activated for cleaning and other related maintenance without the use of any key. When a train is not activated (i.e., keyed-in), the console controls for the HVAC system and full interior lighting activate the respective system on a train basis for a software-adjustable period of time, initially set to sixty minutes. The timer shall be retriggerable. The function shall be available from any console. At the end of the time period the affected equipment shall automatically return to its previous status. Activation of the train by any Master Controller Key Switch shall immediately cancel the car servicing function. Activation of the car servicing function shall also cause the energization of other car systems, such as auxiliary power, as necessary to support operation of the HVAC and lighting systems. Load shedding shall take precedence over car servicing.

6.6.11 Emergency Brake Control

Each cab shall include a conductor’s emergency brake valve with two handles. One handle shall be located above each cab side window, arranged for easy actuation by a Train Operator standing next to the window. Activation of the brake valve shall immediately exhaust air pressure from the brake pipe and shall immediately cause an emergency brake application to be initiated. The conductor’s brake valve shall be active at all times.

Release of an emergency brake application shall be accomplished by placing the active Master Controller handle in the FULL SERVICE BRAKE position and actuating the Emergency Brake Charging control on the cab console. Detailed requirements for emergency brake system operation are specified in Section 10.3.1.2.

6.6.12 Brake Pipe Leak Detection

In the event of a brake pipe system leak, means shall be provided to do the following:

- For the purpose of Brake Pipe Leak Detection-With the master controller keyed OFF, provide a continuous air supply to the brake pipe system sufficient to allow audible detection of the brake pipe leak, but insufficient to charge the brake pipe.

The design must be submitted and demonstrated to NYCT for approval.
6.7 Master Door Control Panels

MOD 02

Two Master Door Control Panels shall be provided in each cab, one convenient to the window at each side of the cab. MDC color shall match that of its mounting location. The Master Door Control Panels shall include, as a minimum, the following controls and indicators:

- Side door controls and indicators as specified in Section 11.6.3; and
- Communications controls and indicators as specified in Section 13.2.3.1.

6.8 Bypass and Cutout Panel

6.8.1 General

A Bypass and Cutout Panel incorporating required bypass and cutout switches shall be provided in each car as specified below. In Cab Cars, the Bypass and Cutout Panel shall be a located in a separate locker at a convenient location in the right side of the cab. In Non-Cab Cars, the Bypass and Cutout Panel shall be located in a readily accessible locker within the passenger compartment at the No. 1 end of the car. Each Bypass and Cutout Panel shall be equipped with a substantial, self-latching door that shall be opened using the standard Master Door Controller key. Switches in the Bypass and Cutout Panel shall comply with the requirements of Section 15.30.

6.8.2 Bypass Switches

CO 03

Bypass switches shall be secured by a frangible pin or seal, so that they cannot be moved to the bypass position without leaving a permanent record. The frangible pin or seal shall be breakable by the Train Operator by normal means without the use of tools.

A mounting location for a train-level CBTC Bypass switch (see Section 7.5) shall be provided only on A Cars.

A car-level No-Motion Bypass switch (see Section 10.2.2.3) shall be provided only on A Cars in the Bypass and Cutout Panel to provide a No-Motion Signal in the event of a no-motion circuitry failure. When activated to the Bypass position in the active cab, No-Motion Signal shall be issued to overcome a failure in the speed detection logic. The bypass function shall be annunciated on the cab console display.

A door enable bypass switch (see Section 11.6.5) shall be provided on each MDC to allow the door enable functions to be bypassed when operating doors from that MDC. The bypass switch shall not affect door operation from any other MDC.

6.8.3 Cutout Switches

The following cutout switch shall be provided only on A Cars and shall be effective only when the Master Controller Key Switch is in an active position in the same cab.
CAB AND CAB CONTROLS

Contract No. R34142A  NYCT Division A

Regenerative Brake Cutout (see Section 10.2.1.2.1.1).

6.9 Circuit Breaker Panels

Circuit breaker panels for all low voltage and auxiliary three-phase ac circuits shall be provided in each car. Separate panels shall be provided for low voltage and 230 Vac circuits. Circuit breaker panels shall conform to the requirements of Section 15.30. Each circuit breaker shall be identified to indicate the circuit it protects.

A protective device shall be provided to secure the Event Recorder Circuit Breaker from any accidental tripping.

In A Cars, the circuit breaker panels shall be conveniently located within the cab. In B Cars, the circuit breaker panels shall be located in the No. 1 End wall below the window. Each circuit breaker panel shall be equipped with a substantial, self-latching door that shall be opened using the standard Master Door Controller Key.

The High Voltage Contactor Controls described in Section 9.3.4 shall be included in the auxiliary three-phase ac circuit breaker panel.

6.10 Doppler Radar Speedometer MOD 02

The speedometer shall be driven by a Doppler Radar speed measuring system per NYCT Specification 2083-PROD-95. Note that the referenced NYCT specification is provided for technical information only. Requirements in Specification 2083-PROD-95 specific to the stand-alone procurement of speedometers are superseded by the requirements of this Contract.

The Doppler Radar speed measuring system shall provide outputs to the console-mounted speedometer and the monitoring and diagnostics system. An additional output shall be provided to permit the speed measuring system to be connected to the event recorder. Interface to the speedometer shall be such that speeds below a pre-determined low speed threshold shall cause the speedometer to read zero. This will avoid non-zero speed readings at standstill caused by measuring system errors. The speedometer shall be active in all cabs of a train, including coupled cabs.
# SECTION 7

## TRAIN AND CAR CONTROL

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### 7.0 TRAIN AND CAR CONTROL

- General

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Conformed Contract Document TOC-1 R142A Vehicle Specification
Issued: September 16, 1999
SECTION 7

7.0 TRAIN AND CAR CONTROL

7.1 General

This Section of the Specification describes the mechanism by which the train control information and other data is communicated among the various pieces of car borne equipment. Crew controls are physically described in Section 6, with additional logical descriptions in the individual systems sections. This Section also provides requirements for the provisions for Communications-Based Train Control.

The train controls shall be designed for the following operation:

- The Train Operator will select any A Car in the train from which to operate the train.
- The crew will select any A Car in the train from which to operate the doors and perform related functions.

The train control system design shall include a response time budget analysis associated with the various commands and data. The response time budget shall allocate time categories, including source processing time, transmission time, destination processing time. The response time budget shall be submitted for approval by the NYCT. The overall system and each element of the system shall be demonstrated to have complied with its response time requirements.

7.2 Trainline Controllers

Each A Car shall contain a group of master control devices. These include the Master Controller itself, as well as various other console controls and indications. These devices shall operate as independent distributed controls, providing and receiving data from the various train-borne systems with which they are associated. The systems using these signals shall each determine the appropriate response to a set of device signals. To this end, systems using these signals shall compare the signals from the various cab devices, check for discrepancies in the signals, and respond in an approved manner. Regardless of supplier, tramline control logic shall be identical for systems performing the same functions, but on different cars.

7.3 Trainline and Local Signal Architecture

7.3.1 General

Trainlines shall consist of discrete wires for selected signals, digitized multiplexed audio signals, common negative reference, and networks for all other signals and data. For transmission through the automatic electric coupler, audio and network data shall be multiplexed using an approved T1/E1 type multiplexing system. Inasmuch as the trainline/network concept is a departure from the historical NYCT concept, the Contractor shall submit a detailed plan regarding the identification and manner of transmission of all control signals. This plan shall include a preliminary Safety and Hazard Analysis, as defined by Section 18.4.2. This plan shall be submitted in advance of the Preliminary Design Review, for discussion at that review.
The graphic depiction of the train and car control architecture illustrates the basic requirements. The chart that follows the graphic depiction identifies trainline signals around which the Specification is structured. Note that the charts represent an estimate of the trainline and coupler pin requirements; final determination of these requirements is the responsibility of the Contractor, as approved by NYCT. Signals listed in the first chart include those which are considered critical and are transmitted by discrete wires and coupler pins. Other signals (e.g., those in the second chart, and any other non-critical signals) shall be transmitted over the coupler as T1 /E1 type multiplexed signals.

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### Signals Transmitted via T1/E1 Type Multiplexer

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* Use of coupler contacts on the vertical center-line of the coupler will reduce the number of necessary contacts. Network trainlines shall be among those that are not on the vertical center-line.

** Implementation Dependent. Refer to the Specification text for additional information.

*** It is estimated that two pin-pairs are needed for the multiplexed signals.

#### 7.3.2 Discrete Trainlines

Conventional battery level trainlines shall be used for the functions in the table above, with the exception of the Audio Circuits and the Train Networks.
The emergency brake trainlines shall consist of one trainline wire configured as follows:

- The emergency brake trainline shall pass through every car in the train. Emergency activation devices in each car shall independently effect an emergency brake application in every car by energizing the emergency brake trainline and locally venting the brake pipe.
- The emergency brake trainline shall feed the emergency application valve circuit on each car in the train.

The power interlock trainline shall provide a positive indication to the Trainline controller that each car in the train has met certain minimum requirements prior to allowing train movement. Included in the Power Interlock trainline shall be the indication that all doors in the train are closed and locked and all parking and emergency brakes are released. Refer to Section 10.2.2.4 for related requirements.

The number of Door Control Trainlines will be dependent upon the technology used to implement the door system.

7.3.3 Audio Trainlines

CO 63

CO 204

The audio signals consist of Public Address, Passenger Emergency Intercom and Crew Intercom operation. All audio and associated control shall be digitized in an approved manner and transceived over two pairs of wires, and shall allow for simultaneous operation of the three types of audio communication, according to an approved priority. Refer to Section 13 for additional requirements. Audio trainline signals shall be transmitted over the coupler using the T1/E1 type multiplexer.

Maintenance of the multiplexer equipment shall be arranged such that the effects of errors are minimized. Equipment used on the R142 and R142A, which appears similar, should employ methods such as keying or modified mounting provisions to prevent installation of non-interchangeable parts.

7.3.4 Trainline and Car Networks

There shall be two redundant trainlined control networks. The design shall allow either network to operate the train in the event of a failure of one of the networks. Management services for the trainline networks shall be provided within the Trainline Controller except as approved. The NYCT will consider alternate scenarios where the two trainlined networks carry different data, as long as the functional network will be used, albeit minimally, for total train operation when one network fails. Diagnostic type data shall be communicated using an independent network.

Each car shall include a Car Network Controller. The Car Network Controller shall manage the local car network(s) and manage the data flow between the local car network(s) and the trainline networks. Data that does not need to pass between the various networks shall be restricted from so doing. Car Network Controllers shall be considered as functional entities that can be physically implemented within a more comprehensive computer. The controller shall automatically identify the car upon which it is installed.
All network(s) shall be implemented using LonMark™ interoperable components. Local car networks shall use free topology transceivers operating at 78 k bits per second. Multicar networks may use free topology transceivers operating at 78 k bits per second, or other approved hardware configurations. Network trainline signals shall be transmitted over the coupler using redundant T1/E1 type multiplexers. Refer to Section 7.4 for general network requirements.

7.3.5 Alternative Configurations

The Contractor may, at its option, submit a proposal of and an analysis for an alternate train and car control scheme. The Contractor’s submittal shall describe each element of the design, the reasons for the particular implementation, and the reasons why such a system would be more beneficial to the NYCT. Factors in the analysis shall include performance, reliability, maintainability, and life-cycle cost.

7.4 Network Requirements

The following general principles and requirements shall be applied to all network designs:

7.4.1 General

- The network protocols and transmission methodology shall be as approved by the NYCT.

- The network system shall utilize an open design that is either non-proprietary or available from multiple sources with complete interface descriptions and details.

- The communication protocol shall provide services at all seven layers of the ISO/OSI communication model. All layers other than the application layer shall be transparent to the various car system suppliers.

- Network components and transceivers shall be available from multiple sources.

- The communication protocol shall support routers for interconnecting networks and for the filtering of network traffic.

- Communication related to real time control, such as propulsion control, shall be prioritized to the extent that related anomalies in system stability and operation are prevented. The Contractor shall present calculations of the variations in transmission time, as related to the real-time control requirements, for approval by the NYCT. The submittal shall include a statement of acceptability by the propulsion and the brake supplier.

- When car Units are coupled and uncoupled and when cars are connected and disconnected, the network shall automatically reconfigure itself for the new train configuration. The configuration shall identify every car in the train, by Car Number. The network system shall know the order of the cars in the train, and shall explicitly identify the ends of the train. Defective network equipment in a car shall not prevent the proper configuring of the
remainder of the train. Under such circumstances, the trainline network shall identify that the defective car is present.

- Prior to approval of the network design, the Contractor shall submit detailed calculations of peak and average data traffic levels, for approval by the NYCT. The Contractor shall also submit peak and average traffic levels for the transmission media, as recommended by the protocol supplier and for approval by the NYCT. The calculated peak and average traffic levels shall not exceed 60 percent of the recommended peak and average traffic levels.

- During vehicle commissioning the Contractor shall measure peak and average traffic levels. The actual peak and average traffic levels shall not exceed 70 percent of the recommended peak and average traffic levels.

- Protocols shall include error detection. All nodes on the network shall collect summary statistics regarding current and historical error rates and make that information available through the Monitoring and Diagnostic System.

- Physical designs shall presume that there are static and dynamic differences in the ground reference level of both cars and equipment packages within a car.

- Trainline networks and/or multiplexed signals shall be designed to consider the coupler pin connections and their limitations. The Contractor shall conduct specific tests to determine the signal voltage levels, bias voltage levels, and data speeds that are appropriate for the application. In no case shall the trainline network speed exceed 500 kilobits per second without prior NYCT approval. Audio system communication is exempt from the 500 kilobits per second requirement. The physical network shall include redundancy and shall be constructed using twisted shielded wire. Multiple logical networks may be employed.

- Network wires shall be physically isolated from sources of EMI. Where redundant networks are employed, they shall not be run in the same conduit, wireway, or other such routing path.

- In the consideration of fault tolerance, the network design shall include an evaluation of the network topology and whether the network is operated as Peer-to-Peer or Client-Server.

- A router or similar device shall be used on each car to isolate car communications traffic from the train network. It shall also prevent local car faults from interfering with train operation.

- Network communication through the automatic electric coupler by optical fiber is disallowed.

- Note related software requirements in Section 16 of the Specification.
7.4.2 Fault Tolerance and Maintenance

- Fault Immunity: Network interfaces shall be designed to minimize the possibility that a transceiver component fault could disable the network. Component faults shall not inhibit or severely degrade train control functions other than the failed component. All single point failures that would cripple a train must be identified for evaluation by the NYCT. Fault recovery shall be automatic. Furthermore, systems shall be designed so that the failure of any system to respond properly shall not inhibit or severely degrade network functions outside of the unresponsive system. The latter case includes periods of time during which a system is being reset.

- The systems designs shall allow all faults to be simply isolated. Network component faults shall cause the offending equipment to be disabled or disconnected from the network.

- The network system shall include self test features that automatically identify defective nodes.

- When nodes on the network are replaced, using parts as supplied by the manufacturer, the network system shall automatically identify the replacement equipment and its communication links.

- Portable diagnostic equipment associated with the networks shall be capable of performing detailed diagnostics and real-time monitoring of network activity. The equipment shall have the capability to disable and enable nodes on the network, and to directly communicate with any node on the network. As an aid to troubleshooting, the diagnostic tool shall be able to independently trigger an LED on each node in the train. The diagnostic equipment shall translate all data, both in and out of the diagnostic units, into engineering units. Any hexadecimal presentation of data shall be in addition to the engineering units. Protocol analyzers shall be provided for any network supplied. Refer to Section 20.4 for tester deliverable requirements.

7.4.3 Future Adaptations

- Replaceability/Upgradeability: Additions and/or changes to any vehicle system shall be easily incorporated into the existing architecture without modification to other portions of the train control system. Interfaces shall be documented as described in other portions of the Specification.

- Expandability: The architecture shall allow for additional subsystems and for additional functions within initial subsystems. The architecture shall allow for additional trainline functions without degrading network operation.

- Trainline control and monitoring data formats shall be structured in a universal fashion, not intimately tied to the needs of a particular supplier. These data formats shall be fully documented.
7.5 Communications-Based Train Control

7.5.1 CBTC Overview

The NYCT is developing its design based upon the future installation of a Communications-Based Train Control (CBTC) System. This section defines requirements that shall allow the CBTC to be installed without substantive car mechanical modifications.

The supply, functional interfaces, and installation of the CBTC is not the responsibility of the Contractor. The Contractor shall be responsible for cooperating with the NYCT in designing and providing the major mechanical and environmental installation provisions.
The CBTC is a safety critical system, and all installation and wiring provisions shall be in accordance with the corresponding requirements of Section 18.4.

Although the specific configuration of the on-board CBTC equipment has not been finalized, a general description of each component is shown below.

- **CBTC Controls:** This constitutes the basic control system. The controls will be located on the A Car and possibly distributed to the B Car.

- **Data Radio Antennas:** Two antennas will be required to be located at the No. 1 End of the A Car. Potential antenna locations include the apex and the upper corners of the car front.

- **Data Radio:** Two Data Radios will be required to be located in the A Car. Potential locations include the Cab Ceiling and the CBTC control compartment.

- **Tag Reader Antenna:** The tag reader shall be mounted on the sprung portion of the truck at the No. 1 End of the A Car, and on the car lateral centerline, in a location to accomplish its intended function.

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7.5.4 Equipment Installation Interfaces

7.5.4.1 Mechanical Mounting

- CBTC Controls: The vehicle shall accommodate a CBTC compartment which measures 24 inches (610 mm) wide by 24 inches (610 mm) deep by 20 inches (508 mm) high, exclusive of mounting brackets and connectors. All electrical interfaces shall be through the rear of the box and confined to the upper eight inches of the box. The mounting location shall allow a full-height, front-hinged cover to be raised 90 degrees.

- Data Radio Antennas: The Contractor shall provide mounting provisions for two antennas. The antennas shall be isolated from the outdoor environment, but shall be electromagnetically unobstructed from wayside radio emissions. The Data Radio Antennas shall be readily accessible for maintenance. Each Data Radio Antenna is estimated to measure 3 inches (76.2 mm) by 3 inches (76.2 mm) by 3 inches (76.2 mm).

- Data Radio: The Contractor shall provide mounting provisions for two Data Radios. The maximum distance between the Data Radio Antennas and the Data Radios, and between the Data Radios and the Control Logic will be identified in design review. The Data Radios shall be readily accessible for maintenance. Each Data Radio is estimated to measure 12 inches (305 mm) by 12 inches (305 mm) by 4 inches (102 mm).

- Tag Reader Antenna: The Contractor shall provide mounting provisions. The tag reader antenna is estimated to measure 12 inches (305 mm) longitudinally by 4 inches (102 mm) laterally by 4 inches (102 mm) high.

- Diagnostic Port: The Contractor shall provide for the future addition of a locked compartment within each cab where a CBTC diagnostic port and Bypass Switch may be located. The compartment shall be located to allow utilization of the port while the train is in operation.

7.5.4.2 Intentionally Blank

7.5.4.3 Interconnecting Wiring

The Contractor shall provide dedicated conduit mounting locations for all CBTC wiring. This includes conduit between CBTC components, conduit between CBTC and other components, and conduit between CBTC components and trainline couplers/jumpers. Wiring between CBTC components need not be installed.

7.5.4.4 Temperature

The Contractor shall design the vehicle such that the CBTC equipment is not exposed to temperatures that are greater than the other microprocessor based equipment mounted in corresponding locations (that is, underfloor, ceiling, etc).
7.5.6 Documentation
MOD 02

The Contractor shall provide a single package of detailed interface definitions for the train-to-CBTC. The package shall include definition of the mechanical interfaces which are provided.

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# SECTION 8
## MONITORING AND DIAGNOSTICS

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SECTION 8

8.0 MONITORING AND DIAGNOSTICS

8.1 General

The Monitoring and Diagnostics System consists of hardware, software and NYCT maintenance philosophy. The maintenance philosophy on which the hardware and software depend shall be defined at the system level during the earliest design reviews. A wide variety of accurate operating (status) information and current and historical fault data shall be available from all subsystems whether or not they utilize microprocessor controls. The system level maintenance philosophy shall clearly define which information is of interest under the operating conditions which will apply to the fleet. The intelligent subsystems each have their own requirements for internal self testing, diagnostics and fault logging. Some of those requirements may be of greater interest during the design and testing of the subsystems than they are when the fleet is in service. NYCT’s interest is in data which assists in operating and maintaining the fleet. The purpose of the Monitoring and Diagnostics System is to minimize the time required to troubleshoot and repair the cars. The system shall make it possible for the Operator or Road Car Inspector to immediately determine the cause of an existing or impending serious problem and take corrective or preventive action. The system shall also make it possible for maintenance personnel to troubleshoot any problems to the Line Replacement Unit (LRU) without the need to use external test equipment.

8.2 On-Board Equipment

Each Unit shall be provided with an on-board Monitoring and Diagnostics System. The system shall collect, analyze, and report information to the crew and maintenance personnel regarding the Unit subsystems.

The Monitoring and Diagnostics System shall consist of Monitoring and Diagnostic Logic (MDL) located in an electric locker in each A Car. It may also have data collection and transfer modules in each car, which facilitate interface with the intelligent subsystems of each car. It shall report information by way of the Train Operator Display (TOD) located in the cab console of each cab. Each individual car subsystem shall perform its own diagnostics and shall log data appropriate to every fault. A subset of this fault information, along with selected operating status information, shall be provided to the MDL. The function of the MDL is to gather, process, and record information from the monitored systems, and report its findings through the TOD. The Monitoring and Diagnostics System shall use the control sensors to the greatest extent possible, and independent sensors only where essential.

8.2.1 Monitoring and Diagnostics System Physical Requirements

The Monitoring and Diagnostics System shall be subject to all design and documentation requirements in Section 16 which apply to “intelligent” microprocessor-controlled systems, including spare hardware input and output and spare memory provisions. The system shall have sufficient memory capacity to save fault data for the time intervals between periodic maintenance without losing data to overwrites.
8.2.2 Interface with Train Operator Display (TOD)

The Trouble Screen and the Maintenance Screens described in Section 6 shall obtain the information to be displayed from the Monitoring and Diagnostic Logic. Each screen may employ one or more levels of subsidiary screens which present more extensive information. No subsidiary screen shall be employed unless the complexity and scope of the information to be presented precludes its presentation directly on a higher level screen. Subsidiary screens shall be arranged hierarchically, with a consistent interface to facilitate moving up and down the hierarchy. Where the same information is provided on several different screens, it shall be presented the same way (text, graphics, color) and in the same location, but not necessarily the same size. The interface for screen selection shall be consistent among all of the screens described in this Section and Section 6. All screens shall display the following information:

- Time and date: Indication of hh:mm in the 24-hour system and MM-DD-YY format.
- Consist: Graphical indication of cars in train, with car numbers shown in order with lead car indicated.

8.2.2.1 Trouble Screen

The purpose of the Trouble Screen is to provide pertinent information to the Train Crew or Road Car Inspector concerning conditions which affect the immediate operation of the train.

Information provided on the Trouble Screen shall be a subset of information being collected from the car and Unit subsystems and analog sensors. Providing the Trouble information to the TOD shall have priority over other activities of the Monitoring and Diagnostics System.

The Trouble Screen shall present, as a minimum, the following train information and functions (finalization to be reviewed and approved by the NYCT):

- Passenger Emergency Handle Unit activation: location
- Door Not Closed: location – leaf
- Door Not Opened
- Doors Not Opened: car-side
- Door Fault
- Stuck Brake: location - car, truck, side
- Brake in Emergency: location
- Insufficient Propulsion: location
- Circuit Breaker Tripped: location - breaker ID
- Auxiliary Power fault
- Air Supply Warning
- Network Fault: location and ID

“Location” information shall be graphical to show which car in train, supplemented by text including car number and enough additional detail to isolate the fault to the subsystem or component.
If corrective action must be taken immediately, the suggested action shall be listed.

8.2.2.2 Maintenance Screens

Where an R142 Unit is coupled to an R142A Unit, Maintenance Screen functions are not required to operate between Units. The MDL system shall identify this situation on the various maintenance screens. Otherwise, both MDL systems shall operate as specified below.

There shall be a selection of maintenance screens, as approved by the NYCT, arranged to provide access to all MDL functions and capabilities. Access to the functions shall be protected by a hard key (the Maintenance Key).

Status screens shall display real time status information from system, subsystem and sensors at the train, Unit and car level. Status shall include "active" faults.

Fault logging screens shall display the major failures of the car's subsystems. The fault data shall include the time, car number, the system and a brief description of the fault. Format of the individual subsystem fault logs shall be consistent regardless of the source of the fault data. The Maintenance Screens shall allow scrolling through all logged faults by subsystem. Provision shall be made to identify the most important fault modes in each car system, whether or not they are “intelligent” (microprocessor controlled), and at the system level, including time keyed in & out and consist coupling history. Provision shall be made to allow the user to scroll through the content of individual subsystem fault logs resident in the subsystems. All fault logs shall be available to the maintenance personnel for review on the screen or to be downloaded to the portable test equipment or storage card. A message "Fault Log Full" shall indicate when newer faults began to overwrite older faults in any fault log. Provision shall be made to conserve fault log memory by incrementing a counter for repetitive faults rather than making a new entry.

The Maintenance Screens shall allow access to the fault logs of every subsystem of every unit in an existing train, without the need to move from car to car.

One of the Maintenance Screens shall allow a maintainer to select customized subsets of historical or status data, such as a time frame of interest or specific data from different subsystems for display on the same screen.

One of the Maintenance Screens shall allow the maintainer to initiate self tests of all intelligent subsystems and view the results without changing screens. Testing shall be disabled when cars are in motion.

A Maintenance Screen shall allow access to the MDL's internal fault logs.

8.2.3 Monitoring and Diagnostics Logic (MDL) Functions

The Monitoring and Diagnostics Logic shall collect and process information from the intelligent subsystems and from other subsystems and sensors. It shall provide access to this information in numerous
ways which are useful to maintenance staff to allow troubleshooting to the Line Replacement Unit (LRU) without the need to employ external test equipment. Therefore, it shall have embedded in it, a subset of the PTE functions for every subsystem which are essential to troubleshooting and accessing and downloading faults. It shall be possible to set up data gathering parameters in advance for a specific test run or revenue service run. Such parameters include selecting signals and sampling rates to be captured.

The MDL shall be capable of capturing the system level and subsystem operating status data, which is then saved in case of a major fault.

Provision shall be made for adding temporary or permanent analog or digital sensors for use in troubleshooting. The MDL shall be capable of handling the additional inputs in the same way as it handles any other data.

The MDL shall collect information at the system level and pertaining to subsystems on all cars in a Unit. Each MDL shall be capable of accessing the data collected by the MDL in any other Unit, from the same Contractor, coupled into the same train. When Units are uncoupled, the fault information of each Unit shall be resident in the Unit of origin. Each Unit MDL shall retain a record of other Units to which it has been coupled.

The MDL master clock shall be changed through the use of a PTE and by trainline command. (Refer to Section 7.5.2.2). Daylight savings time corrections shall be made automatically.

Collecting and presenting Trouble Screen information shall have priority over other MDL functions.

Downloading the fault information to a laptop PC or to a PCMCIA card shall not automatically clear the log. A separate action shall be taken from the PTE to clear the log and reset faults.

**8.2.4 Monitoring and Diagnostics System Interfaces with Other Systems MOD 02**

The Monitoring and Diagnostics System shall be designed and suitably buffered such that a failure of the system does not adversely affect the systems it is monitoring and failures of monitored systems and sensors do not adversely affect the MDS.

Wherever possible, the Monitoring and Diagnostics System shall be capable of distinguishing between a complete failure of a specific system and a failure to communicate with it.

The Monitoring and Diagnostics System shall communicate with other parts of itself and with other systems and sensors through the networks described in Section 7. The coding structure(s) shall be defined during the preliminary design review. Fault information shall not be transmitted as text messages.

The system shall be capable of providing a specific subset of trouble data to offboard data collector modules if such modules are added at a future date. This capability shall consist of an output data port suitable for connection to a radio link or transponder to be added at a future date, along with the necessary software for data port control and access. The transmission (broadcast) technique shall not interfere with or be interfered with by any other system on the train or wayside.
The following interfaces with other systems (also called subsystems) are required:

- **Time Stamp Coordination**: The Monitoring System clock shall provide the official time stamp for information from all subsystems.

- **Exception Reporting**: Conditions outside of specified parameters shall be reported to the Monitoring and Diagnostics System.

- **Failure Indications**: All major system failures during operation or during the self tests shall be reported.

- **Diagnosis Documentation**: All parameters associated with failure indications and exception reporting shall be clearly documented. This includes the identification of the parameters, the relationship(s) among parameters, filtering, time delays, levels, counting and reset requirements.

- **Historical Data Storage**: All subsystem reports shall be stored in a non-volatile memory for diagnostic use. Records shall include time stamp, condition and associated data. Identical log formats shall be used for all car systems. This data shall be accessible at the system, using Portable Test Equipment (PTE, Section 20.4.1) and through the Monitor System.

- **Test on Demand**: Each system shall respond to Monitor System commands for controlled self test and report the results to the Monitor System. Tests will not be allowed when the cars are in motion.

- **Real Time Data**: Each system shall provide specific pre-determined operating (status) data to the Monitoring and Diagnostics System at sampling rates appropriate to the rate of change and priority of the sampled signal and also respond to Monitor System requests for updated data. Sampling rates shall be menu selected. Custom rates shall be adjustable by PTE. Transmission time delays shall be defined and identifiable.

### 8.2.5 Additional Subsystem Diagnostics

The diagnostics for each intelligent subsystem shall meet the following requirements, with the information expected to correlate directly with and be more extensive than that reported to the Monitoring and Diagnostics System:

- **Failure Indications**: All failures during operation or self test shall be recorded.

- **Diagnosis Documentation**: All parameters associated with failure indications and exception reporting shall be clearly documented. This includes the identification of the parameters, the relationship(s) among parameters, filtering, time delays, levels, counting and reset requirements.
**MONITORING AND DIAGNOSTICS**

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- **Historical Data Storage**: All subsystem reports shall be stored in a non-volatile memory for diagnostic use. Records shall include time stamp, condition and associated data. Identical log formats shall be used for all car systems. This data shall be accessible at the system, using Portable Test Equipment (PTE, Section 20.4.1) and through the Monitor System.

An LED display on each system shall allow visual verification of the health of the system without the use of either the Monitoring and Diagnostics System or a PTE.

**8.3 Monitoring and Diagnostics Data Collection and Management**

**8.3.1 Diagnostic Test Equipment**

There shall be a conveniently located connector in the cab for Portable Test Equipment (PTE) to fully test the MDL, to download faults and to make any needed changes to user settings. An approved non-electrical connector, such as an IR optical connector, may be employed with NYCT approval.

The portable testers shall comply with all of the requirements for PTEs specified in Section 20.

There shall be provision for a System Level Dynamic Tester (SLDT), specified in Section 20, to be connected through the MDL. The basic SLDT connector shall be the standard connector for all laptop PCs. Any additional test points required for Unit dynamic testing shall be accessible via "banana" jack or BNC connectors, as appropriate, to provide the capacity to monitor these signals with a voltmeter, oscilloscope, or chart recorder, or software versions of their capabilities. All test connection points shall be mounted at a protected and convenient location in the cab to permit the SLDT to be used when the vehicle is being operated. Because of the safety considerations relative to operation of a vehicle, there shall be buffering amplifiers and voltage dividers provided in the equipment to isolate the vehicle control circuits from the monitoring wiring, cable connector, and SLDT. Appropriate signal conditioning shall be provided to result in mid-scale deflection of the panel meters when a system is functioning properly. Sufficient connections shall be made to the propulsion, brake, and door control systems to permit verification that each subsystem of a redundant circuit is functioning.

The MDL shall have an integrated PCMCIA slot to allow user-selected downloads of fault logs without the use of PTE. Such downloads shall not clear or reset the logs. One hundred PCMCIA cards shall be furnished as part of the Contract.

Offboard data collector modules compatible with the Monitoring and Diagnostics System shall be provided for acceptance test purposes, to demonstrate the capability of the system to receive the trouble data without making a physical connection.
8.3.2 Car Monitor System Data Management

A separate workstation (Section 20.4.3) shall be provided for the storage and analysis of data collected from the Monitoring and Diagnostics System. The workstation shall include a customized program for the following tasks:

- Retrieve data from various PTE computers used to download car data.
- Retrieve data from PCMCIA cards used to download car data.
- Retrieve data directly from a vehicle.
- Provide data storage for both statistical and fault data.
- Sort and store all data using Windows-compatible data storage formats.
- Provide custom reports including multiple variable sorting on time, car, number, specific fault, failed system, and other relevant parameters.
- Provide procedures for archiving and retrieving older data.

8.4 Event Recorder

8.4.1 General

Independent of the Monitoring and Diagnostics, there shall be a separate Event Recorder.

Each Unit shall have two Event Recorders, one per A-Car, located above floor, or in an alternate secure location approved by NYCT, inaccessible to unauthorized personnel.

A dedicated memory shall retain 12-hours of data history before write-over. All channels shall be sampled every 100 milliseconds, unless otherwise approved. Upon change of state of a digital signal and upon change of an analog signal, the change signal shall be recorded. All signals shall be recorded every ten seconds.

A removable memory unit shall store the data. Data shall be retrievable by both removal of the memory unit and through a serial port to a notebook computer. It shall not be possible to erase the data via the serial port.

8.4.2 Signals to Monitor

The Event Recorder shall record the Train Operator's actions, the resulting trainline commands and various system responses. Parameters to record are as follows:

- Brake Cylinder Pressure
- Tractive Effort Level
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- Brake Pipe Pressure
- Cab Status (T/O, C/R, Non-Active)
- Deadman Control
- Direction Fwd/Rev
- Distance
- Door Close Status
- Dynamic Brake Application
- Emergency Brake Application
- Friction Brake Application
- Speed
- Three (3) Spares
- T/O Indication
- Time
- Trip Cock Activation

8.4.3 Construction Requirements
MOD 02

The event recorder shall be designed to protect critical data in incidents, such as derailment, collision, and fire, that could result in a subsequent need to download event recorder data as part of post-incident investigation. To this end, the requirements in the following table shall be met as a minimum. The requirements may be met by the design of the data storage device(s), or by placing the device in a box meeting the requirement, or by judicious placement of the device within the car body envelope to take advantage, for example, of the crashworthiness and fire-barrier properties of the car body, or by a combination of these approaches. In any case, the event recorder shall be located in-board of the secondary collision posts, or in an alternate location approved by NYCT.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Requirement</th>
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<tr>
<td>Fire</td>
<td>1200°F (650°C) for 30 minutes, followed by 570°F (300°C) for 60 minutes, followed by 212°F (100°C) for five (5) hours.</td>
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<tr>
<td>Impact Shock</td>
<td>±100 g peak, 65 ms duration, separately in the direction of each of the three principal axes.</td>
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<tr>
<td>Penetration</td>
<td>50 lbs. (23 kg) weight with a protruding 0.25-inch (6.4 mm) diameter steel pin dropped from a height of 5.0 ft. (1.5 m)</td>
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<tr>
<td>Static Crush</td>
<td>25,000 lbs. (110 kN) for 5 minutes.</td>
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<tr>
<td>Fluid Immersion</td>
<td>- Immersion in any of the following individually for 48 hours: grade 1 and 2 diesel fuel, regular and salt water, and lubricating oil; and</td>
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<td>- Immersion in fire-extinguishing fluids for 10 minutes, followed by 48 hours in a dry location without being otherwise disturbed.</td>
</tr>
<tr>
<td>Hydrostatic Pressure</td>
<td>Immersion in salt water at a depth of 50 feet for two days.</td>
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### SECTION 9

**AUXILIARY ELECTRIC EQUIPMENT AND DISTRIBUTION**

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SECTION 9

9.0 AUXILIARY ELECTRIC EQUIPMENT AND DISTRIBUTION

9.1 General

This section specifies the collection and distribution of power, including various voltage converters and controls. Each car will perform independent power collection from the third rail and distribution within the car. There shall be no third rail voltage level connection between cars.

Auxiliary power conversion equipment shall be distributed within the Unit such that auxiliary power requirements are satisfied for all allowable Unit configurations (i.e., four, five, and six cars). The following types of auxiliary power converters shall be provided:

- Three-phase auxiliary inverters, powered either directly from the 600 Vdc supply or from a local intermediate voltage power supply (IVPS; see below). Inverters may be dedicated to a single load or may supply multiple loads.

- Low Voltage Power Supplies (LVPS), powered directly from the 600 Vdc supply. The outputs of all Low Voltage Power Supplies within a Unit shall be bussed through all the cars of a Unit. Storage batteries shall be provided to supply uninterrupted low voltage DC power in the absence of LVPS output.

In addition, an IVPS may be used on each car to provide an intermediate, conditioned DC supply for use by other auxiliary power conversion equipment on that car. If an IVPS is used, its design and performance shall comply with the requirements of Section 9.5. The IVPS output shall not be bussed between cars.

The Contractor shall be responsible for proper systems interrelation and function of the auxiliary power system. All circuits and equipment shall be designed and protected so that the sustained presence of any voltage from zero to maximum line voltage will not cause damage to any part of the car or cause unsafe operation.

The details of the auxiliary power system architecture shall be reviewed and approved by NYCT.

9.2 Power Collection

9.2.1 General

A current collector assembly shall be mounted to the truck frame on each side of each truck, providing four assemblies per car. Each assembly shall consist of:

- a current collector and associated hardware, and

- a fuse box and fuse.

The current collector shall collect power from the third rail. The fused output of each of the four current collectors on a car shall be connected together to provide the primary source of power for the car. All
current-carrying components, including cabling, shall be sized for continuous operation without distress in the event power collection to a car is effected by a single current collector shoe.

9.2.2 Third Rail Current Collector Shoe Assembly

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A current collector shoe arrangement shall be furnished and fitted to each truck.

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The current collector shoe shall be bushed with one continuous bushing of seamless steel tubing. The outside of the bushing shall be case hardened to a depth of from 1/32- to 3/64-inch (0.8 mm to 1.2 mm). A coil spring, per ASTM A-229 Composition A, shall be provided to insure pressure on the contact rail of between 20 and 30 pounds (9 and 13.6 kg). To minimize potential damage to the equipment and to prevent falling debris, the design shall provide sufficient movement to allow the current collector shoe to rotate beyond the protection board of the third rail system without any damage to the equipment, other than the coil spring or its equivalent. An Over-Travel Indicator shall also be provided. Alternate service proven arrangements may be submitted for NYCT approval.

Five contact shoe slippers shall be provided and mounted in each cab. The slipper shall be lumber as Specified in Section 15.10.1, and shall be thoroughly coated with an approved insulating paint. Refer to Section 15.24 for general paint requirements. The R62 type slipper is acceptable.

The contact shoes shall be suitable for operation at any speed up to the maximum vehicle speed. Contract shoe designs that incorporate a break-away feature will not be allowed.

9.2.3 Current Collector Assembly Supports

The design of the current collector support shall provide for height adjustment of the assembly in 0.25 inch (6.35 mm) increments by means of bolted "washboard" arrangement for engagement of the assembly to the truck frame. The "washboard" engagement portions of the assembly shall be smooth and true, and shall be cast in "chill". Current collector assembly adjustment shall be possible using common tools. Range of adjustment shall compensate for the full amount of wheel wear.

9.2.4 Current Collector Fuses

Current collector fuses shall be of the current limiting cartridge type with current rating and time constant properly selected to reflect the operating currents, the third rail power supply and third rail electrical characteristics. The fuse shall be capable of interrupting fault conditions encountered in service at voltages specified in Section 2.3. The fuse shall include an indicator to show blown fuses.

A cuttable ribbon connection or equivalent between the fuse box shunt and fuse assembly shall be included for the purpose of car isolating in case of emergency.
9.2.5 Contact Shoe and Fuse Box Shunts

The current collector shoe design shall be such that no electrical current shall pass through any bearing or movable connection. The electrical current path shall be from the contact shoe through the contact shoe shunt.
to the fuse box mounted on the current collector assembly. The current collector shoe shunt shall be arranged so as not to interfere with the third rail protection board. Each shunt shall be no less than 80,400 circular mils.

9.2.6 Insulation

A flash shield shall be provided between the current collector shoe assembly and the truck.

Truck trolley and fuse leads shall be encased in thick, durable, non-conductive, silicone boots wherever appropriate to preclude arcing to ground during rain, snow, ice conditions and car washing operation.

9.3 High Voltage Power Distribution

9.3.1 Main Switch

A single pole knife switch shall be located in an undercar position accessible from the side of the car. The current from each current collector shoe shall be routed via the truck trolley cable to this main switch. The main switch shall have four distinct positions as indicated in the following table:

<table>
<thead>
<tr>
<th>Switch Position</th>
<th>Items Connected</th>
<th>Items Isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RUN</td>
<td>a) Third rail shoes</td>
<td>a) Shop power stud</td>
</tr>
<tr>
<td></td>
<td>b) Auxiliaries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Propulsion</td>
<td></td>
</tr>
<tr>
<td>2. RAIL TEST</td>
<td>a) Third rail shoes</td>
<td>a) Shop power stud</td>
</tr>
<tr>
<td></td>
<td>b) Auxiliaries</td>
<td>b) Propulsion</td>
</tr>
<tr>
<td>3. OFF</td>
<td>a) None</td>
<td>a) Third rail shoes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Propulsion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Auxiliaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Shop power stud</td>
</tr>
<tr>
<td>4. SHOP TEST</td>
<td>a) Shop power stud</td>
<td>a) Third rail shoes</td>
</tr>
<tr>
<td></td>
<td>b) Auxiliaries</td>
<td>b) Propulsion</td>
</tr>
</tbody>
</table>

The main switch and vehicle shop power stud shall be fully compatible with existing shop power connectors in the NYCT's maintenance facilities. The shop power stud shall be replaceable without the necessity to remove the main switch from the car. The stud shall be as per NYCT’s commodity number 08-68-2515. The main switch shall include a mechanical interlock which prevents closing the cover unless the switch is in the RUN position.

The outside cover of the main switch enclosure shall contain a high voltage warning and a permanent name plate with the words MAIN SWITCH and the device designation used for the main switch on the electrical schematic.
The main switch shall be mounted on a base of fiberglass reinforced fire retardant thermoset plastic or approved equal material, free from metallic impurities, and shall be housed in a box with a captive hinged cover constructed of insulating material. All screw and bolt heads, fasteners of all types and metal supports or brackets shall be insulated with attached, but removable, dielectric barriers on the interior of the box. The use of RTV or similar formless sealants shall not be acceptable as the sole insulating agent. The box shall be suitable for mounting under the car close to the side. The cover of the box shall have stenciled, in an appropriate manner, the words BEFORE OPENING MAIN SWITCH, OPEN ALL SWITCHES ON PANEL BOARDS.

9.3.2 Main Fuse

The main fuse shall be a copper ribbon type in use on the NYCT of suitable capacity or a cartridge type of suitable capacity. The terminals for holding the fuse shall have ample cross section and shall have clamping screws with large insulated knobs arranged to insure positive contact and to provide for quick renewal of the fuse. The ribbon fuse shall be mounted in a blowout type box which shall be constructed of an insulating material and shall be mounted to the Main Switch enclosure. Metal fasteners and brackets shall be insulated on the interior of the box. The box shall have a hinged captive cover opening upward to facilitate inspection and fuse replacement. One fuse shall be provided for each car. The cartridge type fuse may be designed, one for each inverter system, for improved fuse coordination.

The fuse box shall contain all appropriate caution warning and a permanent name plate with the words "600 V FUSE" and the devise designation used for the auxiliary fuse on the electrical schematic.

9.3.3 Auxiliary Fuse

A 1000 volt dc auxiliary fuse shall be installed in the Main Switch enclosure. This fuse shall be coordinated with load side protection devices such that it provides protection for faults occurring between the fuse and the load protection devices.

9.3.4 Distribution of Auxiliary Power

From the Auxiliary Fuse, power shall be routed to an equipment enclosure in the cab, from which all auxiliary power shall be distributed. The enclosure shall be located on the side opposite the Operator.

The enclosure shall contain circuit breakers controlling the distribution of power to all auxiliary loads.

9.3.5 Distribution Fuses, Circuit Breakers, and Contactors

All fuses or electrical devices shall be identified and readily accessible. Contactors when used in lieu of circuit breakers (Section 15.30) shall be of the quick-make/quick-break type on automatic operation and shall have both thermal and magnetic trip. Contacts of high voltage contactors must be able to close on short circuit current and hold for a sufficient length of time to interrupt the main auxiliary circuit breaker.
All circuits shall be individually protected by circuit breakers except as otherwise specified. Unless otherwise approved, no circuit breaker shall protect more than one circuit. Circuit breaker terminals shall not be used as junction points. All circuit breakers shall be sized to protect both the equipment and the minimum wire size used for power distribution within the protected circuit. Circuit breakers shall be trip-free, molded-case-type, multi-pole with a frame size suitable for the continuous current interrupting duty. The poles shall be connected in series to achieve the stated voltages. The handle shall indicate ON, OFF and TRIPPED positions. Each pole shall be equipped with adequate means of arc extinction to prevent flashover.

Continuous current rating shall be selected in accordance with ANSI C37.16 for the load and type of service specified. Breaker current rating shall be clearly and permanently visible after installation. The breakers shall conform to the requirements of ANSI C37.13 and ANSI C37.14. Electrically operated circuit breakers shall be equipped for operation from the low voltage dc supply.

Every high voltage dc circuit breaker trip or other protective device trip shall be communicated to the car monitoring system.

9.4 Car Body Grounding

9.4.1 General

All equipment on the vehicle shall be safety-grounded to the vehicle structure. Equipment boxes and enclosures with the exception of the battery box, shall be grounded as specified in Section 15.19.8. This car body grounding shall be distinct from power return grounding.

With the exception of primary power circuits that use car body as a return path, each system or circuit fed from a circuit breaker or fuse shall have its own return wiring. Each circuit return wire shall be connected, via its own separate terminal, to a return bus located with circuit breaker or fuse that supplies the circuit, or to a ground pad located underfloor.

9.4.2 Primary Power Return Circuits

Primary power returns shall be connected to ground pads fixed to the car body. The vehicle structure and truck frames shall be grounded to the axles. Car body shall be grounded to all four axles in a car through axle mounted ground brushes. Cabling and grounding configuration shall be as on existing NYCT cars.

Each ground brush and its cable and connections shall be sized such that any two ground brushes on a car are capable of continuously carrying the total primary return current, without damage. In addition, the car body ground circuits, including wires, brushes, and wheels, shall be sized so that each brush circuit can independently carry the maximum fault current without damage and while limiting the voltage difference between the car body and the running rail to 50 volts.

9.4.3 Intentionally Blank
9.4.4 Ground Brush Assemblies

Axle mounted ground brushes may be of the radially mounted type and shall be of a proven design in wide use in the rail transit industry.

Ground brushes shall bear on a bronze or steel ground ring pressed onto the axle. Car body grounding and power return brushes may be arranged to contact the same axle ground brush ring. Brushes shall be made from metal graphite and shall be readily accessible from under the car for maintenance purposes.

9.5 General Power Conversion Requirements

9.5.1 General

All auxiliary power apparatus shall use solid-state devices for all frequency and voltage conversion.

A load analysis for all auxiliary circuits shall be submitted for approval by the NYCT. The analysis shall include both normal and fault scenarios.

9.5.2 Input Voltage Protection

The equipment shall contain over-and under voltage circuitry on the input side (in addition to the fuses already specified) to self-protect in the event third rail supply voltage should fall or rise outside the design range. No damage shall result to the power supply unit as a consequence of any sustained abnormal input voltage.

Automatic shutdown is permissible for input voltages above the maximum and below the minimum, as defined in Section 2.3.1. The power supply unit shall have sufficient protective devices on both the input and output to preclude damage to the power supply unit from both positive and negative transient voltages.

The protective means shall show cognizance of the information relating to the NYCT power distribution system given in UMTA Publication No. IT-060026-73-3 "Investigation of the Voltage Transients and Spikes in Direct Current Rapid Transit Systems" and verified by the Contractor by his own comprehensive measurements on the NYCT.

The power supply unit controls shall be configured such that regulator or control circuit failures reduce the power supply unit output to zero or employ an overvoltage protection circuit that will detect overvoltages and interrupt the power supply system output.

9.5.3 Input Filters

Independent line filters shall be provided for the propulsion system and each auxiliary power converter. Filter capacitors shall be oil filled or electrolytic with 15 years minimum design life. The inrush current due to all capacitor charging shall be limited to 1,000 amperes per car.
The input filters shall be LC circuits. For converters connected to third rail voltage, the resonant frequency of the input filter circuit, under worst case conditions of temperature, tolerance, aging, etc., shall be such that the EMI requirements of Section 2.6 are met. Specifically, the filter design shall limit impressed substation ripple currents and converter-generated harmonics to levels below those specified in Section 2.6, as apportioned to each converter, under all converter operating conditions, including failure conditions. The Contractor shall perform an FMECA on all converter circuits to demonstrate that no failure modes can produce interference currents beyond allowable limits. In the event that this cannot be demonstrated, fail-safe ripple detection circuitry shall be provided to disconnect the faulty converter from third rail power in the event that allowable ripple thresholds are exceeded. The design of the circuit characteristics shall be coordinated with the EMI design of the converter. Filters may be shared between converters, subject to NYCT approval.

The capacitors shall have permanent parallel resistors which upon disconnecting from high voltage will discharge the capacitors within 20 minutes, independently of controlled discharge circuitry. There shall be controlled discharge circuitry which shall automatically discharge the capacitors to less than 50 volts in less than two minutes and to essentially zero volts in three minutes. For all capacitors that are connected to the 600V auxiliary power circuit in the “Shop Test” Knife Switch position, operating of the controlled discharge circuitry shall be independent of low voltage power to the extent that its loss or absence may not preclude controlled capacitor discharge. Permanently connect fast discharge resistors that meet above timing requirements will be considered, where practical, in place of controlled circuitry. The controlled discharge scheme must be submitted for NYCT approval. Each high voltage input filter discharge must be essentially identical in timing and functionally from maintenance perspective. A test point shall be provided and appropriately identified for maintenance personnel to conveniently measure the filter capacitor voltage. Equipment maintenance manuals shall incorporate appropriate procedures to enable NYCT personnel to verify capacitor discharge prior to commencing work on high voltage equipment.

9.5.4 Cooling

Auxiliary power inverters shall be designed to use externally grounded or electrically insulated, non-energized heat sink fins. Ventilation of the enclosure interior is not permitted. Sealed heat pipes which do not require opening during maintenance, are acceptable.

9.5.5 Monitoring and Diagnostics

Each auxiliary power converter (LVPS, IVPS, and Auxiliary Inverters) shall contain comprehensive self diagnostic capability and protective features. A number a specific faults are listed in the sections below. They should be considered as necessary, but not sufficient. Refer to Section 8 for additional requirements related to monitoring and diagnostics and to Section 20.4 for PTE requirements.

For all faults detected, the converters shall respond to the fault and then perform an automatic reset of the fault, in accordance with predefined limits. The mechanism and limits for resetting faults shall be approved by the NYCT. In addition, the equipment shall provide the Monitor System with information regarding the fault.

Loss of input and of output of any converter and the operation of any circuit protection shall be annunciated to the Monitor System.
9.6 Operation From Shop Power

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While the Main Switch is in the Shop Test position, the current shall be limited to a level that will not cause the shop cable fuses to blow. The shop cable fuses are rated at 150 Amps. The car controls shall effect load shedding to keep the current below the limit. The load shedding controls shall be designed to only shed loads as necessary for the actual operating conditions and to allow maintenance personnel to alter the shed load arrangement in order to activate any and all loads.

9.7 Auxiliary Inverter

MOD 06

Each Auxiliary Inverter shall be powered from 600 Vdc primary power (or, alternatively, from an intermediate voltage power supply, if used) and shall provide a three phase, 60 Hz, ac voltage for use within the car. The nominal voltage shall be 240 volts or 480 volts, except as otherwise approved. Inverters supplied directly from primary 600 Vdc power shall have sufficient input filtering and protection to provide reliable operation in the presence of third-rail voltage variations and transients as experienced on the NYCT system. Input filtering shall meet the requirements of Section 9.5.3.

Inverter power outputs shall be suitably conditioned to produce an output waveform which can be used by standard commercially available motors or electronic components without any adverse impacts on reliability, lifespan, or maintenance requirements. Alternatively, if the power output of any inverter is not conditioned to approximate a sine wave, all auxiliary motors supplied by that inverter must be sized to take into consideration any extra motor heating caused by the output waveform of the inverter.

The output shall be regulated using a constant volts per Hertz regulator. The ratio of voltage to frequency shall be within ±2 percent. The frequency shall be regulated to 60 Hz ±5 percent. On startup, the frequency shall ramp from 0 to 60 Hz. Regulation shall be met over all variations in input voltage and output load. Output overvoltage protection shall be provided.

Transient voltage drops of up to 20 percent are allowed, when starting any individual ac motor or motor group. Control interlocking shall prevent the simultaneous running frequency start of several ac motors or motor groups.

The Contractor shall coordinate the design of auxiliary inverters with their input supply characteristics such that the inverters provide full rated performance over the third rail voltage range specified in Section 2, considering an output load power factor of 0.8. The circuit design must include circuits which afford protection and which are resettable. The application or removal of any load at any supply voltage shall not result in the nuisance activation of protective devices.

With the exception of cab heater circuits if supplied from three-phase power, and convenience outlets, inverter outputs need to be galvanically isolated from the input supply except where required by the specific design. The Contractor shall ensure that loads connected to non-isolated inverter outputs are designed to withstand the maximum voltages (including transients) that may be impressed on output phases with respect to ground.
Cab heater circuits where supplied from three-phase power, shall be galvanically isolated from the inverter input by means of a transformer with a wye-connected secondary. The neutral of the secondary shall be grounded, and heater ground fault protection shall be provided. Overhead heater circuits do not need to be isolated unless required by the specific design.

Convenience outlets shall be of the ground fault interrupting (GFI) type, and shall be supplied with nominal 120 Vac from the inverter output through a step-down transformer, as described in Section 9.11. The transformer shall provide galvanic isolation from the inverter output, and the neutral of the convenience outlet supply shall be grounded.

The auxiliary inverter system shall include ground fault detection for the three-phase power output.

The Contractor may use a single Auxiliary Inverter per car or may customize smaller inverters for application with specific loads.

### 9.8 Low Voltage Power Supply

#### 9.8.1 General

The Low Voltage Power Supply (LVPS) shall supply control power to all car systems, power all lights, charge batteries, and power other loads as may be defined in the course of the vehicle design. The LVPS shall be a dc-dc converter. The LVPS shall receive its power from the 600 Vdc auxiliary distribution system. The LVPS shall provide full performance for third rail voltages of 550 Vdc or greater. Below 550 Vdc, the output voltage may be decreased to keep the output current at the level corresponding to full performance and 550 Vdc input. The Contractor shall coordinate the proper relationship between the LVPS capability and the load requirements, including battery charging.

The output efficiency shall be greater than 80 percent at 10 percent of full rated load or above. The LVPS shall be naturally convection cooled, not dependent upon car motion. The LVPS enclosure shall be isolated from both the input and output circuits.

There shall be at least three LVPSs on a 5-car Unit.

#### 9.8.2 Low Voltage Output

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The LVPS output shall conform to the following requirements:

- The output shall be transformer-isolated from the input.
- The nominal output shall be adjustable from 36.0 to 39.0 volts dc, initially set to 37.5 volts dc.
- Allowable Ripple: Maximum peak-to-peak voltage of 3 percent of nominal dc voltage.
AUXILIARY ELECTRIC EQUIPMENT AND DISTRIBUTION

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- Operating tolerance: ±1 percent, except that a load-dependent voltage variation may be applied in order to promote load sharing between LVPSs in a Unit. Such a “droop” characteristic shall not be more than 1 volt, from no load to full load.

- Capacity: With all LVPSs on a unit operable, combined LVPS capacity shall be capable of supplying 120 percent of the full load requirements of a Unit, including battery charging, for all allowable Unit configurations. With one or more inoperable LVPS, reduced battery charging and load shedding per Section 9.10.4 are permitted.

- Output transient response: ±10 percent for any step load change with the battery connected. In all other cases, the maximum overvoltage shall be 42V.

- Load transients: step application and removal of any load value up to the maximum, or over the maximum in the case of dead batteries.

9.8.3 Control and Annunciation

The LVPS shall have a dead battery start feature inasmuch as the converter shall start whenever the input voltage is proper, regardless of whether the vehicle low voltage system is supplying control power. The Contractor shall coordinate the design of the dead battery start function to energize the auxiliary load distribution contactor(s).

Faults shall be uniquely identified on a display within the converter and shall be communicated to the monitoring system as described in Section 8.

9.8.4 Protection

Protective features shall include a limited number of automatic resets. The exact implementation methodology shall be approved by the NYCT.

Input circuit protection: A fuse or circuit breaker shall be provided within the converter. This is in addition to the car's distribution circuits protection.

Input Voltage Range: automatic shutdown outside of the operating range and automatic re-start when the voltage is within range. Hysteresis and timing functions to be approved by the NYCT.

Input Diode: The high voltage input shall include a diode to minimize the possibility of capacitor discharge into third rails and to protect the unit from negative transients.

Internal Overtemperature Protection: The converter shall be self protected against internal overtemperatures.

The converter shall detect internal failures.

Output Circuit protection: An output fuse or circuit breaker shall be provided in the converter and sized to protect the car wiring.

Output Short Circuit Capability: An output short circuit shall not damage the converter and not result in the need to manually reset any protective device. A means shall be provided to limit the current supplied to a
fault. The current into a short circuit shall not exceed 150 percent of normal full load current. Upon removal of the short, the power supply shall resume normal operation.

Output Voltage Range: If the output voltage is out-of-limits, the converter shall shut down. The upper limit is 42 Vdc. The lower limit is 36 Vdc, except for low input voltage and brief periods of current limit. After
a shutdown and a brief delay, the converter shall restart automatically. Repetitive restarts in a short period of time shall cause the converter to be locked out, requiring manual reset.

Output Current Limit: If the current demand exceeds the current limit, then the output current shall be held constant and the output voltage shall be reduced such that the output power remains constant. The limit shall be adjustable up to the converter rating. The final adjustment must consider all load scenarios, including an appropriate value for dead battery charging. Continuous operation at maximum current, but below an expected operating voltage shall cause the LVPS to shut down.

9.9 Storage Battery

9.9.1 General

Each unit shall have at least two nickel cadmium alkaline storage batteries consisting of 25 standard size cells in stainless steel cases. The vehicle battery and battery tray shall conform to NYCT Specification 2071-PROD-91, Rev. E, with possible exceptions permitted to cell size, except as noted herein. The battery shall be float charged using the LVPS output.

9.9.2 Battery Capacity

The Contractor shall provide load calculations for the battery loads under all operating conditions. The IEC 623 rating of the battery, at room temperature, shall be at least 2.25 times the estimated load requirements. The battery shall have sufficient capacity to supply all low voltage power loads with adequate voltage (measured at the load) during the absence of output from the low voltage power supplies for a one hour period. During the one hour period, the following loads, as a minimum, shall remain energized:

- Emergency lights,
- Miscellaneous lights (headlights, taillights, end route sign, Interior Message Display, side destination signs),
- Public address intercom/radio (30 second announcements, every 10 minutes),
- Brake control,
- Door operation (1 cycle after 1 hour)
- Door light indications,
- Event recorder,
- Buzzer signal system,
- Monitoring and Diagnostics.
The Contractor shall present the calculated basis for battery sizing for approval by the NYCT. Low rate cells shall not be used without prior approval by the NYCT.

9.9.3 Battery Box
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The batteries shall be mounted on a single pull-out, drawer-type roller tray in an enclosure located below the car floor to permit ease of installation and servicing accessibility from the side of the car. The enclosure shall be of welded stainless steel construction. The battery box shall be electrically insulated from car body. No flammable, or hygroscopic materials shall be used for any part within the battery enclosure.

Ventilation openings shall be provided. The pull out force required to move the drawer roller tray shall be 25 lbs. (11.34 kg) maximum, measured after reaching the initial peak force required to overcome the inherent inertia. The maximum peak force shall be 31 lbs.

The enclosure shall have a drain plug accessible from the outside. The drain shall be held captive to the enclosure by means of a heavy duty chain of sufficient length to permit insertion and removal of the plug without disengagement of the chain.

The enclosure cover shall be captive to the enclosure sides, through a mechanical linkage arrangement. The cover retaining mechanism shall not interfere with access to, or normal maintenance of, the batteries nor shall it, under any circumstances, contact any part of the battery. The cover shall open so as to permit full access to the battery compartment without cover removal. The cover shall be designed to be easily opened and closed by one person, and it shall not be necessary to hold the cover in place while operating latching or fastening devices. The cover shall not swing open or fall off if the car is moved with the cover unlocked. The roll-out tray shall have a positive lock that when properly secured shall absolutely prevent the tray from moving. This lock shall be arranged so that it must be in the “tray locked” position before the battery box cover can be closed.
9.9.4 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°F (71°C). The protection system shall disconnect the battery in the event of battery over temperature and shall require manual reset. This condition shall be reported to the car monitoring system.

A double-pole battery circuit breaker of adequate capacity and approved design shall be mounted in an environmentally protected enclosure under the car and as close to the battery as possible. This breaker shall incorporate a shunt-trip device and disconnect the battery from car wiring when the battery temperature is excessive. It shall also incorporate a series trip to protect against fault currents.
9.10 Auxiliary Circuits

9.10.1 Circuit Breaker Panels

Refer to Section 6 for cab circuit breaker panel requirements.

9.10.2 Low Voltage Distribution Network

The LVPSs and batteries shall supply low voltage power to the Low Voltage Distribution Network (LVDN). This network shall power all of the low voltage loads of a Unit. Under all operating conditions, the maximum voltage drop between a power source and every load shall be 4 volts, except as otherwise approved by NYCT, including both the supply and return wiring. The Contractor shall perform a test detailed test to verify the voltage drops in a Unit. No resistors shall be installed between segments of the LVDN.

9.10.3 Low Voltage System Return Circuits

An independent negative return shall be provided for each system or circuit fed by a separate circuit breaker. Each of these returns and the negative connection from the battery and the LVPS shall be connected to a common negative bus bar. The low voltage system shall be grounded at one and only one point on each car.

9.10.4 Load Shedding

Load shedding shall be performed in response to loss of one or more LVPSs on a Unit. In addition to sensing LVPS shutdown, load shedding controls shall determine whether 600 Vdc primary power has been lost as well, and shall provide load shedding appropriate for each condition.

While recognizing that load shedding details will depend on factors such as Unit make-up and the number of LVPSs in a Unit, the following requirements shall nevertheless apply:

- For a single inoperative LVPS in Unit configurations with three or more LVPSs, load shedding shall deactivate 50 percent of the non-emergency lights in the Unit after a 15 second time delay along with other loads, as approved by NYCT, after a suitable time delay. The Unit shall otherwise be capable of normal operation indefinitely.

- For a single inoperative LVPS in Unit configurations with two LVPSs, additional load shedding is permitted, as approved by NYCT, together with deactivation of 50 percent of the non-emergency lights in the Unit. The delay for lighting deactivation shall be 15 seconds; longer delays may be appropriate for other loads. The Unit shall be capable of operating indefinitely in this condition, but with non-essential functions disabled. The identification of functions as essential or non-essential is subject to review by NYCT, but the following functions, at a minimum, shall be considered essential to operation:
  - The loads listed in Section 9.9.2, with duty cycles appropriate for normal operation;
Cab controls and indicators (excluding the TOD);  
- Propulsion system; and  
- Air compressor and controls, along with any associated power supply equipment.

Note that a Unit configuration with two LVPSs can only be a 4-car configuration, since 5- and 6-car configurations must have at least three LVPSs, as specified in Section 9.8.1.

- For loss of 600 Vdc primary power on a car with an LVPS, control power to loads on that car requiring 600 Vdc for operation (or three-phase AC derived from 600 Vdc) may be shed after a suitable time delay in addition to loads shed in response to the resulting LVPS shutdown. Continued Unit operation at reduced performance shall be possible in this case.

- For loss of 600 Vdc primary power on an entire Unit, the load requirements of Section 9.9.2 shall apply. Non-emergency lights shall be shed after 15 seconds; other loads may be shed after a suitable time delay. The time delay shall be such that a 2-Unit train can continue to the next station to discharge passengers if one of the Units still has primary power available. In addition, all exterior signs an interior strip maps may be shed after 5 minutes. The interior message display may enter a reduced power mode after 5 minutes. All processor-based systems may shut down or enter a sleep mode after 30 minutes.

- In determining time delays for load shedding (where specific times are not stated), the Contractor shall consider factors such as the reliability impact of additional shutdowns and restarts and the degree of difficulty (e.g., restart delay, coordination with other systems) involved in system reinitialization.

- Reconnection of loads shall be automatic in response to restoration of power. Output sensing devices shall detect the loss of constant voltage dc output from an LVPS, for any cause. The detection devices shall also detect the restoration of constant voltage output and shall automatically reconnect the previously disconnected loads. Loads shed due to loss of primary 600 Vdc power shall be automatically reconnected once primary power is restored.

Load shedding details shall be presented in design review.

Load shedding based on low input voltage (as opposed to total loss of 600 Vdc primary power) shall not be allowed without approval by the NYCT.

9.11 Convenience Outlets

There shall be a 120 Vac, 60 Hertz, 20 ampere, heavy-duty duplex outlet in each car. The outlet shall be grounded and include ground fault protection. The outlet shall be in the cab of the Cab Cars; and in a locker in the Non-Cab Cars. Convenience outlets shall have stainless steel cover plates, with individual spring-hinged covers over each individual outlet. The cover plate shall be attached with tamper resistant screws. The duplex outlet shall be labeled as "120 volts".
The source of the 120 volt power shall be supplied from the auxiliary inverter, via a step-down isolation transformer. The output shall be properly filtered to allow its use directly in standard recording and other types of instrumentation. Such equipment may require low-harmonic sine wave input power to avoid damage to the equipment or errors in the data collection process. In no case shall the harmonic distortion be greater than 5 percent.
## SECTION 10

**PROPULSION AND BRAKING**

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SECTION 10

10.0 PROPULSION AND BRAKING

10.1 General

Propulsion and braking of each Unit shall be provided by the coordinated action of propulsion equipment and friction braking equipment as described in this Section. Propulsion equipment and friction braking equipment shall provide Unit performance as specified in Section 2.4.

All cars shall be equipped with propulsion equipment and friction braking equipment. Cars with unpowered axles shall be equipped with that subset of the propulsion equipment complement necessary to provide propulsion and electric braking on the powered axles and to effect control of the friction brake equipment on the entire car. Control and monitoring of friction braking equipment on each car shall be effected principally by the propulsion control logic on that car.

The friction brake equipment shall be provided by a single supplier and shall be manufactured by that supplier or under his control. The friction brake equipment may be provided by the propulsion supplier or may be obtained directly by the Contractor. It shall be the responsibility of the Contractor to assure that the apparatus shall be properly installed and to ensure successful functioning and proper performance of the car, in accordance with Specification requirements.

10.2 Propulsion Equipment and Controls

10.2.1 General

The propulsion system shall incorporate an inverter-controlled 3-phase induction motor driving system providing both propulsion and electrical braking, and shall interface with and control the friction brake equipment.

At least 70 percent of the axles on a Unit shall be powered.

The propulsion system, including friction brake control, shall meet the performance requirements defined in Section 2, and shall be able to operate continuously, without damage or failure of the equipment to function properly, for all current collector voltages specified in that Section.

The propulsion system shall be designed so that when functioning properly it is completely self-protected against overload or damage due to all possible combinations of speed, third rail voltage, Train Operator’s actions, and prior states of the propulsion controls.

The propulsion system in each vehicle shall respond correctly to trainlined commands, including mode command, direction command, and open-loop rate command. The propulsion system shall respond smoothly, predictably, and safely under all conditions.
Each car shall be equipped with the following propulsion equipment as a minimum:

For cars with two motored trucks:

- One (1) dead rail and gap detector
- Input protective devices
- Two (2) input filters with charging circuits (one per truck)
- Two (2) propulsion inverters with line switches (one per truck)
- One (1) or two (2) resistor assemblies
- Four (4) traction motors (one per axle)
- Two (2) truck cable disconnect units
- Four (4) gear units (one per axle)
- Four (4) flexible couplings (one per axle)
- Four (4) speed sensors (one per axle)
- One (1) load weigh transducer
- One (1) Car Control Unit
- Two (2) Inverter/Friction Brake Control Units (one per truck)
- All other equipment required to perform the specified tasks

For cars with one motored truck:

- One (1) dead rail and gap detector
- Input protective devices
- One (1) input filter with charging circuits
- One (1) propulsion inverter with line switch(es)
- One (1) resistor assembly
Two (2) traction motors (one per motored axle)

One (1) truck cable disconnect unit

Two (2) gear units (one per motored axle)

Two (2) flexible couplings (one per motored axle)

One (1) Car Control Unit

One (1) Inverter/Friction Brake Control Unit (for the motored truck)

One (1) Friction Brake Control Unit (for the non-motored truck)

Four (4) Speed Sensors (one per axle)

One (1) Load Weigh Transducer

All other equipment required to perform the specified tasks.

The propulsion apparatus for each motor truck shall be independent of that for all other motor trucks, except as specified herein.

10.2.1.1 Propulsion

The propulsion system shall provide continuously variable propulsion (positive tractive effort) as required to meet the performance requirements of Sections 2.4.2.1 and 2.4.2.2.

10.2.1.2 Braking

The propulsion system shall provide continuously variable electrical braking (negative tractive effort) as required to meet the requirements of Section 2.4.3.1 and shall operate in conjunction with the friction brake system. Regenerative and rheostatic braking shall be provided with regenerative braking having priority. During partial or zero line receptivity the excess electrical braking energy shall be dissipated by resistor grids as specified in Section 10.2.10. The electrical brake shall be available at all times above a speed sufficient to support motor excitation from the motion energy of the car, regardless of the presence or absence of third rail power. Failure of electrical braking shall result in the friction brake system on the affected truck(s) automatically providing the requested braking effort.
10.2.1.2.1 Regenerative Braking

10.2.1.2.1.1 Performance

CO 03

O 118
The electric brake control system shall continuously monitor line voltage, shall supply to the line the maximum amount of energy possible within the line voltage limits prescribed, and shall divert to the braking resistors only the generated energy in excess of that accepted by the line or used by the vehicle auxiliary systems.

The propulsion system shall be able to return to the line a minimum of 60 percent of the theoretically available Unit kinetic energy for a 2.0 mphps (0.894 m/s²) stop from 40 mph (64 km/n) at AW2 when the line is fully receptive. The maximum regeneration line voltage shall be 690 volts. Regeneration return shall be calculated over the entire stop.

The regeneration feature shall be configured such that it can be disabled as a trainline function, in which case electric braking shall be rheostatic (see Sections 6.8.3).

10.2.1.2.1.2 Dead Rail and Gap Protection

A rail gap/dead third rail detector shall be provided on each motor car. The detector circuit shall detect rail gaps and shall detect the sudden removal of power from the third rail at any location. The detector and its associated controls shall be arranged to prevent operation in regenerative braking mode unless the following requirements are met:

- Before permitting the initiation of regeneration after any interruption, the detector has determined that current is flowing into the car, or that correct third rail voltage is present and that such current has the characteristics of the power substation’s 360 Hz or 720 Hz component(s); and
- While in the regenerative mode, the detector continues to determine that the third rail voltage has the characteristics of the power substation’s 360 Hz or 720 Hz component(s).

The detector shall be able to detect a rail gap and inhibit regeneration within 50 milliseconds while passing through a rail gap at the maximum speed, and shall ensure that no voltage spike in excess of ±500 volts is imposed on the next Section of rail. The detector shall detect a dead rail Section and inhibit regeneration within one (1) second.

The detector shall incorporate a continuous or regular self-test function to ensure its integrity.

10.2.1.2.2 Rheostatic Braking

Rheostatic braking shall supplement regenerative braking when the line is not sufficiently receptive to accept all the electrical braking energy being developed. Rheostatic braking shall be capable of continuous operation with a completely non-receptive line under the conditions specified in Section 2.4.
10.2.2 Control Functions

10.2.2.1 Load Weigh

A load weigh transducer of a reliable type shall be provided to adjust acceleration and braking control with changing car weight. The load weighing transducer shall sense the air bag pressure above the truck that is provided with the single leveling valve as specified in Section 4.5.2.5. The control system shall be designed to ensure that if load sensing is lost, the braking system shall respond as if the car weight were at least AW0 and no more than AW3. Load weigh compensation shall be applied to motoring, electrical braking, and friction braking, as specified in Section 2.4.1.2. The load-weigh system shall be arranged so as not to respond to dynamic suspension motions.

10.2.2.2 Wheel Spin and Slide Protection

The propulsion system shall incorporate a microprocessor-based spin-slide protection function that shall protect against wheel spins in propulsion mode and against wheel slides in braking modes, whether electrical or friction. The spin-slide protection system shall operate on a per-truck basis and shall provide performance as specified in Section 2.4.4. The spin-slide protection system shall be designed so that failures allow more braking effort than would otherwise be commanded.

The spin-slide protection function shall be arranged to take maximum advantage of the inherent slip-arresting characteristics of the three-phase drive.

10.2.2.3 No-Motion Signal

The propulsion control logic shall provide a no-motion signal to systems on the same car, as required. The no-motion signal shall indicate when the speed of the car is less than 0.5 mph (0.22 m/s).

It shall be possible to bypass the output of the no-motion logic by means a bypass switch in the cab, as described in Section 6.8.2, such that a no-motion condition is indicated.

The system shall provide valid no-motion information with up to two failed speed sensors per car. The system design including the bypass circuits shall comply with the train safety design requirements of Section 18.4.

10.2.2.4 Interlocks

The propulsion system shall be interlocked with the side door interlock signal specified in Section 11.10.2. The interlock function shall prevent the train from developing positive tractive effort with an open side door panel and shall remove positive tractive effort whenever there is an indication that a side door panel has opened en route.

Traction power shall be removed when emergency brake application has been commanded. The implementation of the power removal function shall be in conformance with the safety requirements set forth in Section 18.4.
The control logic shall compare the vehicle direction (as sensed by the speed sensors) to the direction commands that are received as a trainline function. Failure of the vehicle direction to correspond to the direction commands shall prevent the propulsion system from moving the vehicle. This failure detection circuit shall be tolerant of minor starting rollback.

The propulsion mode shall also be inhibited by the following:

- Friction brake application at any location in the train (except while rollback protection is active; see below);
- Parking brake application at any location in the train.

A bypass switch shall be provided in the cab to permit movement of the train in an emergency when full brake release cannot be obtained.

10.2.2.5 Protection

The propulsion system shall be protected from damage and incorrect operation by protective functions including, but not necessarily limited to, the following:

- Motor overload sensing in acceleration and braking.
- Motor overtemperature protection (see Section 10.2.8.9).
- Protection against reversed connection of motor leads.
- Propulsion ground fault detection, accomplished by monitoring the balance of supply and return current to each truck's propulsion apparatus. Excessive current imbalance shall cause power removal by opening the line contactor. The detection shall be as sensitive as is consistent with avoidance of nuisance trips.
- Charging resistor and braking resistor open circuit protection with lockout of affected functions.
- Transient voltage protection for all solid state apparatus.
Detection of failure of line contactor to open when commanded.

Detection of excessive inverter ripple current if required (see Section 2.6.7.2).

Brake resistor overtemperature protection by means of an algorithm modeling the thermal performance of the resistor and calculating the temperatures developed by energy inputs to the resistor.

Electrical isolation of battery potential circuits from power collector potential wiring in apparatus enclosures, by means of insulating barriers or separation between the high and low voltage circuits.

Protection of all current-carrying parts connected to circuits with power collector potential by means of insulation, location, or guarding to prevent accidental contact. All doors or cover plates guarding high voltage apparatus shall be marked “Danger-High Voltage.”

Actuation of any protective function shall be annunciated to the Monitoring and Diagnostic System specified in Section 8.

Transient abnormal or fault conditions shall be reset automatically as provided in Section 2.5.5.3. Resets shall be counted as provided in Section 2.5.5.3.

10.2.2.6 Overspeed Protection

The propulsion control system shall include overspeed protection logic operating as specified in Section 2.4.2.2. This protection shall be configured such that no propulsion system on a train can be in power while another is in brake.

10.2.2.7 Odometer

CO 207

The propulsion control system shall also make distance information available to other systems via the Car Network.

10.2.2.8 Friction Brake Test

CO 103

The propulsion system shall include provision to effect, on a per car basis, a running test of friction brakes only.
10.2.3 Control Logic

10.2.3.1 General

The propulsion system shall include control logic that shall interpret commands received as trainline functions and provide necessary signals to the propulsion and friction brake equipment to obtain the requested performance. The control logic shall provide self-diagnostic routines, fault monitoring of internal and external devices, and user programmable operating characteristics. Control programs shall be stored in non-volatile memory.

The propulsion and brake control logic shall be arranged in two distinct levels:

- A car control unit for each car,
- An inverter/friction brake control unit for each motored truck, and
- A friction brake control unit for each non-motored truck.

The control logic shall be microprocessor-based and shall comply with Section 15 and Section 16. Each logic unit shall have sufficient capacity to solve the relevant control equations and provide diagnostic capability while permitting expansion of computer function as specified in Section 16.

The control logic shall provide continuous monitoring of critical parameters, including motor currents, switching device currents, and component temperatures. The control unit and all related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions such that equipment damage is prevented or minimized.

Electronic control equipment shall be segregated from power equipment except for power semiconductor drive circuits which may be located where required to achieve necessary drive signal characteristics. Control circuitry and control voltage sources shall be optically or transformer isolated from power circuitry and high voltage sources.

The propulsion control logic shall be securely mounted in environmentally protected enclosures with adequate provisions for maintainability and safety as approved by the NYCT. Special attention shall be given to the design to provide easy access to, and installation and removal of, control apparatus. Control electronics may be located in one area, but controls for each truck shall be segregated within the enclosure.

10.2.3.2 Car Control Unit

As a minimum, the car control unit on each car shall perform the following functions:

- Communication with the on-board digital networks and discrete trainlines for exchange of command and status information with other vehicle systems and functions;
PROPULSION AND BRAKING

Load weigh compensation;

Rail gap and dead rail protection;

Computation of tractive effort reference for propulsion and electrical braking;

Generation of no-motion signal;

Computation of tractive effort reference for friction braking;

Overall communication with and supervision of the inverter and/or friction brake control units on the same car.

10.2.3.3 Inverter/Friction Brake Control Unit

The inverter/friction brake control unit shall be a single logic unit controlling the inverter and friction brake for one motor truck. As a minimum, the inverter and friction brake control unit associated with each motor truck shall perform the following functions:

- Control and protection of the associated inverter;
- Control and protection of the associated brake chopper;
- Control of friction brake equipment for the associated truck;
- Spin/slide control for the associated truck; and
- Communication with the associated car control unit.

Alternate distribution of functions will be considered by NYCT.

10.2.3.4 Friction Brake Control Unit

The friction brake control unit shall be a single logic unit controlling the friction brakes for one non-motor truck. Its hardware shall be a subset of that provided for the inverter/friction brake control unit of Section 10.2.3.3. As a minimum, the friction brake control unit associated with each non-motor truck shall perform the following functions:

- Control of friction brake equipment for the associated truck;
- Spin/slide control for the associated truck; and
- Communication with the associated car control unit.
10.2.3.5 Diagnostic Features

The control units shall provide diagnostic features complying with the requirements of Section 8.2.

As part thereof, the control units shall log and report each fault. A fault shall be defined as:

- Activation of a protective function; and/or
- Occurrence of an abnormal condition indicative of current or incipient equipment failure.

As a further part thereof, the control units shall record time histories of critical vehicle and propulsion system parameters prior to the detection of any of an approved list of faults. Data for a minimum of ten fault events shall be recorded. If more than ten faults occur before the memory is reset, the new event shall write over the oldest of the stored fault events. Fault data shall be retained as long as battery power is applied or until a reset command is received from either a portable test device, or a reset pushbutton on the control logic monitoring panel is pushed. Fault data shall be addressable by the portable test device for troubleshooting purposes and by the built-in troubleshooting displays.

Sufficient memory shall be included for the purpose of storing all of the significant parameters that occurred over a period of at least 2 seconds before a fault occurred.

Each control logic unit shall include a monitoring panel(s) with visual displays indicating which fault(s) have occurred and other general system conditions.

Each control logic unit shall be arranged for the connection of portable test equipment to permit static testing, diagnostics, and monitoring of the propulsion system during vehicle operations. Refer to Section 20.4.1 for general requirements for portable test equipment.

Each control logic unit shall have a minimum of eight channels available as analog outputs for a high impedance chart recorder, each having the ability to address all logic signals significant to analysis and diagnosis, including signals to and from contactors, and all external inputs and outputs. Scaling shall be integral with the design and require no supplementary effort by the user, and shall be logically decoded. There shall also be an addressable output that is RS232 compatible.

Wiring and test connectors shall be provided to connect the above mentioned test signals to a remote monitoring panel located in an electric locker or in the cab. The remote monitor panel shall include connectors for the portable test unit such that propulsion system status can be monitored statically and when the vehicle is in operation. Testing and diagnostic facilities need not be provided at the remote monitor panel. Installation of this remote panel shall not interfere with or prevent use of the portable test equipment or monitoring panel at the underfloor location when the vehicle is stopped.

The propulsion system shall interface with the Monitoring and Diagnostic System specified in Section 8, and with the System Level Dynamic Tester specified in Sections 8.3.1 and 20.4.6.
10.2.4 Inverters

Two inverter units shall be installed under each motor car in water-tight enclosure(s). The inverter units on each car may share a common enclosure or may be installed in separate enclosures. Each inverter unit shall drive two traction motors mounted on the same truck.

Each inverter unit shall be of the pulse-width-modulation (PWM) type utilizing GTO or IGBT power semiconductors. Power semiconductors shall be selected and applied to operate at no more than 70 percent of their breakdown capabilities. Power semiconductors shall be selected and applied in such a manner that a minimum 40-year design life shall be obtained with respect to cyclic and steady state thermal parameters. The design of the inverter shall reflect a thorough understanding of device and system failure modes and shall include protection for $dV/dt$, $dI/dt$, non-overlap (dead time), and similar design parameters as appropriate. To minimize temperature excursions, power semiconductors shall be mounted such that a low thermal impedance exists between the device and the point of heat exchange with the atmosphere. All power semiconductors shall be housed in watertight, dustproof enclosures.

Inverter unit cooling shall be accomplished by passive means. Cooling blowers are not permitted. No external air shall pass through the interior of the enclosure. Chloro-fluorocarbon or other fluid-based cooling methods of any type shall not be used with the exception of sealed heat pipes containing nonchloro-fluorocarbon based fluids. Tanks containing a cooling liquid and components shall not be permitted. The point of heat exchange with the atmosphere shall be external to the sealed enclosure. Heat exchange fins may be supplied on one or more exterior walls of the enclosure. The heat exchangers may be either a solid metal heat sink or a sealed, clamped-on liquid filled tubular device which does not require opening to service or replace power conversion or control devices, which are mounted external to the device, in which the liquid undergoes changes of state to achieve high thermal transfer capacity and which provides a low thermal impedance to the device. A combination of the two techniques may also be employed. In any case, there shall be no electrically live surfaces external to the enclosure. Air flow across the heat exchanger fins shall be accomplished by natural convection and/or by motion of the car.

The inverter unit shall be capable of operating continuously over the current collector voltage range specified in Section 2.3.1 and shall comply with the input voltage protection requirements of Section 9.5.2. As a minimum, it shall be designed to withstand voltage spikes up to $\pm 3000$ volts and 500 microsecond duration on the third rail without damage or interruption of operation.

All voltage control and status indicator wiring to the inverter shall be connected to it by multi-pin connector meeting the requirements of Section 15.19.6.

Each inverter unit shall have two major elements:

- The inverter, and,
- The braking chopper.
The inverter shall convert the dc voltage supply into a variable-voltage, variable-frequency, 3-phase ac voltage, and shall provide this ac voltage to the traction motors. It shall control the torque developed by the traction motors by varying the output frequency and voltage, and shall control the direction of the torque by proper sequencing of the output phases.

The braking chopper shall modulate the electrical energy delivered to the braking resistors. During partial line receptivity the chopper shall direct the excess energy to the braking resistors. The braking chopper shall operate to maximize the kinetic energy of the cars that is returned to a receptive line.

### 10.2.5 Input Protection

The propulsion system on each car shall be protected with a high speed circuit breaker with a 30 KA interrupting capacity and a total breaking time of less than 15 ms for a current rise of 5 amps per microsecond. The circuit breaker shall be designed for a minimum of 100,000 operations. It shall be installed in its own enclosure.

The arc chute design shall permit the arc to be safely guided away from the opening current carrying contacts. The arcing energy shall be dissipated in a controlled, proportional manner through the use of a series of de-ionizing cavities mounted on the circuit breaker housing. The circuit breaker enclosure compartment shall have atmospheric venting openings to minimize an ozone buildup.

Alternate means of circuit protection, such as a line breaker and fuse arrangement per inverter, may be proposed for NYCT approval.

### 10.2.6 Line Contactors

A line contactor shall be provided for each inverter to make and interrupt power during normal operations. Contactor capability shall be coordinated with input protective device capability. These contactors shall be designed for a minimum of 1,000,000 mechanical operations with a minimum contact life equivalent to 100,000 miles of normal operation. The arc chute design shall permit the arc to be safely guided away from the operating contacts. Venting shall be provided to prevent an ozone buildup in the contactor compartments.

Source and return power for line contactors shall be interlocked such that an emergency brake application deenergizes the contactors.

The line contactor, its control, and associated equipment shall be arranged to limit instantaneous in-rush currents under all operating conditions to a value that will not cause failure or deterioration of any component, including fuses. Any means adopted to achieve this shall not materially interfere with car performance under conditions of intermittent collector contact, as with an icy contact rail.
10.2.7  Input Filter

The propulsion apparatus for each motor truck shall be protected by a separate input filter meeting the requirements of Section 9.5.3. Each input filter shall be provided with a charging contactor and charging resistor(s) that shall limit charging current and input filter voltage overshoot to approved levels.

10.2.8  Traction Motors

10.2.8.1  General

Each motored axle shall be individually driven by a three-phase alternating current traction motor of the squirrel-cage type, with its gearing. The traction motor shall be a totally enclosed, or drip-proof, splash-proof, or open design. Proposals for independent forced air cooling of motors will be considered if ducting can be eliminated or minimized. The traction motor shall be designed so that its torque output is compatible with the maximum 1/4-inch (6 mm) wheel diameter difference between axles on the same truck. The traction motor shall be designed in accordance with IEC Standard 349-2, Electric Traction--Rotating Electrical Machines for Rail and Road Vehicles--Part 2: Electronic Converter-Fed Alternating Current Motors. The motor shall have a safe speed that meets the requirements of Section 6.3 of IEC 349-2.

10.2.8.2  Insulation

The motor, when operated under the conditions specified in Section 2.4.5, shall remain within the Class F temperature designated in Section 5, Table I, of IEEE No. 11 with Class H winding insulation, or within the Class H temperature range with Class C insulation, except as noted in Section 2.4.5.

The completed motor frame with insulated coils shall be given two vacuum-pressure impregnations with a solventless polyester resin compatible with Westinghouse B-7-373, or approved higher temperature resin, with at least a temperature rating class equal to the temperature rating class of the motor winding insulation. The Contractor shall manufacture sample sections of the stator and winding assemblies to verify the VPI process. These sample stator assemblies shall undergo the VPI process simultaneously with production stators. The Contractor shall Section the simulated stator assemblies to establish freedom from voids and to verify that there is good bonding. This VPI verification shall be conducted with the first two stators and two other selected at random by the NYCT. If voids are found, as determined by the NYCT, then the process shall be modified until corrected and the quantity of samples shall be increased. All VPI verification costs, and subsequent corrections to production motors, shall be borne by the Contractor.

10.2.8.3  Rotor

The traction motor rotor cage shall be of copper alloy bars with brazed or welded rings. The rotor and cooling fan shall be dynamically balanced separately so that, after they are assembled, net dynamic unbalance measured at each bearing is less than 1.0 inch-ounces (.72 mm-kg) without any balancing following assembly. Balance correcting weights shall be metal, either welded in place, secured in retention grooves, or bolted in place.
10.2.8.4 Terminals and Leads

MOD 02

Terminals and terminal blocks shall be protected from weather and the operating environment and shall be clearly marked for positive identification. The terminal block design shall use neoprene polyester glass or other approved type blocks or cleats having a high insulating and flame retardant value. Motor leads shall be clearly marked to prevent cross-connecting. The Contractor may propose the use of motor leads of varying length to prevent cross connection; however, the motors, inclusive of the leads, must be interchangeable between any position on any motor truck. Motor leads on all motors shall be provided with Amp, Thomas and Betts or approved equal compression-type, quick-disconnect knuckle joint connectors. Terminals shall be covered with highly insulating hose-type covering clamped so as to be weather tight at both ends or with an approved equivalent method of protection. Cable from the traction motors on each truck shall run from the terminal block on the motor frame to a button-type quick-disconnect or approved alternate mounted on a support attached to the car body in the vicinity of the truck.

The current value used in determining the minimum size of motor leads shall conform to NFPA 130, Section 4.3.3.

10.2.8.5 Bearings and Lubrication

MOD 05

Traction motors shall be equipped with anti-friction bearings, lubricant seals, and lubricant cavities. Lubricant cavities shall have a volume sufficient for 420,000 miles (675,700 km) [seven (7) years] of operation before requiring relubrication. The supplied motors shall be ready for operation. Bearing housings shall be readily accessible to permit addition and purging of lubricant without de-trucking. The bearings shall have an ANSI/AFBMA L\textsubscript{10} rating life of 1,000,000 miles (1,609,000 km). Motor bearing seals shall be labyrinth-type. Lubricant shall be selected from the NYCT List of Lubricants for All Car Classes, Rev. A, within Appendix C.

10.2.8.6 Mounting Details

The traction motor shall be isolated by resilient elements from equipment below the primary suspension, including the gear unit if the latter is axle-mounted. The motors shall be designed for coupling by means of a gear-type coupling to the gear unit. Bolts shall be grade 5 bolts as a minimum and shall be tightened with a torque wrench to a repeatable torque value. If grade 8 bolts are used, they are not to be plated but corrosion protection is required. Hardened steel flat washers shall be used under bolt heads and nuts. If a WN-type drive is employed, tapped holes in the lower motor suspension mounting shall have class 2-B threads or better.

The traction motor shall be provided with lifting lugs or with means for attaching lifting devices such as a tapped hole for lifting eyebolts. The motor configuration shall ensure stability when the motor is placed on the floor.

The traction motor shall be provided with safety straps, tabs, or hangers to prevent the motor from falling in the event of failure of the primary motor mounts. The lifting lugs may be adapted to perform this function.
The motors shall be designed with suitable truck clearances to permit each motor-and-gear-unit combination to be removed from the truck without interference with members of the truck frame. In addition, it shall be possible to remove the traction motor from above the truck without removal of the gear unit.
Clearances beneath the motor and gear unit shall be as specified in Section 4.3.1.3.

10.2.8.7 Vibration Limits

The vibration of any traction motor detached and supported on resilient mountings providing at least 0.25-inch (6.3 mm) static deflection, shall not exceed 0.0015-inch (0.038 mm) peak to peak displacement at the motor bearing housing and at the motor mounting points while the motor is rotating at any speed between 50 percent and 100 percent of the maximum normal operating speed. Each assembled motor shall also meet the vibration requirements of IEEE No. 11, Section 13.2.

10.2.8.8 Ventilation and Noise

Motors shall be self-ventilated with an integral low-noise type fan.

Motor noise shall meet the requirements of Section 2.7.5.

For the drip-proof, splash-proof or open designs, openings shall be provided for inspection and ventilation. The openings shall be arranged to minimize ingestion of snow and dirt from the track bed

10.2.8.9 Over-temperature Protection

In response to excessive dead car scenarios, the Contractors may apply overtemperature protection of the motors. If the winding temperature rises 27°F (15°C) above the designed operating temperature limit, the control unit shall decrease the motor duty cycle by removing the electrical braking and converting into frictional braking. The decision shall be made by calculating the power that the motor is handling. The measurement of winding temperatures with embedded sensors is not permitted.

10.2.9 Gear Units

10.2.9.1 General

Each motored axle shall be driven by a gear unit which shall be parallel single-reduction or double-reduction drive designed and manufactured for bi-directional service. The gear ratio shall be selected to provide the performance specified in Section 2.4 and shall conform to established railcar gear design practice. The motor and gear unit drive and mounting arrangement provided shall meet the specified noise, vibration, ride quality, shock loading and maintenance requirements. Gear unit noise shall meet the requirements of Section 2.7.5.

10.2.9.2 Gears

CO 235

Gears shall be designed and installed for a minimum inspection and adjustment interval of 500,000 miles (804,500 km). One break-in inspection during the first interval shall be acceptable. Gears shall have a minimum fatigue design life of 1,000,000 miles (1,609,000 km) with no degradation of performance. Gears shall be fabricated from high-quality gear steel, designed and heat-treated/hardenened in accordance with AGMA 240.01, Gear Material Manual.
10.2.9.3 Bearings

The gear unit shall be equipped throughout with tapered roller bearings, or approved equal, which shall require a minimum inspection or adjustment interval of 420,000 miles (675,780 km). Bearings shall be quality, grades of steel. All gear unit bearings shall be selected and applied to have an ANSI/AFBMA L₁₀ rating life of 1,000,000 miles (1,609,000 km). External bearing shaft seals shall be the labyrinth type, with supplemental sliding contact seals, if necessary to keep high velocity splashed water from entering the gear units.

10.2.9.4 Lubrication

The gear unit shall be oil-lubricated using approved lubricant specified in NYCT List of Lubricants for All Car Classes, within Appendix C. The gear unit shall be provided with sufficient baffles, dams, passages and similar structures to ensure an adequate flow of lubricant to all bearings and gears under condition specified herein of rotation, speed, load, temperature, and weather, including continuous operation in either direction, at maximum speed. The unit shall be so designed that adequate lubrication will be provided to all bearings and gears under the most severe operating conditions and prevent moisture infiltration into the lubricant. The gear unit shall not lose more than one quart within 60,000 miles and shall not require change more frequently than every 120,000 miles (other than one break-in type lubricant change).

The gear unit shall have sufficient oil capacity for adequate cooling. All gear lubrication shall be in accordance with the applicable sections of AGMA Standards 250.04.

The gear unit shall have at least one oil drain opening located at the lowest point in the case or sump. Drain plug(s) shall be installed in the opening(s) and properly secured. A readily accessible magnetic filler plug shall be provided, with the opening arranged to provide an indication of oil level and also to prevent overfilling. Alternatively, the filler plug may be nonmagnetic, provided that a magnet shall be included in the gear unit, located for maximum contact with the lubricating oil and readily removable for cleaning. Removable and accessible oil-tight and air-tight inspection covers with elastomeric gaskets or approved equivalent method of sealing shall be provided for visual inspection of the gears. All fill drain and inspection plugs shall be safety-wired and shall be of a type or be located to prevent damage by obstacles on the track. The gear case shall be provided with a readily accessible sight gauge for use by the maintenance department.

The quantity and grade of lubricant shall be indicated either on the filler cap or on the gear unit housing adjacent to the caps. Seasonal changes of lubricants shall not be required. The gear unit lubrication system shall be readily accessible without detrucking and shall be designed to prevent overfilling.

10.2.9.5 Interchangeability

All gear units shall be interchangeable.

10.2.9.6 Maintenance

Gear unit components requiring repair or replacement shall be readily accessible with a minimum amount of gear unit disassembly. Parts requiring replacement or adjustment prior to realizing in service the design life
of the system shall be individually replaceable. Adequately bolted and gasketed openings shall be provided for inspection and routine maintenance.

Disassembly, reassembly and service maintenance shall be possible to the maximum extent with tools and items of maintenance equipment in common usage. Special tools, where required shall be subject to approval and shall be provided by the Contractor as specified in Section 20.3.2.

10.2.9.7 Mounting

The gear unit shall be fully suspended from the truck frame with a flexible connection to the axle or shall be axle mounted with a resilient mount at the end opposite the axle. If the latter, the resilient mount shall be the vertical bolt type using bonded rubber pads at the tongue of the gear unit and at the point of suspension from the truck. Bonded rubber pads shall meet the following physical specifications.

- Tensile strength, minimum: 3,000 psi (20.7 MPa)
- Elongation, percent minimum: 450
- Decrease in tensile strength and elongation, after aging (heating in air at 158°F (70°C) for 288 hours), percent maximum: 20.

The drive train design shall not increase the stiffness of the axle suspension within the truck.

10.2.9.8 Manufacturing

Particular attention shall be given to thoroughness of welding, forming, machining and assembling of parts. After assembly, units shall be thoroughly cleaned of loose, spattered, excess metal chips, and other foreign material. Burrs and sharp edges shall be rounded. Standard commercial parts shall be used to the maximum extent. Supplier and part numbers shall be identified on drawings, bill of materials, or parts list.

10.2.9.9 Coupling

A double internal-external, self-aligning gear-type coupling shall be provided between each gear unit and the associated traction motor. The coupling shall be suitably balanced to minimize noise or vibration produced at car speeds up to 60 mph (97 km/h) with fully worn wheels. Lateral, vertical, longitudinal, and angular motion of the arrangement shall be provided for. The coupling shall be grease-lubricated. Suitable seals shall be provided. Lubricant shall be selected from the NYCT List of Lubricants for All Car Classes, reference Appendix C.

10.2.10 Braking Resistors

Dynamic brake resistors shall be edge-wound ribbon, coiled rod helix, or stamped sheet metal types. The application design shall conform to NFPA 130, Section 4.3.5. Braking resistors shall be assembled in frames
of convenient size for natural ventilation. Forced ventilation shall not be permitted. All resistor frames, heat
shields, and hardware shall be made of stainless steel. All resistor components shall be selected both for their
mechanical properties and corrosion resistance. Refer to Section 15 for material requirements.

Capacities shall be such as to meet the braking performance in Section 2.4.3.1 and to withstand the most
severe duty cycles continuously without injurious overheating. The resistors shall have sufficient capacity to
provide power dissipation during operation at full service braking over the specified profile and passenger
loadings up to, and including, AW3, assuming no regeneration into the line.

The resistors shall be mounted underneath the car and shall be protected from wheel splashes. Heat insulation
between the resistors and the car body or car body wiring shall be stainless steel sheet. The sheet shall be of
suitable thickness and adequately stiffen to provide rigidity.

There should be no high voltage present in any of the resistors of the Brake Resistor Assembly when the train
is at standstill. If this not practical, those resistors where high voltage is present should be located at the top
row of the Brake Resistor Assembly to prevent accidental personnel contact.

The resistor grids shall be isolated from their frames, and frames from the car body with high-temperature
insulators. Provision shall be made for grid expansion to prevent warping. Cable connections shall be located
so as not to be subject to overheating due to normal heat dissipation by the resistors.

Maximum operating temperature of any grid shall not exceed 1,112°F (600°C).

The brake resistor assembly shall be designed to minimize the coupling of EMI into track circuits.

10.2.11 Ground Brushes

A ground brush assembly meeting the requirements of Section 9.4.4 shall be provided on each gear unit on
motored axles, and in a suitable housing on non-motored axles.

10.2.12 Speed Sensors

Each axle shall be fitted with a pulse generating speed sensor which shall be installed on the traction motor or
on the gear unit, or shall be arranged to monitor axle rotation directly. Each sensor and its associated circuitry
shall provide positive indication of all motion down to standstill and shall provide a means of determining the
direction of motion. The outputs of the speed sensors, either directly or through a signal conditioner, shall be
used as inputs to the propulsion system control unit for wheel slip and slide control, generation of the no-
motion signal specified in Section 10.2.2.3, and other propulsion functions.

The active face of each speed sensor shall be smooth with no protruding elements. The sensor shall be
hermetically sealed in a stainless steel case. The active face shall be encased in a seamless stainless steel
cover.

Different speed sensor types may be used for motor and trailer truck applications. All sensors of each type
shall be freely interchangeable, without shimming or other mechanical adjustment. It shall not be either
necessary or possible to make any mechanical adjustments to set the gap between the sensor probe tip and the
gear tooth. If mounted to count drive gear teeth, the mounting plate shall be precision milled for this purpose.
and shall be above the normal lubricant level so that removal will not cause lubricant loss. The speed sensor shall be located to provide the maximum protection from flying objects. All speed sensors shall be easily accessible for inspection and replacement with trucks attached to vehicles over maintenance pits or on jacks and with trucks sitting by themselves on the floor.

If used, axle end-mounted speed sensors and associated wiring shall be well-protected from damage due to debris, snagging, and other potential sources of damage. Sensor cable entry and cable dress shall be designed to avoid low-hanging loops and routing that may lead to cable damage from objects along the wayside. In addition, sensor mounting and cabling shall not interfere with wheel truing equipment, and no removal or disassembly of the sensor assembly or associated wiring shall be required for wheel truing.

All speed sensing gears, toothed wheels, or similar devices shall be mounted on their shafts so as to ensure that the speed measuring device cannot indicate speeds other than the actual axle speed under all conditions except massive drive train damage.

Electrically shielded leads shall be used from the sensor to the car body and shall be encased in flexible sheathing. The sensor end of the electrical leads shall be fitted with a quick-disconnect fitting covered by a sliding, molded rubber sleeve to provide a watertight seal around the connection and to prevent fatigue of the wire. The electrical leads shall be dressed and supported on the truck and car body as necessary to prevent chafing and fatigue failure.

10.2.13 Friction Brake Interface

10.2.13.1 General

The propulsion control logic shall interface with the friction brake equipment in accordance with the arrangement specified in Section 10.3, and shall include all necessary output drivers and feedback elements to accomplish continuously variable control of service friction braking on a per-truck basis. The propulsion control logic shall implement all trainline information decoding, blending, load-weigh compensation, failure handling, and other required logic and calculations to produce service friction brake effort as required to meet the performance requirements of Section 2.

The propulsion control logic shall not initiate, propagate, or limit any emergency brake application in any way, nor shall it delay or suppress any emergency brake application other than as specified in Section 10.3.3.6 for passenger-initiated emergency brake applications. No failure or incapacity of the propulsion control logic on any car shall interfere in any way with the normal application and release of the emergency brake, except that charging time may be extended proportionally as specified in Section 10.3.1.2, and response to a passenger-initiated emergency application may be modified as specified in Section 10.3.3.6.

The propulsion logic shall evaluate information received from sensors and/or switches located within the friction brake system in order to monitor the operation of the friction brake system and detect failures and abnormal operating conditions. The propulsion control logic shall provide complete monitoring and diagnostic interface to the MDS for the operation of the friction brake equipment as required in Section 8.
10.2.13.2 System Operation

The control logic shall give priority to electric braking under all conditions up to the electric braking capacity limits specified in Section 2. Additional braking effort required to achieve the requested performance up to the overall limits specified in Section 2 shall be provided by the friction brakes on the non-motored trucks. In the event of complete or partial failure of one or more sets of electric braking equipment, the friction brakes on the affected truck(s) shall make up the missing electric braking effort.

A light snow brake pressure shall be applied in response to a control on the Train Operator's console whenever brake cylinder pressure would otherwise be less than the snow brake pressure. The snow brake pressure shall be just sufficient to preclude icing of braking shoes and to keep the wheel treads clean and dry. The snow brake command shall be communicated to each car as a trainline function. Automatic slack adjusting shall briefly occur at stop.

The propulsion control shall command inshot pressure (if any), command snow brake, and accomplish slide control of friction braking, through the medium of the same continuously variable control used for blending.

Emergency braking shall be controlled as described in Section 10.3.1.2.

The friction brake system shall incorporate a brake cylinder pressure switch for each truck that shall indicate when friction brakes are applied on that truck. These switches shall interface with the discrete Power Interlock trainline(s) described in Section 7.3.2 without the interposition of electronic logic. They shall also interface with the propulsion control logic. In addition, the friction brake system shall incorporate provision to provide brake cylinder pressure status (e.g., brake applied, released) on a per-truck basis for indication on the cab console.

10.3 Friction Braking Equipment

10.3.1 General

An automatic electro-pneumatic friction brake subsystem shall be provided on each car. The friction brake subsystem shall apply retarding force by means of tread brakes and shall have the following primary functions:

- Continuously variable service braking meeting the requirements of Section 2.4.3.1; and
- Fail-safe emergency braking meeting the requirements of Section 2.4.3.2.

Each car shall be equipped with the following friction brake equipment as a minimum, except as noted:

- 2 - Brake Operating Units (one per truck)
10.3.1.1 Service Braking

Service friction braking shall be controlled by the propulsion control logic on a per-truck basis as specified in Sections 10.1 and 10.2.13.

Brake cylinder pressure in service braking shall be controlled on a per-truck basis by means of a proportional valve or functionally equivalent proportional control supplied from the associated supply reservoir. The proportional control shall be controlled by and driven by the propulsion control logic, as per Section 10.2.3.3. If a proportional valve is used, it shall be arranged so that the degree of brake release obtained is proportional to valve energization; loss of valve energization shall result in full brake application. Alternate means of control achieving comparable function may be proposed.

When a service brake command change is a step change from 25 to 75 percent of maximum brake effort, the time required for the brake cylinder pressure to change from 25 to 55 percent of maximum shall be not greater than 0.45 seconds, including dead time no greater than 0.2 seconds.

When a service brake command change is a step change from 75 to 25 percent of maximum brake effort, the time required for the brake cylinder pressure to change from 75 to 45 percent shall be not greater than 0.55 seconds, including dead time not greater than 0.2 seconds.
10.3.1.2 Emergency Braking

MOD 02,06

CO 148,

CO 242

Propagation of emergency braking shall be by means of a pneumatic brake pipe running the length of the train, supplemented by a discrete electric trainline as specified in Section 7.3.2. Pneumatic brake pipe propagated emergency braking shall be available whenever the system is charged. Emergency brake operation shall be generally independent of the proper functioning of the propulsion control logic, as specified in Section 10.2.13.1.

All emergency brake performance requirements shall be met with pneumatic propagation alone, as well as with electro-pneumatic propagation.

The brake pipe shall be charged from main reservoir air and shall operate at main reservoir pressure. Brake pipe pressure shall be initially developed by normally-closed, electrically-operated charging valves provided on each car, and when charged shall be maintained against minor leakage by pneumatic, limited-flow maintaining valves provided on each car. Brake pipe charging shall be initiated by Train Operator actuation of the Master Controller to the full-service brake position, shall commence at the car containing the controlling cab, and shall be assisted by the charging valves on other cars of the train. Brake pipe charging shall be controlled in such a way that any lack of brake pipe continuity throughout the train shall inhibit release of emergency brakes on the train as a whole. Brake pipe charging to operational levels for a ten-car train shall be achieved within twenty seconds of initiation; proportional increase in charging time shall be permissible in the event that local controlling logic on one or more cars in the train is inoperative. The capacity of charging valves and maintaining valves shall be limited in coordination with emergency valve capacity so that failure of any or all charging valves to close when commanded, combined with normal maintaining valve operation, shall not prevent the initiation or propagation of an emergency application by either pneumatic or electric means. Maintaining valves shall also provide for main reservoir back-charging from the brake pipe.

The brake pipe shall be charged only when the reverser handle is set to the forward position. If the train operator wishes to move the train in the reverse direction, the following order must be followed.

- The reverser handle should first be set to the forward position.
- The brake pipe should be charged.
- Following charging action, the reverser handle can be moved to the reverse position, allowing the train to reverse.

Each car shall be equipped with a normally-open electrically-operated emergency application valve that when deenergized shall exhaust brake pipe pressure to the atmosphere at a rate sufficient to ensure initiation of a pneumatically-propagated emergency brake application. Each such valve shall be controlled by the discrete electric emergency brake trainline specified in Section 7.3.2, in such a way that energization of the trainline wire shall result in the simultaneous initiation of an emergency brake application on all cars of the train.
On each car, when irrevocable pneumatic initiation of the emergency application has been confirmed, the emergency application valve shall be allowed to close to permit recharging of the brake pipe.

Each car shall be equipped with a pneumatic emergency vent valve that shall respond to rapid reductions in brake pressure and shall respond by exhausting brake pipe air to the atmosphere at a rate sufficient to ensure pneumatic propagation of an emergency brake application. Once activated the vent valve shall remain open for a period of time sufficient to ensure that the train comes to a complete stop. Alternate means of ensuring that an emergency brake application is irretrievable until the vehicle has come to a stop may be used, subject to NYCT approval.

Each car shall be equipped with one or more normally-open brake pipe pressure switches that shall monitor brake pipe pressure and shall energize the discrete electric emergency brake trainline specified in Section 7.3.2 whenever brake pipe pressure drops below an approved pressure.

It shall be possible to initiate an emergency brake application by either electric or pneumatic means. Means of initiating emergency braking shall include the following:

- Emergency position of Master Controller handle (see Section 6.6.7.2);
- Deadman Control (see Section 6.6.8);
- Conductor’s emergency brake valves (see Section 6.6.11);
- Passenger Emergency Handle Units (see Section 10.3.3.6);
- Trip cocks (see Section 10.3.2.7);
- Reduction of main reservoir pressure below that needed to provide a full emergency brake application at AW3;
- Uncommanded uncoupling;
- Parting or rupture of the brake pipe or brake pipe hose; and
- Energization of the electric emergency brake trainline.

Emergency brake cylinder pressure on each truck shall be developed by supply reservoir air directed to the brake cylinders by a pneumatically operated valve piloted by brake pipe air, and shall be pressure-limited by pneumatic means in response to car load. Emergency braking shall be developed on each truck whenever brake pipe pressure falls below an approved level regardless of the prior state of the propulsion system or the friction brake subsystem.

Pneumatic-only propagation time for a 10-car train shall be less than 2 (two) seconds, measured from the instant of emergency brake command at the lead car until the beginning of brake cylinder pressure rise at the last car.
10.3.2 Truck Mounted Equipment

10.3.2.1 General

The friction brake subsystem shall withstand the loads induced when meeting performance requirements with electrical braking inoperative and shall withstand one and one-half times the main reservoir safety valve pressure.

10.3.2.2 Tread Brake Unit

A tread brake unit, mounted on the truck frame and able to withstand the forces and motions associated with that location, shall be provided for each wheel. Each unit shall receive air pressure under control of the electro-pneumatic control unit and apply braking effort to the wheel tread through a composition brake shoe. The unit shall provide lateral restraint to the brake shoe heads to insure proper location of the brake shoe relative to the wheel to preclude uneven pressure or shoe slide-off when unflanged brake shoes are used. The tread brake unit shall automatically adjust to compensate for brake shoe wear.

Analysis of the self-energizing forces shall be submitted for review and approval. The brakes shall be designed to permit adjustments to accommodate a combined radial wear of 3-1/4 inches (83 mm) on both wheels and shoes. The tread brake unit and truck mounting shall be designed for loading at the maximum brake cylinder pressure plus the handbrake forces with a margin of safety to accommodate a pressure regulation malfunction.

The unit shall be readily accessible for maintenance and inspection without the need to detruck.

All wearing surfaces shall be provided with renewable steel pins and bushings or wear plates. Lubrication fittings shall be provided at all points requiring lubrication, and these fittings shall be fully accessible from a shop pit with the tread brake unit mounted on the truck.

The brake system shall be designed to withstand the loads induced in the system when complying with the performance requirements of Section 2.4.3. The effects of elevated temperatures in terms of forces, thermal stresses and component life shall be included in the affected component analysis.

10.3.2.3 Brake Shoe Heads

Brake shoe heads shall be made of material which has been proven in service on NYCT and shall be designed to permit the brake shoe keys and brake shoes to be readily removed and replaced. The heads shall have a 17-3/4 inch (450 mm) radius surface.

10.3.2.4 Brake Shoes

Brake shoes shall be approved two-inch-thick flangeless composition shoes and shall conform to NYCT internal Specification 2069-PROD-91, latest revision, for composition brake shoes. Brake shoes shall have a good fit with typical brake heads. The composition shoe, when applied, shall not generate noise or harmful gases exceeding levels specified by federal, state and city codes.
10.3.2.5 **Brake Shoe Keys**

Brake shoe keys shall be top mounted and shall secure the standard brake shoe to the brake head.

10.3.2.6 **Brake Levers, Rods, Hangers, Pins and Bushings**

Tread brake unit and parking brake lever, rods and hangers (if needed) shall be steel conforming to requirements of Section 15, and shall be designed to the following requirements:

Allowable stresses of brake parts are based on mild open hearth steel having an yield point of 33,000 psi (227.5 MPa) and shall not exceed the following requirements in pounds per square inch.

<table>
<thead>
<tr>
<th></th>
<th>Tension psi</th>
<th>Tension MPa</th>
<th>Compression psi</th>
<th>Compression MPa</th>
<th>Shear psi</th>
<th>Shear MPa</th>
<th>Bearing psi</th>
<th>Bearing MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rods</td>
<td>15,000</td>
<td>103.4</td>
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<td>10,000</td>
<td>69</td>
<td>10,000</td>
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<tr>
<td>Levers</td>
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<td>158.6</td>
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<td>69</td>
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<td>Jaws</td>
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<td>Pins</td>
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<td>10,000</td>
<td>69</td>
<td>12,000</td>
<td>82.7</td>
</tr>
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</table>

Brake rigging stresses are based on a brake actuator pressure of 100 psi (690 kPa) and shall not exceed 90 percent of the yield point of the material at a cylinder pressure of 140 psi (965 kPa) combined with the normal parking brake forces.

Brake pins shall be induction hardened to an effective depth of 0.100-inch (2.5 mm) minimum and a minimum hardness of Rockwell C60 and shall have a surface finish of 32 micro inches (0.81 micrometers). Pins internal to tread brake units shall be the supplier's standard.

Bushings shall be provided for all holes in brake levers, rods, and hangers. Bushings shall be of cold drawn seamless steel tubing case hardened to a surface hardness of Rockwell C60 and finished to 32 micro inches (0.81 micrometers). Sufficient material shall be removed from each surface to eliminate surface defects. Bushings are to be pressed into holes with a press fit of from .003- to .007-inch (76- to 178-micrometer) interference. Bushings internal to tread brake units shall be the supplier's standard.
10.3.2.7 Trip Cock

MOD 04

Self-resetting pneumatic trip cocks, with adjustable connections, shall be installed as specified in Section 4.3.9. The trip lever shall be of a proper length and shape and shall be located so that it will positively engage the track trip. When activated, the trip cock shall open, shall remain open a length of time sufficient to initiate an emergency brake application and to allow the brake pipe pressure to reduce to a low value, and shall then automatically reset.

All working parts of the trip cocks shall be made of corrosion-resistant materials and provision shall be made for periodic lubrication.

Means shall be provided to connect an additional B Division trip cock on the No. 1 end of each A Car, as specified in Section 4.3.9.

10.3.3 Car Mounted Equipment

10.3.3.1 Brake Operating Units and Brake Pipe Unit

An independent pneumatic brake operating unit shall be provided for each truck. An independent brake pipe unit shall be provided for each car.

Each unit shall be a preassembled laminated pipe bracket arranged for mounting securely to the car underframe. The line filter shall be a disposable element type with a normal replacement life of 60,000 miles (96,540 km).

The unit shall be arranged to permit removal of the individual operating devices without disturbing any pipes, other valves, or other adjacent equipment and shall be located under the car to minimize piping to adjoining equipment.

10.3.3.2 Reservoirs

CO 100

Each car shall have a main reservoir and two supply reservoirs (one per truck) each with a volumetric capacity capable of supplying all systems with sufficient air and with brake system electrical functions working normally, to make five consecutive full-service braking applications and releases at AW3 without initiating an emergency application due to low air. After the five consecutive full-service braking applications, it must be possible to make a normal load weighed emergency brake application. It shall be assumed that the compressor loss occurs when the main reservoir air is at the cut-in pressure setting of the air compressor control. The reservoir sizing will consider worst case temperature conditions and all calculations shall be submitted to the NYCT for approval at least 3 months prior to First Article Inspections.

Only braking air shall be supplied by the supply reservoir, and all other air requirements shall be taken from the main reservoir. The air supply to the supply reservoir shall be protected by a check valve. Reservoirs
shall conform to Section 15.16. Reservoirs shall be low alloy steel with flange fittings and enameled inside and outside to resist corrosion.

The main reservoir shall be protected against loss of air in the event of air hose rupture or other failure between the main reservoir and compressor through a suitable check valve. Each main reservoir shall be provided with a manual drain valve. Each drain cock shall be installed to open by a pull toward the nearest side of the car. Each supply reservoir shall be provided with a manual drain plug. Drain valves and any similar fittings on the bottom of reservoirs shall be provided with protective shrouds to prevent their being knocked off by debris on the track.

10.3.3.3 Cutout Cocks

Cutout cocks shall be provided for all pneumatic components and subsystems. All handles shall be of the locking type, except for multiple access cutouts, and shall be arranged so that in the open position, they shall be crosswise of the flow of the air and in the closed position, parallel with the flow of the air. All cutout cocks shall be permanently marked to indicate the direction of flow. The following cutout cocks shall be provided as a minimum; others as necessary for maintenance, troubleshooting, and failure recovery:

- Brake Cylinder Cutout. A vented cutout cock shall be provided in each brake cylinder line. There shall be two controls for each cock. One shall be located inside the car behind a swing panel, and the other shall be under the car, at the side of the car, visible to a person standing beside the car at the side sill. It shall be possible to cut out and cut in the brakes by means of either of the controls.

- Selector Cock. A selector cock of approved design and manufacture shall be provided for each truck that will cut out air service brakes on that truck while leaving emergency brakes in operation. There shall be two controls for each cock. One shall be located inside the car behind a swing panel, and the other shall be under the car, at the side of the car, visible to a person standing beside the car at the side sill. It shall be possible to activate and deactivate the selector cock by means of either of the controls.

Pressure test fittings shall be provided in the various pneumatic lines and pipe brackets. These test fittings shall permit quick connection of gauges or transducers for testing and trouble shooting. All test fittings shall be protected by either a flow-limiting orifice or isolating cock.

10.3.3.4 Pressure Indication

Brake cylinder and brake pipe air pressure levels shall be furnished for indication on the cab console via a duplex air gauge (see Section 6.6.6.2). The needle for the brake pipe pressure shall be black, and the needle for the brake cylinder pressure shall be red. The background of the gauge face shall be silver with black lettering.
10.3.3.5 Horn

CO 139

One pneumatic horn shall be installed under the floor at each cab and controlled from the cab console at that end. The horn shall have a minimum output of 92 dBA at a distance of 100 feet (30.5 m) from the end of the car on surface or elevated track. Air consumption of the horn shall not exceed 20 cubic feet per minute. A cutout cock shall be provided in the air supply line to each horn. The horn shall be mounted perpendicular to the track.

10.3.3.6 Passenger Emergency Handle Unit (PEHU)

CO 218

Each car shall be provided with two PEHUs. Each PEHU shall include a recessed mounted, manually-operated handle arranged so that a passenger can activate the PEHU by pulling the handle downward. The PEHU located in the wheelchair area shall be recessed and located within ADA height requirements. The handle shall be located within an enclosure with a detent retained, hinged cover. Opening of the hinged cover shall activate an audible annunciator located within the enclosure. The annunciation, powered from the car's low voltage d.c. system, shall sound continuously until the enclosure cover is closed. The audible annunciation shall generate a sound level of 88 to 98 dBA. The handle shall require no less than fifteen pounds nor no more than twenty pounds of force to actuate, and shall not rattle. The handle once pulled shall remain in the activated position until reset by a mechanism operated by the Master Door Controller key. The activated status of the handle shall be clearly visible.

When activated, the PEHU shall cause the following to occur:

- The emergency brake shall be applied if and only if the train has proceeded 600 feet (183 m) or less from its most recent station stop;
- If the train has proceeded more than 600 feet (183 m) from its most recent station stop, the emergency brake shall be applied when the train has reached its next station stop; and
- An indication shall be made in each cab in which a Master Controller or Master Door Controller is activated.

For the purposes of this Section, a station stop shall be considered to take place whenever the no-motion signal is true and the car doors are commanded to open.

The PEHU circuits shall be so arranged that, in the event of failure of the logic implementing the functions described above, the response to actuation of the PEHU shall be an immediate emergency brake application.
10.3.4 Air Compressor Unit

10.3.4.1 General

Each Unit shall be provided with a minimum of three (3) air compressor units.

The air compressor unit shall contain a heavy-duty compressor, direct driven from and integrally mounted to an induction motor of approved design, sump reservoir, cooling system, safety valve, automatic drain valve with heater, governor, intake filter, dryer, and all other required accessories. The compressor unit shall be under car mounted and shall be of a rotary screw or reciprocating design. The unit shall comply with noise and vibration requirements of Section 2.7.

The compressor, when driven by its 3 phase induction motor operating against a pressure of 150 psi (1,034 kPa) shall be designed so that if one of the air compressors of a Unit has malfunctioned, the remaining air compressors can handle all operating and emergency requirements of the train indefinitely. It shall also operate successfully and maintain a positive pressure at the compressor of from 130 to 150 psi (896-1,034 KPa). The compressor shall have an integral sump. Compressor lube oil consumption shall not exceed 2 pints (0.94 liters) in 60 days with 16 hours per day operation.

10.3.4.2 Intake Filter

The compressor intake filter shall be an approved 10 micron disposable element of adequate size to permit passage of the volume of air required for the maximum compressor capacity. Filter element replacement, under normal maintenance requirements, shall be not less than every 30,000 miles (48,270 km).
10.3.4.3 Discharge Temperature

The air discharge temperature of the compressor unit shall be within 8°F to 10°F (4.4°C to 5.5°C) of inlet ambient temperature with the compressor running continuously under full load for one hour. A pressure relief bypass branch shall be provided near the end of the cooling coil so that, in case of an ice blockage at the end of the coil, air is permitted to bypass the after-cooler.

10.3.4.4 Subsystem Pressure

MOD 02

Maximum pressure in the pneumatic subsystem shall be 160 psi (1,103 kPa). The subsystem shall be protected by a main reservoir safety valve.

10.3.4.5 Leakage Rates

Leakage rate if any shall be included in the allowable system leakage specified in Section 10.3.7.3.

10.3.4.6 Compressor Control

CO 03

Compressor operation shall be automatically controlled on a per-Unit basis to maintain pressure at 130-150 psi (896-1,034 kPa). A synchronizing unit line that starts all compressors on a unit at the same time shall be provided. Details of the control scheme selected are subject to approval by NYCT. Positive action of the compressor control shall not be influenced by a slow rate of depletion of the main reservoir pressure. It shall be readily adjustable, positive in action, and able to function repeatedly under all service conditions.

10.3.4.7 Power Supply Operating Modes and Capacity

The compressor shall be operated from the Car Auxiliary Inverter described in Section 9.7 and shall conform to the electrical design requirements of Section 15.27.

10.3.4.8 Compressor Motor

The compressor motor shall be a standard industrial-grade, squirrel-cage-type, three-phase alternating current motor. It shall be designed in accordance with the requirements of NEMA MG1 or other approved standard and shall be rated for operation under the duty cycle specified in Section 10.3.4.1.

Shaft bearings shall be of the anti-friction, ball or cylindrical roller, double-width, pre-lubricated and sealed type.
10.3.4.9 Air Dryer MOD 02

A regenerating-type air dryer, twin tower design, shall be provided. The dryer shall have adequate capacity to reduce the relative humidity of the compressed air to 35 percent at working pressure under all ambient conditions specified in Section 2.1.3, throughout the desiccant's useful life, which shall be minimum of one year. Replacement desiccant for dryers shall be available in bulk or in prepackaged bags from multiple sources. The air leakage of the dryer, if any, shall be included in the allowable system leakage specified in Section 10.3.7.3.

10.3.4.10 Automatic Drain Valve MOD 04

An automatic drain valve shall be applied directly to the sump reservoir. An automatic drain valve that is in satisfactory use on the NYCT shall be provided. The automatic drain valve shall be actuated by a device to guarantee the periodic actuation of the drain valve with the compressor running continuously. The drain valve heater shall be thermostatically controlled as described in Section 10.3.4.11. Before leaving the manufacturer's plant, all automatic drain valves shall withstand an air pressure test of 160 pounds per square inch (1,103 kPa) minimum, and shall operate satisfactorily under all pressure conditions.

10.3.4.11 Drain Valve Heater

A thermostatically controlled 37.5 Vdc supplied heater shall be installed in the air compressor drain valve.

10.3.4.12 Air Compressor Cutout Cock CO 168

A vented cutout shall be provided on the pneumatic line between the air compressor and the main reservoir tank. The cutout cock will be on the air compressor side and will allow for the isolation of the air compressor from the pneumatic system.

10.3.5 Test Points

The electropneumatic brake circuits and components shall be arranged for the plug in of a portable analyzer which shall check all valve electric functions. The following air pressures shall also be checked:

- Brake Pipe Pressure
- Brake Cylinder Pressure
- Main Reservoir Pressure

Brake system operation, while the analyzer is in use, shall be from the cab console or from the PTU. Pressures shall be taken from the test connections described in Section 10.3.3.3. The analyzer and the procedure for its use shall together provide a clear pass/fail test of each of the above functions. The pass/fail criteria may be based on magnitude and speed of air pressure responses to stated actions (rather than on electrical voltage and current values) where such responses provide a positive test.
Analyzer unit shall be constructed as outlined in Section 20.4.
10.3.6 Parking Brake

10.3.6.1 General

A spring-applied, pneumatically-released parking brake shall be applied to one truck of each car. The parking brake shall transmit force to the parking connections on the tread brake unit. The parking brake shall incorporate a readily accessible self-resetting manual override feature that shall permit release and reapplication of the parking brake from above the floor without an air supply. Any ratchet or pump used in this design shall not require more than 30 handle cycles to accomplish the intended purpose. The manual override feature shall be arranged so that receipt of a normal pneumatic parking brake release signal shall permanently cancel any manual release then in force.

A mechanism for manual reapplication of a manually released parking brake shall be required on A-Cars only.

Exhaust of the air supply to the spring brake cylinder shall result in the required holding power at the tread brake units.

10.3.6.2 Controls

CO 191

The parking brake shall be controlled by Main Reservoir pressure and shall apply incrementally when the Main Reservoir pressure is below an approved value. The design of the parking brake control must be submitted to NYCT for approval.

10.3.6.3 Capacity

The parking brake shall provide performance as specified in Section 2.4.3.3.

10.3.6.4 Parking Brake Rigging

The parking brake rigging shall be rattle-free and designed to provide equal forces to a tread brake unit on each axle. The swivel of the truck on curves shall not cause the parking brake to be applied.

Rods, lever, jaws and pins shall meet the stress requirements of Section 10.3.2.6.
The parking brake unit shall incorporate a switch to indicate parking brake release to the propulsion control logic.
10.3.7 Design and Application Requirements

10.3.7.1 Design Life

The brake system, including mechanical linkages, shall be designed for $5 \times 10^6$ cycles of operating loads without failure, excluding planned replacement of expendable items.

10.3.7.2 Pressure Vessels

Pressurized vessels and components shall conform to the requirements of Section 15.16.

10.3.7.3 Air Leakage Rate

Allowable air leakage for the total car shall not exceed 5 psi (34.5 kPa) in 10 minutes following a five-minute settlement period from the point at which the subsystem had been charged to 150 psi (1,034 kPa) and the air compressor had been shut off.

10.3.7.4 Mounting

All parts of the air brake system shall be mounted in close proximity to minimize piping and so that it will not be necessary to remove piping, conduits, or a complete assembly for replacements, repairs, oiling and inspection.

10.3.7.5 Air Pipes and Hoses

Air line piping shall be as specified in Section 15.15 and shall comply with the following requirements:

- Piping shall be clamped to prevent vibrating, rubbing and chafing. Clamps shall be insulated to prevent noise generation.

- Flexible connections shall be provided on all piping between the car body and the trucks and couplers. Hoses shall conform to AAR Specification M-618 with AAR-approved reusable fittings meeting AAR Specification M-927. Air hose applications shall not be permitted in locations where adequate visual inspection cannot be assured. Flexible connection between air compressor unit and car body shall not be required if such isolation is provided within the unit.

- Piping shall be installed with the minimum number of fittings. Unions shall be used to permit replacement of apparatus and hoses.

- All piping and fitting shall be arranged to assure moisture drainage.

- All piping, fittings and valves shall be protected from damage caused by flying ballast and other foreign materials which are encountered in operations.
• Piping located in close proximity to exposed high voltage surfaces or equipment shall be insulated to resist the initiation or propagation of electrical arcing.

• The Contractor shall obtain concurrence of the friction brake supplier regarding piping procedures and arrangement, and those details shall be submitted for the NYCT's approval prior to review of the undercar mockup.
SECTION 11
SIDE DOOR OPERATORS AND CONTROLS

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SECTION 11

11.0 SIDE DOOR OPERATORS AND CONTROLS

11.1 General

Each car shall have six side door openings. The location of the doors shall be as shown on "MTA-Car Plans", Drawing No. LTK 1-1, within Appendix D.

Side doors shall be of the bi-parting, sliding pocket design. Door panel requirements are contained in Sections 3.10.2 and 3.12. Threshold requirements are contained in Section 3.9. Each door opening shall be equipped with two fully-independent electric door operators which shall control the motion of its respective panel and monitor its closed status. NYCT will consider alternative designs utilizing one operator per doorway provided that the Contractor can demonstrate that in-service reliability will be unaffected.

The side door system shall include, but not be limited to, door panels, overhead door operators, mechanical linkages, Master Door Controller, Door Control Relay Panel, Door Operator Control Panel, discrete panel locks, panel cutout locks, obstruction detection and a safety circuit indication summary signal system that conveys continuous door panel closed and locked status. The side door controls shall use relay-based logic and discrete trainlines for control commands to the doors. Discrete trainlines shall also be used to monitoring the door closed and locked status of all doors in the train, and for providing the required indications to the train crew. Functions that are not safety-critical may use electronic logic in lieu of relay logic.

All door equipment of like function and the same hand shall be interchangeable. To this end, all mounting holes for all door hardware shall be jig-drilled. All door system equipment shall be installed in such a manner so as to be readily accessible to maintenance personnel with minimal effort. The door system shall be designed such that mechanical systems shall not require adjustments.

All areas of access visible to the riding public shall be made vandal- and tamper-resistant, either by lock and key, or similar methods as approved by NYCT.

The side door system shall be designed and constructed to have operational interfaces with several train subsystems such as traction trainline controls, emergency handle, public address announcements and monitoring to ensure train coordinated functioning. There shall be sufficient isolation designed therein to ensure that none of these interfaces can deliver an unwanted signal into the door control or indication systems. The door control system shall be designed in accordance with safety requirements of Section 18.4.

Plastic circular-type connectors may be used in the door system.
11.2 Functional Requirements

11.2.1 General Requirement

The passenger side door system shall perform, but not be limited to, the following functions:

- OPEN
- CLOSE
- OBSTRUCTION SENSING
- POSITIVE PANEL LOCK
- LOCAL RECYCLE (AUTOMATIC AND CREW INITIATED)
- EMERGENCY HANDLE
- TEST SWITCH
- DOOR CUTOUT
- SHUTTLE
- CREW SWITCH OPERATION
- ZONED CONTROL
- FAULT LIGHT INDICATION
- GUARD LIGHT INDICATION
- TRAIN OPERATOR INDICATION
- CONDUCTOR CLOSED INDICATION
- DOOR CLOSING WARNING SIGNAL
- SINGLE PANEL DOOR OPENING
- DOOR SYSTEM INTERLOCKS WITH:
  - PROPELLSION SYSTEM
- DOOR INTERLOCK BYPASS SWITCHES
- DOOR SYSTEM INTERFACES WITH TRAIN MONITORING SYSTEM AND AUTOMATIC ANNOUNCEMENT SYSTEM

11.2.2 Performance Requirements

Door motion shall be smooth and free of shock and impact. Damping shall be provided at the ends of travel of the door panel in both the opening and closing directions. This may be accomplished through the use of electrical controls or linkage geometry, as may be appropriate, to provide cushioning and to prevent oscillation about the open or closed end stops. Door panel speed shall be relatively constant throughout the open and close strokes, other than for the ramp-up and ramp-down of speed for damping.

Doors shall open and stay open upon receiving a valid open command, until that command is interrupted. When commanded to open, each door panel shall require 1.6 seconds to move from the closed position to within 3 inches (76.2 mm) of the fully-open position. When commanded to close, each door panel shall require 2.6 seconds to move from the fully-open position to the fully-closed position, at which time the door panel
shall be automatically locked. Respective opening and closing times of 1.6 and 2.6 seconds are nominal, and are expected to be achievable without adjustment and at the rated nominal voltage. An additional -0.2, +0.8 second adjustment capability shall be provided, with opening and closing speeds independently adjustable.

Each door panel operator shall exert a maximum closing force of 30 lbs. (134 N) over the entire door travel throughout the opening and closing cycle when energized by the LVDN operating normally, and shall open or close with a 60-pound force (267 N) applied normal to the interior door surface at approximately shoulder height (56 inches). Total door panel static friction, including seals, but excluding the internal resistance of the door operator, shall not exceed 5 lbs. (22.2 N).

Door panels shall be held fully-open by friction with power available to, but withheld from, the door operators. If panels should drift away from their fully-open rest position, such as may occur when on a grade, the power shall be reapplied to re-open the panels. This requirement will be waived should it be proven that the door operators and linkages can resist against this type of drift when the car is on a ±4 percent grade.

The door operator shall positively retain the door panel in the closed position. Solenoid-released, mechanical locking shall take place automatically when the door panel reaches the fully-closed position. Separate electrical position-sensing devices shall be provided to detect that each door panel is fully-closed and locked. If the Contractor can show that an alternative approach utilizing one device per panel will provide the same level of safety as two devices per panel, the NYCT will consider approval of other arrangements provided that they positively detect both closed and locked positions. The mounting of all sensing devices shall be such that no adjustment shall be necessary when any given device is replaced.

The control system shall be designed to withstand, detect and annunciate single point safety failures without doors unlocking and opening. B+ on any unlock and/or open trainline or carline shall cause the Train Operator's Indication (all Doors Closed, see Section 11.10.2) to be extinguished.

11.3 Side Door Hangers MOD 02

Side doors shall be hung on co-axial or other NYCT-approved, low-friction hangers specifically designed for use on top-hung panels. Door hangers shall be constructed so as to allow simple, easy disconnection of the panel from the door hanger and drive mechanisms, yet be sufficiently rugged to hold vertical and horizontal adjustments permanently. Dual hangers, bolted to the door panel, are acceptable. Inverted "T" hangers that slide between door panel sheets are not allowed. The door panels shall be oriented so that they are readily removable from the inside of the car from the center of the doorway.

The hangers for the doors shall be protected from the weather. They shall be able to withstand the normal driving forces which occur during the repetitive open and close cycles typically experienced on NYCT subway operation, including those forces external to the door system which act thereupon. These forces shall not be transmitted to the operators or other moving parts of the door support system in a manner that could cause damage.
The hanging system shall be designed and constructed such that the tolerance on the closing position is well within that of the closing position indication and shall remain within that range for the life of the system. Adjustable and lockable rubber stops shall be provided at both the top and the bottom of the door open and close positions to prevent undue noise and canting of doors. Horizontal and vertical adjustment capability shall be provided and easily accomplished. All mounting and adjustment hardware, support and connections shall be invisible to the riding public, yet readily accessible to the car inspector, for any and all inspection, adjustment, repair or replacement maintenance functions. Lubrication shall be of a permanent nature, eliminating the need for re-lubrication during maintenance cycles. If lubricant is added, no adverse operation of the doors shall result.

The bottom of each side door panel shall be provided with a removable, 0.25-inch (6 mm) thick, guide plate constructed of an approved high-density, high-molecular weight, polyethylene material. The guide plates shall be adjustable in a vertical direction. Design of the bottom guide and thresholds shall act to prevent foreign material from affecting operation of the door. The guide plate shall be concealed between the inside and outside door sheets and reversible about its vertical and longitudinal axes. The closing edge of the guide plate shall be tapered to fit the door guide slot in the threshold. The material of the guide plate shall be long-wearing with a maximum anticipated wear of 0.030 inches (0.76 mm) in eight years.

All numbering of doors openings, operators, and panels shall conform to Section 2.2. Door location and markings shall maintain their address interface compatibility with the monitoring system if car location changes.

11.4 Door Operator Control Panel

A Door Operator Control Panel shall be installed at each door panel in the overhead compartment. This panel shall contain the door operator and its controls, rigid drive train, panel sensing and locking devices, and local relay controls required to operate a door panel as commanded when control signals are received directly from the Door Control Relay Panel (see Section 11.6.4). Control signals shall also be received from the Crew Switches. Both Door Operator Control Panels installed at a doorway shall be completely independent.

The Door Operator Control Panel shall be supplied as an integral unit and be modular in design to allow major subassemblies to be removed and replaced on an individual basis. While a left hand and right hand configuration will be required, components shall be interchangeable between configurations to the maximum extent possible.

Other features to be incorporated into or interfaced with the Door Operator Control Panel include the following:

- An LED display indicating the status of the associated closed and locked panels sensors; Crew Key Switch where installed; the closed, open and unlock signals for that side of the train; and the two status indication trainlines.
- An Emergency Handle for crew emergency use (see Section 11.8), and
Mechanical position sensing switches shall not be used except as approved by the NYCT. Where used, they shall be Shaltbau Model 826e or 847 switches, or approved equal. When position sensing switches are changed, no adjustment shall be required.

### 11.4.1 Electric Door Operator Requirements

#### 11.4.1.1 General

Each Door Operator Control Panel shall be provided with a single electric operator capable of opening and closing the door panel. The operator shall be powered from the low voltage distribution network (LVDN) as specified in Sections 2.3.3 and 9.10, and shall be capable of operating over the entire voltage range of the LVDN without affecting the reliability and serviceable life of the operator. The specified door operating times shall be met when the LVDN is within its nominal voltage range, as measured at the output terminals of the power source. The operating speeds over the entire design voltage range shall not result in panels slamming open or closed.

Should the door operator require a speed reduction gear unit, the unit shall be sealed and capable of withstanding repetitive instantaneous reversals without damage. The unit shall be closed to atmosphere, with access for inspection, and designed for a minimum of 2 million open/close cycles between relubrication.

The door operators shall be capable of providing continuous repetitive operation under the most severe conditions, with inspections and other scheduled attention performed in accordance with NYCT's reference document entitled, "SMS Generic Car Workscope and Time Intervals", within Appendix C.

#### 11.4.1.2 Electrical Protection

The door operator motors shall be insulated with class F insulation or better, and be capable of remaining continuously energized when stalled, with maximum low voltage distribution network voltage applied, without overheating; or alternatively, capable of detecting this condition and removing power if it persists for a preset time. No adverse affect on the reliability and serviceable life of the equipment shall occur in either case. If the alternative approach is used, re-issuing any door control command shall cause power to be reconnected to the door operator and the time-out feature to be reset.

Each door operator, its wiring and equipment shall be protected electrically by means of a circuit breaker at each location, and a circuit breaker at the Low Voltage Breaker Panel. The motors shall also be thermally protected with an automatic-resetting “Klixon”-type (or equal) device for current limiting purposes.
11.4.2 Door Panel Locking

Automatic mechanical door panel locking, independent of the door operator and rigid linkage, shall be provided to effectively hold each door panel in a fully-closed position, even in the event of any failure of the door operator or linkage mechanism. The use of over-center locking is deemed insufficient for locking the door panels closed. It shall not be possible for the lock to deploy unless the door panel is in the fully-closed position. The panel lock shall be designed to be spring-applied and solenoid-released.

11.4.3 Manual Test Switch

A Manual Test Switch shall be provided for each door operator in order to facilitate operation of an individual door panel for test purposes by maintenance forces. The Manual Test Switch shall not be capable of issuing a door open command. The test switch shall have two positions: NORMAL and CLOSE. They shall function as follows:

- NORMAL: This shall be a maintained position. When the switch is in or moved to the NORMAL position, the door shall remain in the last valid trainline or Crew Key Switch commanded position. If it is open, it should remain open. If it is closed, it should remain closed.

- CLOSE: This shall be a momentary position. When the switch is moved to the CLOSE position, the open command shall be interrupted, causing the door to close and lock within the prescribed time (see Section 11.2.2).

All other door functions shall operate as they would if the door were being commanded from the Master Door Controller.

11.5 Obstruction Detection

A method for detecting an obstruction and preventing the closure of a side door shall be included as part of the design of the door controls. The doors shall not lock and permit a doors closed indication if an obstruction is detected. The use of nosing seals with air chambers to activate a pressure wave switch is not acceptable for implementing obstruction detection.

11.5.1 Detection Sensitivity

The sensitivity of the obstruction detection system shall be as follows:

- It shall detect a flat bar, 1/4-inch (6.35 mm) wide and 3 inches (76.2 mm) high, held rigidly between and perpendicular to the door panel, as a hand might be held to stop the doors. This sensitivity shall be required everywhere along the length of the panel except the uppermost 3 inches (76.2 mm) and lowermost 1 inch (25.4 mm) of the nosing seal. This obstruction shall cause the doors to recycle as described in Section 11.5.2.
It shall detect an object, 3/8-inch (9.53 mm) in diameter, held rigidly between and perpendicular to the door panels at all locations along the length of the door nosing seal, except the uppermost 3 inches (76.2 mm) and lowermost 1 inch (25.4 mm) of the seal. This obstruction shall cause the doors to recycle as described in Section 11.5.2.

The equipment shall also permit a thin flexible object which might become enclosed in the nosing seals to be pulled free from doors that are fully closed and locked. The force required to remove the object shall be 20 pounds or less, exerted perpendicular to the door panel toward the outside with the object enclosed in the door at mid-height. NYCT Drawing 553-2038, Rev A, depicts the cloth gauge to be used to verify conformance with this requirement.

11.5.2 Recycle Operation

Upon sensing of an obstruction on which recycling is to occur, the local door controls shall cause the door operator on the obstructed panel to immediately reverse and open, either partially or fully as approved by NYCT. The panel shall attempt to close up to a total of three times. The number of recycles shall be selectable by NYCT from 0 to 3.

(0) Recycle - No recycling occurs. The obstructed panel closes on the obstruction and stays in that position with obstruction detection protection active at all times.

(1, 2 or 3) Recycles - As the door attempts to close and an obstruction is detected the door panel shall immediately open approximately three inches from the detected obstruction and attempt to close. This cycle is repeated 1, 2 or 3 times depending on the NYCT selection. If the obstruction is still detected after completing the selected number of closures the door remains closed on the obstruction with obstruction detection remaining active at all times.

For operation of the Local Recycle Pushbuttons see Section 11.6.3.6.

11.6 Controls

11.6.1 General Requirements

Passenger side doors shall be controlled by the train crew from door control pushbuttons located in the Master Door Controller (MDC) and from the Crew Key Switches. Door controls for each side of the train shall be independent. Door control and indication trainlines shall be isolated from other trainline circuits wherever possible. The trainlines shall be shielded, with copper braid-type, or equivalent approved covering, grounded to car body, but not capable of trainlining that ground. Shielding shall be as specified in Section 15.17.4.4.

Door control and indication trainlines shall be split into zones fore and aft of the operating MDC position. All door system trainlines shall be interrupted before reaching an open-end coupler electric head, such that a feed to an open-end electric coupler head contact shall not be able to be transmitted into the trainlines. Two valid trainline commands, open and unlock, shall be required to cause passenger side doors to open. Loss of either or both commands shall cause the doors to close and lock.

Switches and pushbuttons shall be designed with a life expectancy of at least half that of the railcar when operated in the NYCT’s operating environment. Door control switches shall be of the illuminated-, toggle- or rotary-type to signify their position and/or operating status.
The Train Operator console shall also include provisions (space and necessary wiring) for future opening of the left side doors in a train for one-person train operation. The same control logic as the conductor’s controls shall be used.

11.6.2 Crew Key Switches

Crew Key Switches shall be provided inside and outside the car at the door panel closest to the No. 1 end on both sides of each A car. On each B Car, Crew Key Switches shall be provided inside and outside the car at diagonally opposed sides of the car door at locations approved by the NYCT. The switches shall have three positions as follows: OPEN, NEUTRAL and CLOSE.

The key shall be insertable and removable only in the NEUTRAL position, and springs shall cause the switch to always be returned to this position after operating to the OPEN or CLOSE positions. The positions shall not be labeled.

In the NEUTRAL position, the door panel controlled by the Crew Key Switch shall remain in the last valid commanded position. The OPEN and CLOSE positions shall have momentary-contacts, and when operated to these positions, shall cause the unlocking and opening, or closing and locking, of the adjacent door panel, respectively, within the specified time. A door panel opened from an exterior Crew Key Switch shall be able to be closed from the interior Crew Key Switch and vice-versa. When doors have been opened (or closed) by a Crew Key Switch, it shall be possible to subsequently control them from trainline commands, and vice-versa.

Each exterior and interior Crew Key Switch shall be located at a height convenient to personnel standing on station platforms or inside the car. The exterior Crew Key Switch shall be equipped with a weatherproof, spring-loaded cover which shall automatically close when the key is removed.

The Crew Key Switch shall interrupt the All Doors Closed Circuit (see Section 11.10.2) and illuminate the Guard Light (see Section 11.12.4) when the exterior switch is moved to the OPEN or CLOSE positions, and when the interior is moved to the OPEN position.

11.6.3 Master Door Controller Panels

Master Door Controllers (MDCs) shall be provided to enable train conductors to control the passenger side doors in zones within a train consist from one cab location, typically from the center of a train. An MDC shall be located on each side of the cab as described in Section 6.7. The MDC shall operate the doors on the side of the train on which it is located, and be totally segregated from the controls on the opposite side of the train.

Other features and interfaces to be incorporated into or interfaced with the MDC which are described elsewhere are as follows:

- Communications controls and indicators as specified in Sections 13.2.1.1.2 and 13.2.1.4.
11.6.3.1 Master Key Switch

One heavy-duty, standard, key-operated switch shall be incorporated in each MDC and on the left side of the vertical face of the console to control the circuit connections for the passenger door controls. The key shall be the NYCT's standard, square-type, MDC key as described in Section 3.12.4. The lock shall be driven from the outside as well as the inside of the key.

The switch shall have three maintained positions labeled in the following clockwise order: RUN, ON and TERM. The key shall be insertable and removable only in the RUN and TERM positions. The function of each position shall be operationally identical to the R44 through R68A Car classes as presently configured and shall be as follows:

- **RUN**: When the switch is in the RUN position, all MDC pushbutton controls are disabled, except for the Dezoning Pushbutton on both MDCs in a zoned-in operating cab (see Section 11.6.3.2).

  When an individual MDC in a cab is turned from ON to RUN, the conductor's zone indication function shall remain. The Zone Status indicator lights (see Section 11.6.3.2) included as part of the Dezoning Pushbutton shall remain illuminated as long as the MDCs in that cab are zoned-in. Turning the MKS from the ON to RUN position with doors open on that side shall result in the dropping out of the pushbutton relays and the removal of B+ to the door unlock and open trainlines (D1/D2 or D4/D5), causing doors on that side to close. With the MKS in a zoned-in cab in RUN, B+ shall be continuously applied to the door enable trainline on that side of the train.

- **ON**: When either MKS in a non-zoned cab is first placed in the ON position from the RUN position, both MDCs in that cab shall zone-in. Door control and status indication trainlines shall break at this cab, automatically establishing four door control zones: two forward of the cab, one for each side, and two aft of the cab, one for each side; and two zone light zones: one forward of this cab for both sides and one aft of this cab for both sides. Additionally, the Zone Status lights of both MDCs shall illuminate to indicate that the door control status is established at both MDCs until this cab is de-zoned. All MDC door system pushbuttons and status indicators in the MDC with the MKS in ON shall be electrically enabled, except for the Shuttle Pushbutton (see Section 11.6.3.5) which shall remain electrically disabled. The train operator's door closed indication shall be interrupted.

  Door system control pushbutton shall be electrically disabled until such time as the MKS is placed in the on position.
TERM: When the switch is placed in the TERM position from the ON position, all MDC door system pushbuttons shall be disabled, except for the Shuttle Pushbutton (see Section 11.6.3.5) which shall be enabled. The MDC shall remain zoned-in to allow the conductor to leave the train with the doors open and key removed. The Zone Signal Lights (see Section 11.6.3.8) shall be extinguished. The doors shall remain in the last valid commanded position when the MKS was in the ON position.

11.6.3.2 Dezoning Pushbutton

A Dezoning Pushbutton incorporating LED illumination to serve as a Zone Status Indicator Light shall be provided in each MDC. The Dezoning Pushbutton shall be of the momentary-contact type. The light to indicate Zone Status shall be illuminated on both MDCs in a zoned-in cab.

The Dezoning Pushbutton shall function only when both MDCs in that cab are in the RUN position and the cab is zoned-in. When the Dezoning Pushbutton is depressed, that cab shall de-zone, re-establishing continuous control and indication trainlines.

Both MDCs’ Pushbuttons shall illuminate when that cab is zoned-in. Both MDCs’ Dezoning Pushbuttons shall extinguish when that cab is de-zoned.

11.6.3.3 Door Open and Close Pushbuttons

Passenger side door Open and Close Pushbuttons shall be provided in each MDC. Two sets of pushbuttons shall be provided, one set each for the fore and aft door control zones, and arranged to minimize the potential for accidental operation. These pushbuttons shall be of the momentary-contact type.

When activated, the Open Pushbutton shall cause all doors in the associated zone to unlock and open within the specified period of time. This command shall be overridden by a simultaneous Close command.

When activated, the Close Pushbutton shall de-energize any open and unlock trainlines, and cause all doors not closed and locked in the associated zone to close and lock within the specified period of time. This command shall override any simultaneous Open or Partial Close command.

11.6.3.4 Intentionally Blank

11.6.3.5 Shuttle Pushbutton

One Shuttle Pushbutton shall be provided in each MDC. This pushbutton shall be of the momentary-contact type. This switch shall be enabled only when the MKS is in the TERM position and doors on the associated side of the train are open, and the drum switch is in the “Isolate” position, and shall illuminate when activated. When momentarily activated, the Shuttle Pushbutton shall cause the door open command on that side of the train to be preserved, when the MKS is returned to the RUN position. Shuttle cancel function shall be provided by activation of the Buzzer Trainline.
11.6.3.6 Local Recycle Pushbutton

One Local Recycle Pushbutton shall be provided in each MDC. This pushbutton shall be of the momentary-contact type. When activated, the Local Recycle Pushbutton shall cause the obstructed panels (all panels not closed and locked in the zone activated by the close button) on the same side of the train, to immediately open approximately three inches from the detected obstruction, and immediately close. This will be done without the recycle operation as explained in Section 11.5.2. The obstruction will remain active. All other doors shall remain closed and locked.

11.6.3.7 Door Partial Close Pushbutton

Two Partial Close Pushbutton shall be provided in each MDC. These pushbuttons shall be of the momentary-contact type. When activated, the Partial Close Pushbutton shall cause all non-crew door panels on the same side of the train within that zone to close. This command shall be overridden by a simultaneous Close command.

Non-crew door panels closed by activation of the Partial Door Close pushbuttons, shall fully reopen when the Open Pushbutton associated with that zone is subsequently activated.

Crew door panels remaining open due to activation of the Partial Door Close pushbutton shall fully close when the Close Pushbutton associated with that zone is subsequently activated.

11.6.3.8 Zone Signal Lights

Each MDC shall include two Zone Signal Lights, one for the zone on both sides forward of the cab, and one for the zone on both sides to the aft of the cab. These indicators shall be LED-illuminated and shall indicate that all doors in the zone are closed and locked. These indicators, on both MDCs in a cab, shall be electrically enabled whenever a cab is zoned-in. These indicators, however, are not electrically enabled when either MKS is in the TERM position.

11.6.3.9 Door Enable Indicator

Each MDC shall have a Door Enable indicator, which shall function as described in Section 11.6.5. The indicator shall illuminate on any active MDC when door operation has been enabled by the Operator.
11.6.4 Door Control Relay Panel

Each car shall be equipped with a Door Control Relay Panel (DCRP) to monitor all trainline open and close commands and transmit them to the Door Operators Control Panel at each door panel within the car. The DCRP shall also contain the relays necessary for indicating door closed summary status on a per car basis, and the relay logic necessary to control the Conductor Zone Lights. The panel shall be located within the cab or passenger compartment as may be appropriate and as approved by the NYCT.

11.6.5 Door Enable Function

A Door Enable function shall be provided to allow the Operator to control whether or not door operation from a Master Door Control panel is permitted. Operation of the function shall be as follows:

- After stopping at a station and verifying proper berthing, the Operator depresses and holds the Door Enable switch corresponding to the platform side of the train (see Section 6.6.5) until the Conductor turns the Master Key Switch to the ON Position. These two actions shall cause the Operator’s B+ to be removed from the enable trainline. The depressing of the Door Enable Switch in the Train Operator’s cab shall cause the All Doors Closed and Locked (Train Operator’s) Signal Light on the console to extinguish. For as long as the Door enable switch remains depressed, the All Doors Closed and Locked signal light on the console will remain extinguished. The Door Enable circuitry shall be such that the MDC door control for the side of the train remains enabled after the Train Operator releases the switch and the Conductor turns the Master Key Switch to the ON Position.

- Door operation for that side is enabled, and the Door Enable indicator for the side is illuminated on the Conductor’s MDC. Door operation is now possible from the Conductor’s MDC.

- The Door Enable is disabled (B+ restored to the trainline) when the MKS is returned to the RUN position.

- The Enable Switch shall incorporate an illuminated indication to annunciate the status of the associated door enable trainline. The indication shall function irrespective of switch position. The All Doors Closed and Locked signal shall be restored on the console once the MKS is placed in the RUN position and all doors are closed and locked, allowing the application of propulsion power.

- The Doors Enable switches shall in no way allow the Train Operator to close the doors after open permission (enable) was given.

Depressing the Door Enable switch in an inactive cab shall have no effect.
11.7 Circuit Breakers

Circuit breakers shall be provided for wire and component overcurrent protection, but shall also function in specific circuit feed capacities, as follows:

- DC1, DC2 Door operator motor power B+
- D8-1 Door control trainline B+
- D8-2 Door control car body B+ (for car isolation)
- 24 Door car body and/or trainline closed status summary B+
- GL Door fault and guard light closed and locked status light B+

The D8-2 Circuit Breaker, when switched to the OFF position, shall disable the operation of all side doors in the associated car.

11.8 Emergency Handle

An Emergency Handle (EH) shall be provided for crew-only emergency use at each door operator. The EH shall be located behind a small, locked, hinged access panel accessible only to the train crew. The location of the lever shall be designed so that it is easy to reach and grasp, that the train crew can attain adequate leverage on the handle without resorting to an awkward position of the hands or arms, and that there is adequate knuckle clearance throughout the entire movement of the lever. The force required to activate the manual release lever shall not exceed 10 lbs. (44.5 N).

The EH shall be red and contrasting in color with the other devices and components in the vicinity to make it obviously visible once the access door is opened. The lever shall be permanently identified and there shall be a permanently affixed plate in an NYCT approved location showing simply and clearly how to operate the lever.

The lever shall have two position: NORMAL and OPEN. In the NORMAL position, the door operator shall follow the trainline commands from the Door Control Relay Panel. When the lever is moved to the OPEN position, the lever shall stay in the open position until manually restored, power shall be interrupted to the door indication is received, before brakes can be release and power taken.

The closed and locked sensing devices and Crew Key Switches shall be arranged in a series loop circuit for each side within each car to energize a relay to indicate that all door panels on that side within that car are fully-closed and locked, and that the Crew Key Switch is in the NEUTRAL position. These outputs shall be arranged in a series circuit for each side for each door control zone to power the MDC Zone Signal Lights on the respective sides of the car and in association with the MKS switches in the zoned-up panels in the RUN position, to power the closed indicator on the cab console (see Section 6.6.6.2). The closed indicator on the cab console shall include two indicator elements such that if one element fails, the other will continue to provide the indication.
The position of the door panel shall be directly sensed to detect that a door is fully-closed. Alternative locations for detecting that a panel is closed shall be permitted only as specifically approved by NYCT.

11.9 Mechanical Lock/Cutout Switch

A key-operated Mechanical Lock/Cutout Switch shall be provided for each door panel to enable the crew to cut-out a door. The key escutcheon plate shall be mounted on the side of the door post. The panel lock shall be operated by standard car key (see Section 3.12.4).

The Mechanical Lock/Cutout Switch shall have three positions: NORMAL, OFF, and CUTOUT. The key shall be removable in the NORMAL and CUTOUT positions only. The Mechanical Lock/Cutout Switch shall function as follows:

- **NORMAL**: In the NORMAL position, the door operator shall be allowed to follow the trainline commands from the Door Control Relay Panel, and all panel position sensing switches for detecting a closed and locked condition shall be electrically enabled. B+ from Circuit Breakers DC1 and DC2 shall be available in the NORMAL position.

- **OFF**: When the key is moved to the OFF position, the door operator shall be disconnected from all open commands. The series loop circuit consisting of panel position sensing switches for detecting the closed and locked position shall be interrupted for that side of the car.

- **CUTOUT**: When the key is moved to the CUTOUT position, the door shall be mechanically locked in the closed position, and the door operator shall ignore all open commands. The Emergency Handle shall be ineffective and the fault light shall not be illuminated, and all panel position sensing switches for detecting the closed and locked condition shall be bypassed. It shall be possible to CUTOUT a door panel only when it is in the fully-closed position.

11.10 Interlock Requirements

11.10.1 Intentionally Blank

11.10.2 Door Closed Interlock

A Door Closed Interlock shall be provided to prevent the issuance of any propulsion trainline commands when any door panel in a train is sensed as being unlocked or open, when any Emergency Handle (see Section 10.3.3.6) has applied and emergency brake, when any Exterior Crew Key Switch is operated, when any Interior Crew Switch is operated to the OPEN position, or when B+ is sensed on any open or unlock trainline or carline door control circuit.

If an attempt to take power is made with any door unlocked or open, with the Crew Key Switch operated, or with B+ on any open or unlock trainline or carline door control circuit, the Master Controller command shall be limited to COAST, and it shall be necessary to cycle the Master Controller to a BRAKE position (any Brake position) after a doors closed indication is received, before power can be taken.
The Door Closed Interlock shall not affect friction brakes in any way.

The closed and locked sensing devices and Crew Switches shall be arranged in a series loop circuit for each side within each car to energize a relay to indicate that all door panels on that side within that car are fully-closed and locked, that the Exterior Crew Key Switches are in the NEUTRAL position and the Interior Crew Switches are in the NEUTRAL or CLOSED positions. These outputs shall be arranged in a series circuit for each side for each door control zone to power the MDC Zone Signal Lights on the respective sides of the car and in association with the MKS switches in the zoned-up panels in the RUN position, to power the closed indicator on the cab console (see Section 6.6.6.2). The closed indicator on the cab console shall include two indicator elements such that if one element fails, the other will continue to provide indication.

The position of the door panel shall be directly sensed to detect that a door is fully-closed. Alternative locations for detecting that a panel is closed shall be permitted only as specifically approved by NYCT.

### 11.11 Bypass Devices

#### 11.11.1 General Requirements

Bypass devices shall be provided to circumvent specific door system faults so that a train can continue in revenue service, can move to clear the line, or can be removed from service and returned a maintenance facility.

#### 11.11.2 Intentionally Blank
11.11.3 Door Interlock Bypass Switch

Door Interlock Bypass Switch per Section 6.6.6.1 and console indicator shall be located in each cab. The Train Operator’s signal light shall be part of the Train Operator's Display indications described in Section 6.6.4.

The switch shall include two positions: NORMAL and BYPASS. When operated to the BYPASS position, the door interlock circuit shall be bypassed. The Door Interlock Bypass circuit shall be provided with a hold-in function which shall latch when the Master Controller is moved to POWER or COAST with the Door Interlock Bypass Switch held in the BYPASS position, and shall unlatch (only in the controlling cab) when the Master Controller is subsequently moved from a POWER or COAST position and then moved to a BRAKE position. It shall be permissible to operate the Door Bypass Switch in any Master Controller position, but the circuit shall not latch until the Master Controller is moved to a POWER or COAST position.

The Door Bypass Switch shall not affect the Train Operator's door closed indication in any way.

11.12 Annunciators

11.12.1 General Requirement

Signals, both visible and audible, shall be provided on the exterior and in the interior of the car to indicate door system status.

11.12.2 All Doors Closed and Locked Signal Light

An All Doors Closed and Locked Signal Light shall be provided on the Cab Console (see Section 6.6.6.2). The indicator shall be visible when all door panels throughout the train are sensed as being closed and locked, all Exterior Crew Key Switches are in their NEUTRAL positions, all Interior Crew Key Switches are in the NEUTRAL or CLOSED positions, all console Door Enable switches on the active console are in the NORMAL position, and all zoned-up Master Door Controller Key Switches are in the RUN position.

11.12.3 Conductor’s Zone Lights

Two Zone Lights shall be included in each MDC and shall be illuminated to indicate the status of the side doors and Crew Key Switches in each zone on both sides of the train, one forward and one aft of a zoned-in cab. The indication shall be LED based, and illuminated as described in Section 11.6.3.8.
11.12.4 Guard Lights

Guard Lights shall be provided on the exterior and interior of each car. The indicators shall be red and shall illuminate anytime any passenger side door is not fully-closed and locked, when an Emergency Handle is activated, when B+ is detected in any Open or unlock trainline or carline door controls, and when a Crew Key Switch key is activated as described in Section 11.6.2.

Two LED-illuminated indicators shall be provided on the exterior and mounted on each side of the car. Each indicator shall have two red lenses, one facing to the front of the train and one to the rear so as to be visible by the train crew looking down the side of the train. These exterior lights shall indicate the status of the doors on the associated car, independent of side.

Four LED-illuminated indicators shall be provided on the interior with two mounted on each end wall. Each light shall be visible from any point in the car, and shall indicate the status of the doors on the associated side of the car. Each indicator will illuminate red when any door on the associated side is unlocked or open, and extinguish when all doors on the associated side are closed and locked.

11.12.5 Fault Lights

A red, LED-illuminated Fault Light will be provided on the interior near the top of the wall adjacent to each door panel so that it is visible throughout the car. The Fault Light will be illuminated anytime the adjacent door panel is not sensed as closed and locked. Light replacement shall be made from within the car from the open side of the hinged panel.

11.12.6 Door Closing Warning Signal

An audible Door Closing Warning Signal shall be annunciated within a zone inside the car upon initiation of a close command to alert passengers that the doors closing sequence is starting (see Section 13.2.1.4). The signal shall not be annunciated when a door panel is commanded to close from the Crew Key Switch.

11.12.7 Door Closing Warning Message

The communication system shall be required to provide a trigger for the automatic announcement system for a door closing message. The initiation method for this shall be submitted for review by the NYCT. This message shall not be annunciated when a door panel is commanded to close from the Crew Key Switch.

11.12.8 Door Closing Warning Indicator

A yellow, LED-illuminated Door Closing Warning Indicator Light visible to passengers inside and outside the car shall flash at each doorway upon initiation of the door close command, and shall continue to flash until the door is closed and locked. The visual warning light operation shall be synchronized with the operation of the Door Closing Warning Signal (see Section 11.12.6). The warning light shall not function during closing after a Local Recycle command and a close command from the Crew Key Switch.
11.12.9 Door Closed Enable Indicator

Two green LED illuminated Doors Enable Trainline Indicators shall be provided as part of the console Door Enable Switches. Each indicator shall illuminate anytime the Door Enable trainline is energized for that side of the train. The function of the light shall be independent of switch position.

11.13 Diagnostics

Each Door Operator Control Panel or doorway shall be equipped with a data port which will connect to laptop computers (Section 20.4.1) for diagnostics, and functional monitoring of each Door Operator Control Panel. Displayed information shall show functional parameters, both within the Door Operator Control Panel and commands from the Door Control Relay Panel, position sensing switches, mis-events, display messages aided with graphics when necessary for maintenance and trouble shooting, and display door panel opening and closing times. Information shall be accurate, simple and easy to understand. Failure and mis-event information shall be stored in memory until cleared by maintenance personnel. Possible failure and mis-event scenarios shall be determined during the design phase and shall be able to be fine tuned and/or eliminated during the warranty period. Failures in this system shall not interfere with the safe and normal operation of the door system.

The diagnostics shall also report the closed and locked status of every door panel to the Monitoring and Diagnostic System (see Section 8).
SECTION 12
HEATING, VENTILATION AND AIR CONDITIONING

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SECTION 12

12.0 HEATING, VENTILATION AND AIR CONDITIONING

12.1 General

Each vehicle shall be provided with a heating, ventilation and air conditioning system to meet the requirements identified in this Section. Each end of the car shall have a direct expansion, unitized (self-contained, roof-mounted) air conditioning system using HCFC-22. Each unit shall be independent and shall be designed to provide one-half of the vehicle's total required capacity. The units shall be interchangeable between car ends.

Equipment design and installation shall provide full accessibility for maintenance, trouble-shooting, and repair without interference with other systems. Each unit shall be provided with a main power disconnect switch to allow the unit to be serviced and maintained. The disconnecting means shall be readily accessible through the hinged return air grille.

The electrical compartment, as described in Section 12.4.6, air filters and fresh and return air thermistors shall be a part of each unit and shall be accessible for servicing and replacement through a ceiling-mounted hinged grille which provides access to the return air plenum.

All other components shall be accessible for ease of servicing and replacement from the top of the unit through access panels/covers or through the return air plenum.

All electrical connections to the units with the exception of the grounding strap shall be by means of quick disconnects, in accordance with Sections 15.19.6 and 15.19.7 for each voltage level.

The roof mounted units shall be secured to the car structure with a maximum of eight (8) stainless steel fasteners. A ground strap shall be provided between the unit frame and the car body. The unit shall be furnished with lifting bolts and shall be removable without disassembling refrigerant piping.

The air conditioning equipment shall blend into the surrounding contour of the roof to provide a streamlined appearance. It shall not, however, be a part of the car body structure. The unit compressor/condenser, evaporator and return air plenum sections shall be separated from each other by insulated walls.

The control system shall be designed to automatically maintain the car interior temperature and relative humidity at the ambient conditions specified in Section 12.5.4, including variable solar load, both with and without variable internal heat loads such as passengers, motors and lights. The control system shall operate from the low voltage power supply (LVPS), and its sensitivity and accuracy shall permit the requirements of Section 12.5.4 to be met. Activation of all HVAC systems in the train shall be controlled from the Train Operator’s console.

The air conditioning equipment shall be tested in accordance with Section 17.3.4.6. Sound and vibration levels shall meet the requirements of Sections 2.7.3 and 2.7.6. The equipment shall be identified and marked with nameplates according to U.L. 465, Paragraph 78.
12.2 Ventilation

12.2.1 General

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Ventilation of the car shall be accomplished by the centrifugal fans supplied as part of each unit. A total vehicle fresh air volume of 830±30 CFM shall be provided at all times, regardless of the position of the car in the consist, and at any train speed. Fresh air volume supplied by each unit shall be equal within 10 percent. Ventilation shall be available at all times in accordance with design criteria of Section 12.4.2, 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.

Fresh air shall be drawn into each air conditioning unit through screened weather-protected openings on the unit, shall be filtered and then delivered to an integral mixing plenum. The design shall preclude wind-driven rain or snow from accumulating and leaking into the vehicle interior. The mixing plenum shall be a discrete sealed unit. It shall not rely on the car structure or interior panels for air tightness.

Recirculated air shall pass through the ceiling-mounted, hinged grilles to the plenum where it shall mix with the filtered fresh air. The mixture of filtered fresh air and recirculated air shall then pass through a filter into the blowers or evaporator coil. Air flow shall be uniform across the entire face of the filters and evaporator coils.

Temperature sensors shall be positioned and protected (if required) to ensure they sense the correct unbiased fresh, recirculated or supply duct air as appropriate.

The cab door shall be provided with a grille as specified in Section 3.12.1.4. It shall permit cab air to recirculate to the passenger section and to the return air grille.

12.2.2 Motor-Blower Assembly

A motor-blower assembly shall be supplied as 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 units shall be arranged to maximize the coverage of the air distributors throughout the length of the vehicle to provide uniform temperature and ventilation distribution. To accomplish this the conditioned air, if possible, shall be discharged from the outboard ends of each unit.

The blower motors shall be powered from the auxiliary ac power supply. Evaporator blowers shall be direct driven, and have permanently-lubricated rolling-element bearings. A flexible, braided, tinned copper ground strap shall provide electrical grounding of the motor to the structure of the unit.
The motor-blower assembly shall be balanced in accordance with IEEE Standard 11. Imbalance shall be less than 0.001 peak-to-peak displacement 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 Sections 2.7.3 and 2.7.6. One motor shall be subject to a motor winding temperature rise test, prior to, or during the qualification testing.

The evaporator coil face velocity shall be as required to successfully pass the condensate carry-over test of Section 17 without additional baffling devices upstream or downstream of the coil. The velocity across the coil face shall be sufficiently uniform to prevent condensate carry-over.

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. Motor-shaft-to-blower-shaft connections shall be bolted flanges, unless it can be demonstrated to NYCT's approval that motor and blowers can be easily maintained, removed and replaced individually or as an assembly with an alternate arrangement. Interior inspection doors, if required, shall be accessible without removing any other parts except the interior ceiling panels or opening of the return air grille. Routine blower assembly inspection and maintenance shall not be required more often than once every ninety days.

12.2.3 Air Distribution Ducts

12.2.3.1 Main Air Ducts

The main air distribution ducts shall be located above the car ceiling. The main air distribution ducts shall be sized so that air velocity does not exceed 1,200 fpm (6.1 m/s) while meeting all other criteria of this section. The top and sides of the main air distribution ducts shall be constructed of stainless steel or aluminum and shall be thermally and acoustically insulated on the inside of the ducts. The bottom of the duct shall be similarly constructed or the ceiling panels may serve as the duct bottom. In either case, its insulating value shall be sufficient to prevent the formation of condensation. The top of the ducts shall be insulated to a thermal resistance value of R-11 or greater including the car body insulation. The sides of the distribution ducts shall be insulated to a thermal resistance value of R-4.5 or greater, as required to prevent the formation of condensation, and shall be provided with an approved vapor barrier or vapor barrier coating. Insulation spikes or other NYCT-approved supplementary mechanical fastening method shall be used on vertical duct surfaces. Thermal breaks shall be used where ducts are fastened to the car structure. All insulation and adhesives shall be in accordance with the smoke and flammability requirements of Section 15.25. Air shall be ducted to the cab by insulated branch ducts.

12.2.3.2 Unit/Car Body Transition Ducts

Transition ducts shall be provided between the in-roof-mounted unit and the supply air distribution duct. To minimize noise, air turbulence and eddies, sound-attenuating turning vanes and straighteners designed in accordance with the recommendations of the AMCA Fan Application Manual shall be incorporated for uniform air flow from the unit into the supply air ducts. The air duct connections between the unit and the car body supply and return shall be sealed by means of a soft silicone rubber or approved equal compression gasket meeting the flammability and smoke emission requirements of Section 15.25. The car body air interface openings shall be raised above the surface of the roof sheet sufficiently to preclude the possibility of accumulated water entry.
If required, individual supply ducts from each blower fan may be routed from the discharge on either side of the return air section, to connect to the main center distribution duct section.

12.2.3 Acoustic Insulation

Acoustic insulation shall be used on the inside of the ducts and plenums. Insulation shall be sufficient to meet the specified interior noise requirements of Section 2.7.

12.2.4 Air Diffusers

12.2.4.1 Passenger Compartment Diffusers

Air shall be discharged into the passenger compartment through two rows of continuous, flush, double-slot air diffusers, located in the ceiling. The diffusers shall be designed and/or adjusted to provide uniform distribution of air throughout the car. The diffusers shall extend longitudinally along the bottom of the supply air distribution duct. The inward facing side of the diffusers shall be restricted adjacent to the return air grilles to prevent short circuiting of the air flow.

In the climate room test car the diffusers shall be adjustable from within the passenger compartment without dropping panels or dismantling the diffusers, using a screwdriver, molded plastic slot plug or other NYCT-approved method for adjustment. Production cars shall have double slot-type diffusers identical to the ones in the climate room test car, except that they shall be non-adjustable. The settings of the diffusers in production cars shall be identical to those developed in the climate room test.

The efficiency of the diffusers shall be such that the initial temperature differential is reduced by at least one-half at a distance of 6 inches (152 mm) below the face of the diffusers. The maximum velocity of discharged air shall not be greater than 100 fpm (0.51 m/s) at 6 inches (152 mm) below the diffusers. When the car interior temperatures are within the ranges specified in Section 12.5.4, the air temperature differential between the car interior and the air leaving the diffuser at the slot outlets shall not be greater than 25°F (13.75°C). Maximum air velocity throughout the car interior, 48 inches (1,219 mm) above the floor shall not exceed 50 fpm (0.25 m/s). All exposed surfaces of the diffuser shall be powder coated to match the ceiling panels.

12.2.4.2 Train Operator's Cab Diffusers

The Train Operator's cab shall be provided with two or more supply air diffusers arranged on each side of the cab. The diffusers shall have manual air volume and direction adjustments. The Train Operator shall be able to direct the air to any point within the cab area. Train Operator's cab diffusers shall not be subject to the 100 fpm (0.51 m/s) velocity limitation. Booster blowers shall be installed in the supply-air ducts to the cab to provide air volume required to maintain the specified cab temperatures. The design shall automatically prevent operation of the booster fans when the diffuser is throttled below approximately half its full open position, if such throttling causes the diffuser to generate objectionable noise.
12.2.5 Return Air Grille

Recirculated air shall be drawn back to the mixing plenum and the air conditioning unit through grilles in the low ceiling area located as selected by the Contractor and approved by NYCT. The grilles shall be powder-coated aluminum to match the surrounding ceiling and shall be hinged on one of the long sides and shall be provided with 1/4-turn, captive, tamper-proof fasteners and safety retention devices on the other long side. If safety chains are used, they shall be jacketed to prevent rattling and shall automatically stow upon closing of grilles. The return air grilles shall be designed to pass the required quantity of air with sound levels such that the car interior noise requirements of Section 2.7 are met.

12.2.6 Water Eliminators

Water eliminating baffles or louvers shall be provided if required to prevent water from being drawn into the fresh air inlets. Eliminators shall be fabricated from stainless steel. Cleaning and servicing of the water eliminators shall not be required more often than once a year without any significant reduction in the system performance. Fresh air filters shall not be considered part of the water elimination design.

12.2.7 Air Filters

Air shall be filtered by disposable-type filters of 2-inch (50.8 mm) minimum thickness. The filters shall be pleated media or viscous impingement type. The filters shall be capable of 60 days of normal operation between changes and the Contractor shall make every attempt to provide the maximum thickness within the space available to meet this requirement. Air velocity shall not exceed 300 fpm (1.52 m/s) across the surface of the filters. Filters shall be commercially available, of standard size, and shall not ignite when exposed to a lit cigarette.

New filter pressure drop shall be a maximum of 0.12 inches of water (29.8 Pa). The system shall be capable of maintaining the total design air flow against an air flow system resistance that includes twice the clean filter pressure drop. The average filter efficiency within the design filter operating pressure drop range at a constant velocity of 300 fpm (1.52 m/s) shall be a minimum of 70 percent, when tested in accordance with AFI Code Section 1 using standard AFI contaminant.

The filter holders shall be designed to eliminate filter bypass. The filter arrangement and securement shall allow unimpeded access for replacement from inside the car through the return air grille. All filters shall meet the requirements of UL Standard 900, Class 2.

12.2.8 Ventilation System Prototype

Prior to final acceptance of the design of the air conditioning system, the Contractor shall construct and test a full-scale functional prototype of the air duct system for an entire car. The test article shall include fresh, return and supply-air duct systems with design supply-air distribution duct static pressure. The air systems 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 of the prototype shall confirm the following:

- The capability of the evaporator blower section to supply the design airflow,
- Main duct air velocity,
- Diffuser discharge velocity and mixing capability specified in Section 12.2.4.1,
- Blower total static pressure,
- Available duct static pressure,
- Electrical power requirements of the blower motors,
- Blower speed,
- The ability of the fresh air system to preclude the entrance of moisture into the car body (worst case rain and snow simulation at the air inlets may be simulated on a separate test),
- Preliminary air baffling requirements necessary to balance the specified ratio of fresh and recirculated air,
- Accessibility for maintenance of all filters, and
- Absence of potential problems, such as excessive noise, pure tones, air turbulence and blower instability.

All necessary changes and adjustments shall be made during the prototype test such that the requirements of this Specification are met.

12.3 Heating System

12.3.1 General

The car heating system shall be electrically powered, thermostatically controlled and shall consist of a combination of cab and passenger compartment strip heaters for floor heat and unit-mounted open element heaters for overhead heat. The control of all heating system devices shall be automatic.

12.3.2 Overhead Heat

Electric resistance type heaters shall be supplied within each unit to provide tempering of fresh air intake. Each heater assembly shall be arranged in a single proportionally controlled circuit.
The overhead heater elements shall be open coil construction mounted in a stainless steel frame. All heater elements shall be of one size and electrical rating to minimize inventory. The heater elements shall withstand corrosion, and shall not change materially in conductivity during the design life of the car.

The heater elements shall be located downstream from the cooling coils, and as a minimum shall have sufficient capacity to heat the specified quantity of fresh air described in Section 12.2.1 from 11°F to 65°F (-11.67°C to 18.33°C) at the nominal auxiliary ac power voltage level.

Access to the heater units shall be through a panel on the top of the unit.

12.3.3 Floor Heat

12.3.3.1 General

Passenger compartment, cab and layover heat shall be provided using electric strip heaters mounted behind stainless steel heater guards along the side walls at the floor level.

Passenger compartment and layover heat shall be automatically controlled by the temperature control system and shall function as described in Section 12.5. The passenger compartment and cab compartment heaters shall not have less capacity than that necessary to meet all of the following requirements:

- Sufficient capacity to raise and maintain the interior car temperature 54°F (12.22°C) above outside ambient temperature at all Unit operating speeds.
- Raise the average interior temperature from stabilized layover conditions to 65°F (18.33°C) within 40 minutes at the minimum specified exterior ambient temperature.
- Allow continuous operation at minimum ambient conditions with door cycling as defined in Section 12.5.4 without degradation of the average interior car temperatures measured just before each door open cycle.

These requirements shall be met without the benefit of solar or passenger load. The required capacity shall be available at the nominal third rail voltage level. Each heater circuit shall be arranged so that in each stage of heating the heat distribution will be uniform around the periphery of the passenger compartment in a manner to meet the required interior temperatures.

12.3.3.2 Cab Heat

Cab heaters shall be provided on each side of the cab compartment. One shall be located under the left-hand side window and the other under the operator's seat. The heaters shall be designed and mounted as specified in Section 12.3.3.4. Control of the cab heaters shall be as described in Section 12.5.6.2.2.
12.3.3.3 Convective Air Flow

Air shall enter the heater guard through slots in the bottom, pass over the strip heaters and discharge directly through perforations in the upper front face of the heater enclosure.

12.3.3.4 Heater Elements

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, and sealed within a rust-resistant high-heat transfer steel sheath. All passenger interior area heater elements shall be of one size and electrical rating to minimize inventory. 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 car body. The heater elements shall be mounted on insulators to the car body, not to the heater guard.

12.3.3.5 Heater Guards

Passenger heater guards shall not have a surface temperature that exceeds 125°F (51.67°C) when heaters are operational unless otherwise approved. (Reference Section 3.11.6.1 for further details).

12.3.4 Protective Heaters

12.3.4.1 General

Low-temperature, freeze protection heaters shall be provided for items subject to malfunction or damage due to water accumulation and freezing in low-temperature operating conditions.

12.4 Cooling System

12.4.1 General

The air conditioning system shall be capable of cooling and dehumidifying the car with electromechanical vapor-cycle equipment based on HCFC-22. The system and component design and selection shall allow replacement of HCFC-22 with its presently available environmentally compatible equivalent without making any major changes to the equipment or replacement of any parts. For the purpose of these requirements, retrofit shall be limited to changing refrigerant, oil and if necessary, changing expansion valve power elements and adjusting system pressure control settings. An environmentally compatible refrigerant shall have a GWP (Global Warming Potential) less than the 1.0 and a zero ODP (Ozone Depletion Potential). Also, the environmentally-compatible equivalent must have not less than 95 percent of the capacity of R-22 at design conditions, nor have any toxic or flammable components. All components within the system, including seals, shall be compatible with synthetic lubricants.

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 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.

The refrigerant system controls shall include an automatic pump-down cycle or other NYCT approved system. Pump-down 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 until the compressor suction pressure drops below the low-pressure cutoff set-point, and the low-pressure switch opens and stops the compressor. Pump-down shall not be initiated if the system shut down is initiated by a protective safety device such as excessive pressure, temperature or current protective devices.

Except for the pressure switches, the refrigerant system shall be non-field accessible. EPA-required service valves shall be located on the low side and one on the high side of the system and shall be accessible only with the unit removed from the car. Service valves shall be Henry valves, or approved equal. All tubing shall be joined as specified in Section 15.15.4.

An air flow switch shall be installed in the evaporator blower section. The switch shall initiate system pump-down upon reduction in airflow below a level where equipment damage may occur.

12.4.2 Design Criteria

The air cooling equipment shall have sufficient capacity to maintain car interior conditions in compliance with the requirements of Section 12.5.4 under the following conditions. The car's cooling capacity shall be determined by the methods described in ASHRAE Standard 37, and shall be submitted for NYCT approval:

- Ambient tunnel temperature (fresh air and condenser intake): 105°FDB (40.56°CDB)
  80°FWB (26.67°CWB)

- Car interior temperature: 78°FDB (25.56°CDB)
  55 percent RH

- Passenger load: 150 passengers, 450 Btu/h per passenger with a sensible heat ratio of 55 percent

- Fresh air: 830±30 CFM (Minimum)

- Total air flow: Sufficient to meet the internal temperature, humidity and car pressurization requirements of this equipment Specification

- Car body heat transmission: In accordance with the Contractor’s car body and insulation design to meet the requirements of Section 3.7.2

- Lighting load: Total wattage of interior lights with ballast efficiency of 83 percent
The cooling system shall be able to start and operate without damage at any time of the year when exterior temperature is above 45°F (7°C). The temperature controls shall prevent compressor operation when the temperature is below 50°F (10°C). The system design shall allow full cooling operation without the influence of modulation control with the ambient temperature up to 110°FDB/81°FWB (43.3°CDB/27.2°CWB) at the condenser and fresh air intakes. The cooling system shall also remain in operation, at reduced capacity if necessary, with an ambient temperature of 125°FDB/84°FWB (51.6°CDB/28.4°CWB) at the condenser and fresh air intake.

12.4.3 Evaporator Section

12.4.3.1 Evaporator Coil Assembly

The evaporator coil assembly shall be housed in a rigid stainless steel or copper alloy frame. The tube support sheets shall be constructed of stainless steel or copper alloy with die formed support collars for each tube. The coil shall utilize copper tubes of sufficient wall thickness to withstand the maximum pressure specified in Section 12.4.1 and copper fins of 0.008-inch (0.20 mm) nominal thickness with the minimum fin spacing of 0.1-inch (2.54 mm). The Contractor may submit an alternate design for a coil with coated aluminum fin construction for consideration by NYCT. The alternate proposal must include service history of the proposed coating material in similar severe duty applications and any expected benefits from a cost, reliability, weight saving, efficiency or other factors offering a benefit to NYCT.

The unit design shall exclude air by-pass through the drain pan and around the evaporator coil.

12.4.3.2 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 or copper-alloy fittings. The drain pan and fittings shall be baffled and arranged so that water does not spill over into the ceiling area under any operating conditions, including the worst case combination of grade, superelevation, acceleration (positive or negative) and car roll.

Condensate drain lines shall be sloped for positive drainage to the underside of the car and shall not be routed through electrical or electronic cabinets. An elastomeric flapper valve shall be attached to the drain line termination underneath the car. The condensate drain lines, coil housing, and pan shall be insulated to prevent condensation formation.
12.4.3.3 Other Evaporator Components

Other components which may be permitted as part of the evaporator section are as follows:

- A liquid line solenoid valve for the evaporator coil. The solenoid valve shall be of a compact design with pilot-operated disc construction.

- Non-adjustable thermal expansion valve (TXV) for each evaporator coil circuit. It shall have an external equalizer, and replaceable working parts. The TXV diaphragms shall be flat (not corrugated), stainless steel. The TXV's shall be located such that on-car access is not possible. The TXV superheat shall be set at the manufacturer’s recommended setting and shall not vary more than 2°F (1°C) from the design settings throughout the entire air conditioning operating range. Capillary tube evaporator feeding devices will be considered, subject to NYCT approval, if it can be demonstrated that the system can operate continuously at any point in the specified operating range without damage or detriment to the system.

- Pressure tap fittings in each suction header adjacent to the expansion valve equalizer connections, for test purposes, on the manufacturer's qualification and all climate room test car units only.

- Liquid line pressure tap fitting to be used for qualification testing on the manufacturer's qualification and all climate room test car units only.

12.4.4 Compressor/Condenser Section

12.4.4.1 Refrigerant Compressor

Each unit shall be equipped with a hermetic or semi-hermetic scroll compressor, sized to meet the performance requirements of this Specification. Compressor capacity reduction shall be effected by varying the compressor motor speed, or other means recommended by the compressor manufacturer and approved by NYCT. Hot gas bypass type capacity reduction will not be allowed. Alternate compressor arrangements may be submitted for NYCT consideration, if it can be demonstrated to NYCT's satisfaction that the alternate configuration and control scheme meets NYCT's principal goals of minimized size, cost and weight, and maximized performance and reliability. It shall be demonstrated to NYCT’s satisfaction that the compressor capacity reduction and associated system and control design shall allow the system to operate continuously at any point within the specified control range without damage or detriment to the system or its components. The qualification test compressor shall be provided with one oil level sight glass. Since the design may require the compressors to cycle on and off frequently when load conditions are below the capacity reduction limits of the compressor, it’s design must address these harsh conditions with particular attention to the lubrication system and the compressor motor and its associated starting equipment. A predicted compressor life analysis shall be
submitted (as included below) based on typical NYCT environmental and service conditions. The following data is required to be submitted for design approval in addition to that specified in Section 19:

- A complete list of the air conditioning system components, including capacity and safety control devices.
- Failure rate and maintenance intervals of the system and individual components (compressor, coils, expansion valves, capacity control devices [if any]) for the proposed system under meteorological and design conditions similar to those specified.
- Engineering evaluation to show that performance requirements of this Specification can be met. This shall include a detailed technical proposal which provides a one-to-one comparison of the proposed arrangement and materials with the Specification's requirements.
- Recommendation on list of spare parts required for routine maintenance and repairs.
- Service history of the proposed components as used on other rail applications, identifying the application, time in revenue service, actual average time of the air conditioning system operation, failure rate, mileage, and preventive maintenance requirements and intervals.
- Drawings of the proposed system showing all components, maintenance points, and access for maintenance.

The compressor shall be resiliently mounted to the unit frame. A flexible copper strap shall be provided to electrically ground the compressor to the unit frame. The compressor shall be powered from the ac auxiliary power supply.

### 12.4.4.2 Condenser Coil Assembly

The condenser coil(s) shall be housed in a stainless steel or copper-alloy frame with suitable fan shrouding and protective screening. The coil shall have copper tubes and copper fins, with minimum nominal fin thickness of 0.008 inches (0.21 mm). The minimum fin spacing shall be 0.125 inch (3.2 mm). The tubes shall be expanded to positively retain the fins in position. The tube support sheets shall be constructed of stainless steel or copper alloy with die formed support collars for each tube. Support collars shall be free of burrs to prevent sharp edge contact with condenser coil tubes. The coil shall utilize copper tubes of sufficient wall thickness to withstand the maximum pressure specified in Section 12.4.1. Coil capacity shall limit condensing temperature to 29°F (15.95°C) above the condenser cooling air temperature conditions at design-condition load. The condenser coil housing shall be designed to facilitate the cleaning of the coil. The condenser coil design shall provide a minimum of 10°F (5°C) subcooling, measured at the expansion valve inlet at design load conditions.
12.4.4.3 Condenser Fan

Condenser fan(s) shall be provided for each unit. They shall be directly driven and powered by the ac auxiliary power supply. The motors shall be totally-enclosed with permanently lubricated ball bearings and have sufficient capacity to drive the condenser fan under all load conditions. To facilitate removal of the condenser fan, the condenser fan motor shaft shall be of a corrosion-resistant material, or it shall be treated to prevent corrosion and seizing of the fan hub on the shaft. A flexible copper strap shall be provided to electrically ground the condenser fan motor to the unit frame.

12.4.4.4 Other Condensing Section Components

Other components which shall be included as part of the condensing section are as follows:

- A filter-drier assembly in the liquid line. The filter-drier's water capacity, refrigerant flow, filtering area, and acid removal ratings shall comply with ARI Standard 710.

- Discharge line and suction line vibration eliminators to minimize transmission of noise and vibration along the rigid piping. The vibration eliminators shall be provided with an elastomeric covering meeting the requirements of Section 15.7 and Section 15.25 over the flexible bronze wire braid to provide resistance to abrasion and to prevent condensation from freezing between the ferrules. Each vibration eliminator shall consist of two straight sections joined by a rigid 90° bend to provide equally effective isolation in all directions.

- Protection against refrigeration system explosion: pressure relief device as recommended by UL Standard 465, Section 33.

- Refrigerant piping installation and piping materials meeting the requirements of Section 15.15.3 and 15.15.4.

- All necessary tubing which shall be arranged to prevent any metal-to-metal rubbing caused by vibration.

12.4.5 Refrigeration Control Compartment

The control equipment compartment within the unit, shall contain a low-pressure cutoff switch, high-pressure cutoff switch, and a modulation-pressure switch. All pressure switches shall be service proven and non-adjustable. Set-point tolerance shall not exceed ±10 psig (69 kPa) for the discharge sensing pressure switches, and ±3 psig (20.7 kPa) for the low-pressure switch. All pressure switches shall be replaceable and shall be provided with pulsation snubber as required. Alternate means of performing the functions specified in Sections 12.4.5.1, 12.4.5.2 and 12.4.5.3 listed below may be submitted, subject to approval by the NYCT.
12.4.5.1 Low-Pressure Cutoff Switch

An automatically-resettable low-pressure cutoff switch shall be provided to monitor compressor suction to protect the compressor and other system components from potentially damaging low pressure operation. In addition to providing the low pressure protective function, the low pressure control shall act as the normal compressor shutoff device following the pump-down cycle.

12.4.5.2 High-Pressure Cutoff Switch

An automatically-resettable high-pressure cutoff switch shall be provided to monitor the compressor discharge to protect the system from excessively high system pressures. The circuit shall be arranged such that condenser fan(s) operation is not interrupted by the high pressure cutoff control. When the reset pressure is reached, the compressor shall restart following a time delay period recommended by the system supplier and approved by NYCT.

12.4.5.3 Modulation-Pressure Switch

An automatically-resettable modulation-pressure switch 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 set-point.

12.4.5.4 Intentionally Blank

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12.4.6 Electrical Compartment

The electrical compartment shall be an integral part of the unit. It shall be accessible for system servicing through the return air grille.

The electrical control compartment shall contain the following components, except as noted:

- Relays, contactors, solid-state power controllers and individual component isolation circuit breakers.
- Electrical controls and pressure switches.
- Diagnostic test plug for attachment of a portable test unit. *
- Power and control wire terminals.
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- Main and control power disconnect switches.
- Static temperature control unit.
- Fault indication panel.

Where a dedicated inverter is packaged with the motor it is driving, there does not have to be a circuit breaker between the inverter and motor.

Alternately, items marked with an asterisk may be installed separately in the ceiling area in close proximity to each unit. Static temperature control units shall operate their respective HVAC units, independently.

Equipment qualification test, car climate room test, and car production acceptance test shall be conducted according to Section 17 of this Specification.

12.4.7  Intentionally Left Blank

12.4.8  Insulation

All insulation and adhesives shall meet flammability and smoke emission requirements of Section 15.25. All piping insulation corners shall be mitered and sealed with a sealant recommended by the manufacturer of the insulation.

12.4.9  Evacuation-Dehydration

As part of the refrigeration system processing procedure, the equipment manufacturer shall evacuate and dehydrate the refrigeration system to 50 microns pressure, or less. Following isolation of the vacuum pump, the system pressure shall not rise above 300 microns in a two-hour period.

12.4.10  Refrigerant Charge Determination

The refrigerant charge weight shall be determined during the equipment qualification test. The refrigerant charge established at this test shall be included on the unit nameplate.

12.5  HVAC Control Arrangement

12.5.1  HVAC Trainline Control

The HVAC system shall be energized whenever the auxiliary systems are energized and the HVAC trainline is activated from the Train Operator’s console. Interlocking of the blower fan and the compressor motor contactors shall be provided to prevent compressor actuation unless the blower fans are operable.
Sequential start or ramped soft-start control of the air conditioning compressors shall be provided as required by the Contractor to prevent excessive power demands from the auxiliary inverter upon power loss and reapplication. In any case, the air conditioning equipment shall reestablish full-commanded operational status within 10 seconds following reapplication of power.

The air conditioning control system shall normally be activated from the controlling cab. An air conditioning control circuit breaker, supplied in each car shall provide a means to disable air conditioning operation, on that car only, regardless of the status of the air conditioning control trainline.

12.5.2 Static Temperature Controller

The temperature controller provided for each unit, shall control the heating, ventilation and air cooling power switching devices of that unit directly through solid state switching devices. The use of pilot relays will not be allowed.

The static temperature control electronics shall be in accordance with the requirements of Sections 15.27, 15.28, 15.29 and 15.30 and shall be packaged in a single, metal enclosure. Required heat dissipation shall be accomplished by convection cooling. Cooling fins shall be arranged to avoid the collection of dirt. The unit enclosure shall be arranged for removal and replacement with no more than four captive fasteners. A method of securing the unit during installation or removal is required. All electrical connections, including portable test unit connections, shall be by cable connectors, as specified in Section 15.19.6.

A display shall be provided to indicate:

- Cooling Fault,
- Heating Fault,
- Control Fault, and
- Power Fault.

The “Control Fault” indication shall facilitate identification of major control circuit problems. As a minimum, it shall indicate abnormal input voltage, power supply voltages, or abnormal operation of the temperature sensing thermistors. The Contractor shall provide labeled red LEDs to indicate all faults.

The temperature control shall provide the necessary logic, memory and interface provisions to log key faults status information and communicate this information to the Monitor and Diagnostic System.

12.5.3 Temperature Sensors

Both air conditioning units of the same car shall be controlled by a single set of return and fresh air thermistor sensor(s). Separate duct air sensors shall be provided in the supply ducts from each unit to control the discharge temperature of each unit individually. Thermistors shall be encapsulated in a corrosion-resistant metal tube. Temperature sensors shall be mounted to preclude the influence by local sources of heat, such as motors, resistors or air streams with different temperatures. The sensors shall be accessible for maintenance.
and replacement, and protected from damage during routine air conditioning servicing, such as replacing filters.
Sensor accuracy shall be sufficient to meet the requirements of this Specification. The thermistor assemblies shall have:

- An accuracy of 0.5°F (0.28°C) for life,
- A minimum life of two million cycles,
- The ability to withstand shocks and vibrations specified in Section 2.7.6 and 2.7.7; and
- Adjustment capability in 0.5°F (0.28°C) increments of each control point over at least ±5°F (2.75°C) range. The adjustments shall be accomplished by password-protected software changes or other NYCT-approved means which prevents unauthorized modifications.

### 12.5.4 Required Interior Car Conditions

The average temperature inside the car shall be within the following ranges when the associated ambient temperatures are present. The allowable point-to-point variations which immediately follow the specified control range for Ti are not to be added to the value. Interior relative humidity shall not exceed 55 percent when the system is operating at the design conditions specified in Section 12.

<table>
<thead>
<tr>
<th>Ambient Temperature; ( T_a )</th>
<th>Average Interior Temperature, ( T_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>11°F ( \leq T_a \leq 40°F )</td>
<td>62°F ( \leq T_i \leq 68°F )</td>
</tr>
<tr>
<td>((-11.67°C) (4.44°C))</td>
<td>((16.67°C) (20°C))</td>
</tr>
<tr>
<td>40°F ( \leq T_a \leq 60°F )</td>
<td>65°F ( \leq T_i \leq 75°F )</td>
</tr>
<tr>
<td>((4.44°C) (15.56°C))</td>
<td>((18.33°C) (23.89°C))</td>
</tr>
<tr>
<td>60°F ( \leq T_a \leq 95°F )</td>
<td>71°F ( \leq T_i \leq 78°F )</td>
</tr>
<tr>
<td>((15.56°C) (35°C))</td>
<td>((21.67°C) (25.56°C))</td>
</tr>
<tr>
<td>95°F ( \leq T_a \leq 105°F )</td>
<td>71°F ( \leq T_i \leq 78°F )</td>
</tr>
<tr>
<td>((35°C) (40.56°C))</td>
<td>((21.67°C) (25.56°C))</td>
</tr>
<tr>
<td>105°F ( \leq T_a \leq 115°F )</td>
<td>( T_i \leq (T_a - 20°F) )</td>
</tr>
<tr>
<td>((40.56°C) (46.11°C))</td>
<td>( (T_i \leq (T_a - 11°C) )</td>
</tr>
<tr>
<td>115°F ( \leq T_a \leq 125°F )</td>
<td>( T_i \leq (T_a - 20°F) )</td>
</tr>
<tr>
<td>((46.11°C) (51.67°C))</td>
<td>( (T_i \leq (T_a - 11°C) )</td>
</tr>
</tbody>
</table>

As the system will provide
The following variations in interior passenger compartment temperatures are the maximum that shall be allowed during stable operation unless otherwise approved:

- At any given point in the car, and in the entrance ways, and at least 12 inches (305 mm) from the ceiling and 6 inches (152.4 mm) from the floor and walls over a period of time: 5°F (2.75°C)

- At any given time, among all points in the same horizontal plane from one end of the car to the other: 4°F (2.2°C)

- At any given time, between any point 48 inches (1,219 mm) above the floor and the corresponding point 6 inches above the floor in a vertical plane: 4°F (2.2°C)

The average car temperature shall recover to its original temperature ±2°F (1°C) within two minutes maximum following one-minute open, two-minute closed cycle. It shall be demonstrated that this requirement can be met during one hour of continuous door cycling at this rate at design conditions in both air conditioning and heating modes at the climate room test specified in Section 17.3.5.4.

12.5.5 Temperature Control Arrangement

The Contractor shall be responsible for providing uniformly distributed system airflow, selection of switch point temperatures and proper proportioning of cooling stages to meet the temperature control requirements provided in Section 12.5.4. The final selection of temperature control switch points shall be approved by NYCT and shall be verified at the system qualification and vehicle climate room tests. The climate room test car's temperature control system shall be arranged for easy adjustment of the control switch points for this purpose. The Contractor shall make all modifications necessary to the controls and cooling apparatus to make all cars conform to the final control configuration determined at the climate room test.

12.5.6 Heating Control

12.5.6.1 Overhead Heat Control

Overhead heat shall be powered from the 3 phase auxiliary ac power supply. Each unit’s overhead heating assembly shall be arranged such that all three phases may be modulated in unison by an infinite proportional control.

When in the heating mode, the overhead heater shall be controlled to maintain duct discharge temperature slightly above the desired average car temperature. The final temperature shall be determined at the climate room test.
12.5.6.1.1 Overheat and Loss of Air Flow Protective Devices

The blower control circuitry shall be so arranged and interlocked that power cannot be supplied to the overhead heaters, at any time, unless ac power is available to the evaporator blowers. In addition, three levels of backup overheat protection shall be provided as listed below:

- Air Flow Switch installed in the unit air outlet, which shall remove control power from the heating equipment contactors upon the loss of air flow.

- Automatically resettable high-limit thermostat installed adjacent to the heater unit. Upon detection of overtemperature, the high-limit thermostat shall open the overhead heat control circuit. The high-limit thermostat shall be designed to cycle indefinitely, if conditions dictate, while preventing overtemperature which could cause activation of the back-up protection device, or otherwise cause damage to the equipment and other car body components.

- A manually resettable shunt trip circuit breaker shall be provided in the line to the heater coils to remove power in the event of excessive heat and failure of all other protection devices. The location of the sensing device and its setting temperature shall be coordinated with the high-limit thermostat to avoid nuisance activations but prevent damage to the equipment and other car body components. The shunt trip circuit breaker and its sensing device shall be accessible for inspection and maintenance in the installed unit.

- All protective devices shall have their ratings, type, and location designed such that maximum protection is provided, without the hindrance of nuisance activations, under all possible combinations of operating conditions.

12.5.6.2 Floor Heater Control (Passenger Compartment)

The floor heaters shall be powered from the 600 Vdc source. The power for each floor heater circuit shall be supplied through a separate circuit breaker. Separate floor heat contactors shall be provided for cab heat, Floor Heat Stage No. 1 and Floor Heat Stage No. 2. The floor heat contactors shall be controlled by the recirculated air thermistor through the static temperature controller.

12.5.6.2.1 Layover Heat Control

The layover mode of operation shall automatically take over whenever the HVAC control trainline is de-energized and no cab in the train has assumed control. In the layover mode, car temperature shall be maintained at 45°F ±5°F(7.22°C ±2.75°C) by means of a separate sensor mounted in a protected, but accessible location. The location proposed shall be thermally representative of the average car temperature when operating in the "Layover" mode. The sensor shall control the cab and passenger compartment floor heat through the same static temperature controller and contactors used for normal heating system operation.
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12.5.6.2.2 Cab Heat Control

Control of the heat in the Train Operator's compartment shall be by means of a manual three-position control. The three positions shall be “OFF”, “LOW” and “HIGH”.

12.5.6.3 Low Temperature Protective Heat Control

The protective heat circuits described elsewhere in this Specification shall be enabled at 40°F (4.44°C) as sensed by a protective heat sensor.

12.6 Design Approval

The detailed design of the system shall be submitted to the NYCT prior to manufacturing the equipment. The required drawings and at least the following additional information, if not shown on the drawings, shall be submitted:

- An air cooling loads analysis;
- Heating load analysis;
- An analysis of air flow requirements when cooling at design conditions;
- Evaporator coil design criteria: Entering and leaving wet and dry bulb conditions at design conditions; wet and dry coil pressure drops at the specified air flow rate; coil circuiting; and the rows and fins spacing;
- Compressor: Compressor capacity curves; make and model number of the compressor;
- Capacity and coefficient of performance under nominal and extreme conditions;
- Condenser coil design: Coil selection curves or computer analysis illustrating air-to-refrigerant temperature differential, degrees of subcooling, and pressure drop at the design conditions;
- Motors: Current draw, horsepower, speed/torque curves, efficiency;
- Pressures and temperatures: design saturated suction and discharge temperatures at full load activation pressures and differentials for all pressure-activated devices;
- Equipment manufacturer's evacuation, charging and test procedures; pipe processing/cleaning;
- Electrical and control arrangement schematics; wiring diagrams showing resistance value of each resistor, contactor and solenoid valve coils, and wire sizes;
- Temperature Control arrangement;
- Refrigerant system piping diagram showing pipe sizes;
- Vibration mount design selection;
- Evaporator blowers: type, dimensions, model numbers, and manufacturer of the wheel and housing; head flow and power flow curves for selected assemblies; maximum allowable wheel speed; nominal blower speed, balancing criteria for the wheels and fan-motor assemblies; and
- Exterior noise level of operating unit.
# SECTION 13
## COMMUNICATIONS

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SECTION 13

13.0 COMMUNICATIONS

13.1 General

The design of the communication system shall provide the functional requirements listed in this Specification. All communication subsystems shall utilize digital technology for the propagation and transmission of all communication signals and controls.

13.1.1 Required Functions

Each car shall have communication apparatus installed to provide the following services:

- One-way audio communication from the Train Operator and/or Conductor to the passengers (Public Address System) via interior and/or exterior speakers;
- Automatic announcements including route, destination, door closing, next station, etc.;
- Recorded announcements to the passengers (Public Address System);
- One-way audio communications between the wayside radio and passengers by Public Address;
- Two-way communication between wayside radio and Train Operator and/or Conductor;
- Two-way Passenger Emergency Intercom for passenger-initiated communication between Units and Train Operator/Conductor;
- Intercom between all cabs on a train for crew communication;
- Interface with the vehicle interior and exterior message displays;
- Wire and cable installation to provide for future interior and exterior Closed Circuit TV to provide passenger area and door entrance monitoring; and
- Commercially available train radio equipment operating within the 150-174 MHZ range on multiple frequencies presently in services on NYCT. This equipment shall operate in combination with the apparatus described above to provide the required service.

13.1.2 Power Distribution

The communications equipment shall be powered from the Low Voltage Distribution Network (LVDN) with a separate circuit breaker for each major subsystem. A separate power supply, compatible with the radio equipment, shall be provided. The radio subsystem, including power supply and associated controls, shall stand alone from other elements of the communications system.
COMMUNICATIONS

13.1.3 Vehicle-to-Vehicle Interface

The Audio trainline information (transmit and receive) shall be transmitted digitally, along with associated controls signals, over two pairs of wires. (Refer to Section 7.3.3).

Maximum permissible variation in sound levels shall not exceed 5 dB regardless of the number of cars on the train. The system shall provide maximum intelligibility under the conditions of high noise and vibration normally encountered with a train in motion under subway conditions.

The Public Address and intercom system shall be protected against transient voltage electrical shorts and grounds appearing on the trainlines.

13.1.4 Crew Interface

All crew controls for the communication equipment shall be located in the cab. These controls shall include but not limited to the following elements:

- Two Speakers;
  - Radio Dedicated
  - Cab speaker for PA and Intercoms
- Microphone located on the Communication Control Panel, Auxiliary Microphone Panel and Conductor Panels;
- Speaker Volume Controls;
- Two Push-to-Talk (PTT) buttons located on the cab console;
- Mode selection for PA, Train Radio, Crew Intercom, Passenger Emergency Intercom, and Radio-to-PA located on the Communication Control Panel;
- Two Conductor Panels mounted one on each side of the cab, including PTT for PA and Crew Intercom with dual height microphone;
- Radio Controls;
  - Channel Selection
  - Control Center or Train-to-Train Selection
  - Pushbutton for Emergency Transmission
- Passenger Emergency Intercom Controls;
- Public Address Speaker Selection for interior only and interior/exterior combinations;
Automatic Announcement and Sign controls via Train Operator Display to select line, route, stop pattern, adjust for reroutes, and control special sign displays and announcements.
13.2 Public Address/Intercom System

13.2.1 System Operation

13.2.1.1 Public Address System

The public address system shall permit announcements to be made to all passengers in a train from a cab or by the automated announcement system. It shall include, as a minimum, the following major items:

- one solid state automatic announcement unit per cab car;
- one encoder/decoder for digital signal reception/transmission per car;
- one solid state preamplifier per cab;
- one solid state amplifier unit per car;
- at least eight interior ceiling speakers per car; and
- four exterior speakers per car.

The circuitry shall be arranged so that the audio sources feed a pre-amplifier which feeds the encoder. The digital audio trainlines shall feed decoders which in turn shall feed power amplifiers on each car. The power amplifiers shall drive the speakers.

13.2.1.1.1 Automatic Announcement System

Automatic announcements shall include, but not be limited to route and destination information, transfer information, next station and station arrival. Automatic announcements shall be performed by an automatic announcement unit built into the public address system. Manual announcements shall always override the automatic announcements.

The system shall utilize digitally stored messages and present these messages to the passengers at the designated times. Digitally recorded audio messages shall be broadcast over the PA system. Textual messages shall be displayed on appropriate message display units. The presentation of the audio and textual messages shall be synchronized with one another.

A test control shall be provided on the cab console (Section 6.6.6.1) that will, when activated, cause a test announcement and interior display message to be repeated every 5.0 seconds until the switch is deactivated.

Each audio and text message shall be stored along with information identifying the conditions under which the message is to be broadcast. Sufficient storage capacity shall be provided to store up to three hundred (300) stopping pattern files, each supporting up to sixty (60) stations and up to twenty (20) transfer messages, plus spare storage space sufficient to store up to 100 files for updating stop pattern files. Each of these messages can be selectable by time-period (from up to seven (7) pre-defined time-periods). The time-periods shall be based on the time the operator enters on the Train Operator Display (TOD), via the Display Time Set-Up screen. Spare memory requirement called for in Section 16.4.1 does not apply for this application. Full
concatenation of audio messages is permitted. Modifications to the stored messages shall be via a serial link from a portable computer (see Section 20.4.1) or an integrated PCMCIA slot. It shall be possible to modify all aspects of stored messages patterns, including content, time of broadcast, and addition or subtraction of messages. It shall be possible to modify, update, or replace complete patterns and routes, as well as to customize single messages. The R142 Contractor shall supply the AAS Workstation. The R142A Contractor is not required to provide the AAS Workstation.

The message system shall provide the following audio announcements, and corresponding textual messages.

- **Pre-programmed Announcements**

  Each station shall have at least four separate announcements similar to the following:

  - Current stop (station name) station with available transfers upon entering a station.
  - The train’s identification and destination while in a station.
  - Next stop (station name) station while in a station.
  - Next stop (station name) station during departure.
  - Last stop (see definition below)

- **Sign Messages**

  - **Exterior**
    - Train identification and destination
    - Last stop (see definition below)

  - **Interior**
    - Current stop (station name)
    - Train identification and destination
    - Next stop (station name)
    - Time of Day: The time of day will be displayed at least once between stations. The time of day shall be visually displayed on the Interior Message Display (IMD) **ONLY** like a regular message line.
    - Last stop (see definition below)

Last Stop: A “Last Stop” announcement shall include an audio message and visual message on both IMD and Side Destination Sign (SDS) when at the last stop on the currently loaded stopping pattern. The last messages displayed on all signs (ERS – End Route Sign, IMD, SDS and ESM – Electronic Strip Map) will stay until “Cancel” on the TOD is pushed, and then all signs (ERS, IMD and SDS) and all the indicators and text on ESM will be cleared.

In addition, the AAS System shall be able to perform, as part of the route pattern, current audio announcements and provide the capability to automatically blank the ESM at specific stations (that are not shown on the Electronic Strip Map), as programmed in the AAS database files. In this case, the AAS shall trigger a one-time audio message at a pre-determined location to advise passengers to disregard ESM information without operator intervention and without disruption, and on ESM, the direction indicator and stations shall be blank, but the ESM text “Route Change: This map is not in use”, shall be illuminated.
It shall be possible to download via the PTE a single set of pattern modification files to the AAS system, such that they will not take effect until a date (“Trigger”) specified when the files are to be downloaded. The AAS shall support multiple trigger dates but only one (1) trigger date shall be handled per day. Each stopping pattern file that is downloaded in this way takes away from the total storage capacity specified above.

The switching of stopping pattern files on the Trigger Date shall be prevented from taking place while a route file is loaded and running. While the switching of stopping pattern files on the Trigger Date is occurring, the loading of routes and playing of special messages may be prevented.

The Train Operator or Conductor shall be able to adjust the automatic announcements and signs with ease and without disruption, such as when the train is rerouted or station(s) are skipped.

When disabling of AAS is required, the AAS shall behave as follows:

1. When the automatic announcement is turned-off, the exterior signs will stay as they are.
2. The interior signs (IMD, ESM) will be turned “off” and manual Announcements can be made. The ESM text “Route Change: This map is not in use” shall be illuminated.

The automatic announcement unit on the train shall interface with the Car Network to obtain train travel distance and door status.

13.2.1.2 Door Closing Announcement CO 03

A pre-recorded announcement advising passengers that doors are closing shall be output over the interior speakers. The announcement shall be initiated by a momentary switch on the Master Control Panel controlling the doors (see Section 11.6.3)

13.2.1.2 Crew Intercom

Each cab of the car shall have a voice intercommunication system (Intercom) to allow communications between all cabs in a train. Selection of the Intercom mode shall cause a communication circuit to be established between the cabs. The push-to-talk button shall then be used to communicate from cab to cab.

13.2.1.3 Passenger Emergency Intercom CO 82

The passenger compartment of each car shall be equipped with at least two Passenger Emergency Intercom (PEI) stations located diagonally opposite doors as described in Section 3.16.4. Each station shall consist of a speaker, a microphone, a heavy duty push-button and an indicator light. The indicator light shall be a flush mounted LED (illuminated steady when active and blinking when on hold). Operation of the push button shall signal the crew in the cab. The crew shall thus be able to establish a communication circuit with that PEI station. The crew shall also have the ability to put that PEI "On Hold" in order to use the radio or crew intercom. If more than one PEI station is pushed, then the crew shall have the ability to answer them in the order received, and to put other PEI stations "on hold" as needed.

The PEI station shall be vandal resistant and equipped with a heavy-duty, push-button (illuminated when active or on hold); a speaker; a microphone; and a heavy-duty faceplate.
13.2.1.4 Door Closing Warning Signal

At any closing of doors, a local two-tone annunciator of different tones from the announcement tone shall be energized and output over the interior speakers, as required in Section 11.12.6.

13.2.1.5 Door Closing Warning Message

A door closing warning message shall be broadcast throughout the train over the Audio Trainline as required in Section 11.12.7.

13.2.2 Performance Requirements

13.2.2.1 Uniformity of Coverage

The sound pressure level throughout the passenger compartment at a height of 5'-4" (1.63 m) shall not vary by more than 3 dB for a pink noise signal over the octave band centered at 4 kHz.

13.2.2.2 Sound Level

The public address system's output level in each car shall be automatically set in accordance with the ambient noise level in the car just prior to activation of the system. The range of automatic level adjustment shall be at a minimum 10 dB.

No adjustment potentiometers shall be used in the PA System, except as permitted by Section 2.5.3.1. Where potentiometers are not allowed, gains, line levels, compressing levels and equalization shall be fixed by design and confirmed by test. Where compensation is required in order to maintain interchangeability between car designs, it shall be done by fixed resistors installed in the car wiring side of the system connectors.

13.2.2.3 Amplifier/Speaker Arrangement

The arrangement shall be such that the loss of a car's power amplifier will not result in a complete loss of announcements in that car.
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Pre-amplifiers shall be located in close proximity to the microphone plate. The pre-amplifier input shall match the microphone output. The total harmonic distortion shall be no greater than 1 percent at full output, and minimum frequency response shall be 100 to 8,000 Hertz, ±3 dB.

The pre-amplifier shall contain a compressor-limiter section carefully designed to hold the output level within ±2 dB past threshold with a change in input of 40 dB. Suitable circuit provision shall be incorporated so that if this 40 dB compression range is exceeded, symmetrical clipping will prevent the resumption of the normal input-output gain relationship. The attack time of the compressor shall be fixed at 10 milliseconds and the release time shall be adjustable, but shall be factory set at 800 milliseconds for a 20 dB incremental input. The compressor total harmonic distortion shall not exceed 1 percent at levels more than 10 dB below the clipping level. The input necessary to drive the compressor amplifier into full compression shall be 250 millivolts with a 1 kHz test tone input.

The power amplifier shall be capable of delivering a minimum of 35 watts at not more than 1 percent THD in the range of 100 to 8 kHz within the full voltage operating range of Section 2.3. The input necessary to drive the power amplifier to full-rated output shall be no more than 500 millivolts. The frequency response shall be within ±1 dB from 100 to 8,000 Hertz, with provision for a 6 dB per octave roll-off below 100 Hertz. The signal to noise ratio of the amplifier below the compression threshold shall be at least 65 dB.

Each amplifier shall be stable and there shall be no oscillation present for any normal operation of the system and for any setting of the amplifier controls. The output circuit and power supply shall include short circuit protection without the use of fuses. The amplifier power supply shall have transient voltage spike protection of up to 2,500 peak volts with total energy of 80 watt-seconds, and shall comply with the requirements of Section 2.3.

The PA amplifier shall be capable of driving the external speakers in sets or groups according to zone selection.

Design, materials and workmanship shall be in accordance with Section 15, and suitable for the intended use. All terminals and wires shall be properly identified. With speech or pre-recorded message input, the amplifier shall operate continuously with full output at rated input voltage without damage to any components.

The amplifier assembly shall be located behind an access cover located within the car interior. The assembly shall have a dust-tight cover secured by heavy duty hardware with provisions for applying a lock. Once the access cover and the amplifier assembly cover is removed, all amplifier components shall be
accessible for adjustment or removal, and access shall be provided to test jacks and potentiometers for setting volume levels. The amplifier and its mounting shall be approved by the NYCT.

The use of high gain operational amplifiers where possible and appropriate feedback around all circuits shall eliminate the need for potentiometers.

The amplifier shall be of modular design, with cable connectors conforming to Section 15.19 for all electrical connections.

A diagnostic connector shall be supplied as well as a battery operated portable test unit (per Section 20.4.1). The test unit shall plug directly into the amplifier during operational conditions and a diagnostics check shall be performed to indicate the amplifier failure.

13.2.3.3 Speakers

13.2.3.3.1 Interior

A minimum of eight ceiling speakers per car shall be evenly spaced longitudinally in the passenger seating area, alternately mounted on opposite sides of the aisle or in a row on the longitudinal center line of the car.

All interior speakers shall be transportation grade, direct radiating, permanent magnet field type. Frequency response with proper enclosure shall be ±5 dB from 100 to 8,000 Hertz, with a plateau of at least 8 dB in the 2,500 to 3,500 Hertz band compared to the 1,000 Hertz response. There shall be a gradual roll-off in response above 7,000 Hertz. The dispersion angle shall be at least 120 degrees. The nominal axial sensitivity shall be a minimum 92 dB at four feet (1.22 m) with 1 watt input. Average power handling capacity shall be a minimum of 5 watts continuous sine wave input without cone breakup, rattle, etc.

Each speaker shall be protected by a metal or plastic enclosure designed to adequately protect the speaker from the effects of dust, moisture, ferrous materials or other foreign objects. The protective enclosure shall be rustproof, and 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 resonances or vibrations occur.

13.2.3.3.2 Exterior

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Four weather resistant exterior speakers shall be used per car, two per side. They shall be located below each passenger side window between side doorways.

The exterior speakers shall be weather resistant and shall be installed to prevent water ingress.

The exterior loudspeakers shall be submersion-proof reflex horn type with a die cast aluminum reflector that can be removed from the front. The diaphragm shall be linen base phenolic with two inch tropicalized voice coil. The loudspeaker shall have a minimum power handling capacity of 15 watts. Finish shall be gun-metal gray baked enamel speaker plate. The loudspeaker shall be University Model MM-2F or as approved by the
NYCT. The external speakers shall be active only on the side of the car where the doors are open and when selected by the Train Operator/Conductor through a switch in the cab (Reference Section 13.4.3.4).

13.2.3.4 Ambient Noise Sensing Assembly

An ambient noise sensing assembly shall be provided in each car. The assembly mounting shall be acoustically transparent to the ambient noise in the car. Amplifiers shall adjust their outputs according to the ambient noise level.

13.3 Buzzer Signal System

13.3.1 General

Each car shall be equipped with a buzzer system to be used solely for train operation. The buzzer system shall be functionally identical to that used for the NYCT R62 vehicles. Pushing any buzzer button in any cab in the train shall cause the buzzer in every cab in the train to sound. The buzzer system shall be energized from the low voltage supply.

13.3.2 Buzzers

One electric buzzer shall be furnished for each cab. The buzzer shall be of substantial construction, designed for electric railway service. An electronic buzzer may be provided upon approval of the NYCT.

13.3.3 Buzzer Push Buttons

Three buzzer push buttons of an approved design shall be provided in each cab. One pushbutton shall be part of the cab console and one shall be part of each Master Door Controller.

13.4 Radio (Train On-Board Radio)

13.4.1 General

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The radio assembly for the NYCT trains shall be designed to function with the existing communications system including complete operational compatibility as per NYCT Contract W32642, latest Addendum.

The train on-board radio furnished by the Contractor shall be a Bendix/King radio, manufacturer’s part number EM4599OASP5301M, or as approved by NYCT. Where the Bendix/King radio manufacturer’s specifications are different from the Technical Specification, the Bendix/King radio manufacturer’s specifications will be allowed.

Equipment shall be furnished and installed by the Contractor. Equipment shall be supplied for each cab car and shall consist of the following subsystems:

- Radio transmitter/receiver
- Control panel
- Antenna
The radio shall be capable of having a total of not less than fourteen (14) distinct channel modes. Channel modes include channel name, TX frequency, TX CTCSS, RX frequency and RX CTCSS.

The equipment shall operate at the following frequencies:

<table>
<thead>
<tr>
<th>Channel</th>
<th>TX (MHZ)</th>
<th>RX (MHZ)</th>
<th>CTCSS (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Command Center</td>
<td>Train</td>
<td>CMD/Train</td>
</tr>
<tr>
<td>A</td>
<td>158.880</td>
<td>161.190</td>
<td>161.190</td>
</tr>
<tr>
<td>Y</td>
<td>160.845</td>
<td>160.845</td>
<td>160.845</td>
</tr>
<tr>
<td>B1</td>
<td>158.775</td>
<td>161.505</td>
<td>161.505</td>
</tr>
<tr>
<td>B2</td>
<td>158.805</td>
<td>161.565</td>
<td>161.565</td>
</tr>
<tr>
<td>5</td>
<td>158.775</td>
<td>161.505</td>
<td>161.505</td>
</tr>
<tr>
<td>6</td>
<td>158.880</td>
<td>161.190</td>
<td>161.190</td>
</tr>
<tr>
<td>7</td>
<td>158.805</td>
<td>161.565</td>
<td>161.565</td>
</tr>
</tbody>
</table>

Emission designators for this radio shall conform to the FCC Rules and Regulations as they apply to type acceptance and refarming. The minimum operation emission must be 20KOF3E.

The continuous tone coded squelch system (CTCSS) shall be in accordance with the table of frequencies and be on a per-channel basis.

The transceiver shall be module designed, capable of being mounted into a shelf compartment.

All equipment and circuitry shall be so shielded that it will operate within specifications in the presence of electromagnetic radiation from adjacent circuitry, equipment and the general train environment.

All radio equipment shall be fully solid state with maximum use of integrated circuits.

13.4.2 Operational Requirements

13.4.2.1 Transmitter

The transmitter shall have a protective circuit which will prevent damage to the RF stages should the antenna circuit fail and which will automatically reset when proper operation is restored.
The transmitter shall have a timer to cut off transmissions in the event of a transmission or a radio malfunction which results in continuous RF power being radiated for more than one minute. A 1.0 kHz tone shall alert the Train Operator during time-out and the timer shall reset automatically when normal conditions are restored. The timer shall be adjustable up to three minutes.

The duty cycle shall be EIA Intermittent.

Tuning controls shall be accessible without disassembly after the cover is removed.

The transmitter shall comply with all applicable EIA standards and FCC rules and regulations.

The transmitter shall consist of an exciter, a power amplifier, a harmonic filter, anti-mismatch protection and an antenna switch. The modulator, consisting of an audio amplifier, limiter, and postlimiter filters, shall be contained in a plug-in integrated circuit module.

### 13.4.2.2 Receiver

All essential metering points shall be available on a multi-pin socket for general maintenance without disassembly.

Squelch sensitivity control shall be provided inside of the receiver enclosure.

### 13.4.3 Performance Requirements

#### 13.4.3.1 General

The minimum standards of TIA/EIA 603 shall be met or exceeded without explicit reference. However, in no instance shall the specifications of this document be relaxed to comply with EIA Standards.

Frequency stability of both the transmitted carrier and the receiver tuning oscillator shall be within ±0.0005 percent over the ambient temperature range of -22°F to +140°F (+77°F reference) (-30°C to +60°C (+25°C reference) with a ±20 percent variation in input supply voltage and without the use of heaters or ovens. Controls for minor frequency adjustments shall be provided within the enclosure.

All equipment of the mobile assembly shall perform to specification under any combination of ambient temperature between -22°F to +140°F (-30°C to +60°C) and relative humidity between 10 percent and 95 percent.

The RF impedance at the antenna terminals shall be 50 ohms.

All wire insulation used in the inter-equipment wiring and external cable wire to the equipment shall be in accordance with Section 15.17.
13.4.3.2 Transmitter
MOD 04.06

The transmitter shall be capable of being adjusted to 15 watts output into a 50 ohm load under Intermittent Duty conditions. The radio RF output connector shall be connected to an appropriate 3 dB RF attenuator that is rated for continuous duty at the output power level of the radio. The overall output of the radio and associated RF attenuator to the vehicle antenna shall be 8 watts. The attenuator shall not appreciably diminish receiver sensitivity as noted in Section 13.4.3.3.

The transmitter radio frequency output circuits shall be designed to operate with a standing wave ratio of ten to one (10:1) or less into a nominal 50 ohm load. Adjustable coupling and a variable reactance shall be provided to match the transmitter to the antenna circuit.

The transmission emission shall be designated as defined by the F.C.C. Rules and Regulations, and shall comply with all applicable EIA standards and F.C.C. Rules and Regulations.

The transmitter shall be capable of operating intermittently with a load VSWR of up to 10:1, nominal 13-volt input and an ambient temperature of 77°F (25°C) for up to eight hours. Intermittent duty shall be defined as a transmission of one minute and a silence of four minutes. At completion of this period, the transmitter shall meet or exceed all specifications contained herein.

Conducted spurious and harmonic emission shall be attenuated at least 85 dB relative to the carrier level. If the radio is capable of other modes of transmission and bandwidths, the specifications must conform to FCC Rules and Regulations for operation in this mode.

In accordance with FCC Rules and Regulations, Paragraph 89.109 (C), 91.105 (C) and 93.105 (C), deviation shall be limited to ±5.0 kHz relative to the center frequency. An instantaneous deviation limiter shall be incorporated in the design to restrict the deviation to this width. The deviation limiter shall have performance characteristics such that a 20 dB increase in the audio signal input level over that required for a 3.0 kHz deviation shall not increase the deviation to greater than 5.0 kHz. A 1,000 Hz tone shall be used as a standard reference frequency in setting the deviation control.

FM noise and residual hum shall be at least –45 dB relative to audio standard level. The audio frequency response shall not vary more than +1 or -3 dB from a 6 dB per octave pre-emphasis characteristic over the frequency range of 300 to 3,000 Hz with 1,000 Hz as a reference.
Audio harmonic distortion shall not exceed 3 percent with a test tone of 1000 Hz at an amplitude sufficient to produce 60 percent of maximum modulation.

The transmitter shall have a protective circuit which shall prevent damage to the RF stages should the antenna circuit fail (open or short) and which shall automatically reset when proper operation is restored.

The transmitter shall incorporate a subsonic continuous tone encoder, which generates a continuous, pure, highly stable tone.
The radio shall be capable of transmitting a five-tone type signal protocol. The radio shall have a software-only programmable fixed unit ID which is unique to the radio plus a soft ID that is entered into the radio via the keypad.

The unit ID shall consist of a four (4) digit software programmed identification number. The range of unit IDs shall be in the range of 0000-9999. The soft ID shall be a seven (7) digit number which shall be entered by the user through the keypad on the radio. These seven digits may range from 0000000-9999999.

To prevent an accidental or unauthorized programming of the soft ID, a sequence of push-button keystrokes shall be required of the user prior to beginning each soft ID entry.

The complete data message comprising the radio identification shall be transmitted in no more than 500 milliseconds.

The repeat time for the ID transmission shall be variable from 0 to 99 seconds and shall be preset initially to 15 seconds.

The emergency debounce time shall be variable from 0 to 1 second and shall be preset initially to 300 milliseconds.

The number of emergency ID transmissions shall be variable from 0 to 99 and shall be preset initially to 10.

The time between emergency ID transmission shall be variable from 0 to 99 seconds and shall be preset to 10 seconds.

The radio shall provide a tone to the user to indicate that the radio is ready and that the user may begin speaking with assurance that the message is being transmitted. The tone shall be programmable as an on/off feature. The radio's microphone shall be muted during transmission of its identification data.

Removal of battery power to the radio shall not erase the radio's soft ID. Once a soft ID has been entered, the radio shall retain it until another soft ID has been properly entered.

When PTT (Push-To-Talk) on the cab console is activated, the radio shall transmit the fixed ID and the soft ID. The CCP speaker shall then provide a “go-ahead” beep indicating that the operator may begin speaking into the microphone. At the end of the transmission, the radio shall also transmit the fixed ID and the soft ID, although no additional audio tones (e.g. courtesy beep) shall be transmitted. The capability of either mode of ID transmission (beginning or end) shall be programmable. A pre-signaling delay capability must be available in a 50-millisecond interval ranging from 0 to 300 milliseconds from the initial PTT if the ID is transmitted at the beginning of the transmission.

13.4.3.3 Receiver

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There shall be at least two transistorized limited stages preceding the discriminator. Essentially, noise excitation alone shall saturate the second limiter at all times. FM noise shall be at least 60 dB below 2/3 rated deviation at 1,000 Hz.
The receiver modulation acceptance shall be ±7.0 kHz minimum.
The resonant frequency of the receiver shall be maintained to within ±0.0005 percent for any ambient temperature in the range from -22°F to +140°F (+77°F reference) (-30°C to +60°C) (+25°C reference) or any voltage variation up to ±13 percent of nominal.

The intermodulation spurious response at the usable sensitivity level (12 dB SINAD) shall be attenuated at least 75 dB.

Employing the two signal SINAD method as described in EIA Standards, the minimum adjacent channel selectivity shall be at least 80 dB. Desensitization at ±200 kHz shall be at least 100 dB, and 120 dB at ±1 MHz.

All spurious responses, including image response, shall be attenuated by a minimum of 90 dB relative to that resonant frequency signal level that produces 20 dB of noise quieting.

The audio frequency response shall be within +2 dB to -8 dB of the normal 6 dB per octave de-emphasis characteristics from 300 to 3,000 Hz.

The combined receiver 12 dB SINAD sensitivity with the 3 dB RD attenuator attached shall not exceed 0.5 microvolts.

All noise and residual hum shall be at least 40 dB below the audio output level.

The audio stages of the receiver shall deliver an output of at least five watts or, if a more effective system is proposed by the Contractor, he shall demonstrate to the satisfaction of the NYCT, that the audio output is of sufficient level of override the ambient noise level inherent in the Train Operator's cab.

Total audio distortion shall be less than 5 percent at rated output.

The squelch circuitry shall be a noise compensated type activated by carrier and tone with an adjustable sensitivity of 0.35 microvolts or less.

The receiver shall incorporate a low frequency continuous tone decoder.

13.4.3.4 Communication Panels

MOD 04
One Communication Control Panel shall be provided in each cab on the left side above the console.

The Communication Control Panel shall include the following: Volume control, Interior and Exterior Speaker Indicators, Radio, PA ICS, PEI, Speaker and radio-to-PA pushbuttons, a Microphone, a Speaker, a Transmit Indicator, an Emergency Pushbutton (near the Radio Control Head), and the Radio Control Head.

The speaker pushbutton shall allow selection between stages of speaker control (interior or both interior and exterior).

If a rotary volume control is used, a device such as a clutch, shall be provided to prevent over-torquing due to rough handling. The design to be approved by NYCT. The volume control knob shall be tamper resistant.

The speaker shall be designed to provide good sound reproduction in the voice frequency range from 300 to 3,000 Hz under severe noise conditions and shall be rated for a minimum of four watts. The input impedance shall match the driver output.

An Emergency Pushbutton shall be provided on the CCP. When the emergency pushbutton is pressed, the fixed (hard) ID and the soft ID (route and interval) shall be transmitted. The transmission shall be automatically repeated several times. The number of transmissions and the period of time between them shall be programmable.

The radio control head, which shall provide the operator interface to the radio, shall be integrated into the Communication Control Panel. The radio control shall consist of a self-contained keypad/LCD display unit which shall be mounted on the CCP. The keypad/LCD display unit shall interface with the radio transceiver via a standard RS-232 interface and shall employ standard VT-52 protocol. The keypad shall be a 16 key matrix arranged as four rows by four columns. It shall be a sealed unit with membrane type keys. The keys shall be backlit so that the key legends will be visible in low ambient light conditions.

The keypad shall have a tactile and audible feed back that keypad entry has been made. The audible feedback shall be chirp tone of approximately 100 milliseconds in duration.

In addition to the numeric keys (0 thru 9), the radio control head shall have the following keys:

- **CH SEL**: The key labeled CH SEL (Channel Select) shall be used to scroll through the frequency channels programmed into the radio from the present setting in order of A, Y, B1, B2, 5, 6, 7, and then back to A. See Specification Paragraph 13.4.1 for the frequencies associated with these codes.

- **MON**: A key labeled MON (Monitor) shall be provided and its function shall be to disable the receiver CTSCC feature.

- **CLR**: The CLR (Clear) key on the keypad shall be used to correct erroneous entries during route and interval programming.

- **#**: The # key on the keypad shall be used to activate display of the unit’s hard ID code.
PRI: The keypad shall include a key labeled PRI (Program Route and Interval) which shall allow the operator to enter a Soft ID code consisting of a seven digit number into the radio.

C/T: The C/T (Control Center/Train-to-Train) frequency select between communications with the Control Center and Communications with other trains (talk-around mode).

No audio tones other than the audible keypad feedback shall be generated during the route and interval entry sequence.

The radio interface logic board design shall accept only military time entry, with hours from 00 to 23 and minutes from 00 to 59. Any other entry shall not be accepted, with a 100 msec duration error beep tone generated to warn the operator of an illegal entry.

PTT: When PTT (Push-to-Talk) is activated, the radio shall transmit the fixed ID and the soft ID. The CCP speaker shall then provide a “go-ahead” beep indicating that the operator may begin speaking into the microphone. At the end of the transmission, the radio shall also transmit the fixed ID and the soft ID, although no additional audio tones (e.g. courtesy beep) shall be transmitted.

When the emergency pushbutton is pressed, the fixed (hard) ID and the soft ID (route and interval) shall be transmitted. The transmission shall be automatically repeated several times. The number of transmissions and the period of time between them shall be programmable.

13.4.3.4.2 Conductor Panel (CP)

CO 82

CO 222

13.4.3.4.2.1 General

Two Conductor Panels shall be provided in the cab on the bulkhead, one beside each window.

The Conductor Panel shall include the following: Volume Control, Interior and Exterior Speaker Indicators, High and Low Microphone Indicators, PA, ICS, PEI SPKR and PTT Pushbuttons, dual height microphones with Microphone Selection, a speaker, a voice level indicator and door warning pushbutton. The speaker pushbutton shall allow selection between stages of speaker control (interior or both interior and exterior). The panel LED’s shall indicate the proper speaker(s) selection, high or low microphone and voice level.

If a rotary volume control is used, a device such as a clutch, shall be provided to prevent over-torquing due to rough handling. The design to be approved by NYCT. The volume control knob shall be tamper resistant.

The Mic-Sel pushbutton shall allow selection between the high and low microphones.
The microphone arrangement shall allow proper operation independent of whether the operator is seated for standing.

The microphone shall consist of rugged dynamic or electret element suitably shock mounted in a tamper-resistant enclosure which shall provide complete protection for the microphone. The aperture shall consist of non-coincident sound entrance holes to prevent the insertion of sharp objects. If an electret element is provided and FET amplifier and transformer shall be included as part of the assembly, with power for the FET simplex on the balanced signal pair.

The selection of the microphone and their location in the cab shall be determined for effective operation.

The momentary push buttons shall be vandal-resistant and shall be designed and type tested for ten million failure-free operations.

13.4.3.4.2.2 Electrical Specifications

The microphone plate assembly shall meet or exceed the following specifications:

- Microphone free field response: 100-12,000Hz, ±2.0 dB, re. 1kHz.
- Microphone sensitivity: -50 dBm ±1.0 dB, re. 1 Pascal (94dB SPL).
- Microphone impedance: 150/200 Ohms nominal.
- Push-to-talk switch contact rating: as required
- Visible Indicators LEDs with appropriate resistors.

13.4.3.4.2.3 Mechanical Specifications

The microphone plate assembly shall meet or exceed the following specifications:

- Impact test: The microphone plate assembly shall withstand the impact from a drop of a 1 pound (0.454 kg) steel ball from a height to six feet (1.83M), anywhere on the front surface of assembly, for 10 times in succession, without incurring any damage.
- Visual indicator for proper level: Visible to Operator under all ambient operating conditions.
- No component mounting screws shall be accessible on front of panel.
- The microphone plate, the microphone element protective housing, and the microphone plate assembly protective enclosure shall be constructed of aluminum alloy with an anodized finish to meet requirements of Section 6.5.
### 13.4.3.5 Train Mounted Antenna

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**O 102**

The Contractor shall furnish and install an antenna, sufficient coaxial cable, connectors and hardware all as approved by the NYCT.

The antenna shall be a rigid low-profile transit-type antenna. The antenna, after being mounted and connected on a train car, shall maintain a VSWR of less than 2:1 over a frequency range between 150 MHZ to 162 MHZ minimum RF bandwidth. This may be achieved using a matching network.

Mechanically, the antenna shall be completely enclosed in a non-conductive, high impact resistant case with the exception of an approved RF connector and, if required, a tuning adjustment which shall have a weatherproof seal. A waterproof method of mounting the antenna to the train surface shall be provided, as approved by the NYCT. The coaxial antenna cable shall be a low loss UHF-RG-213/u, solid conductor cable with a nominal attenuation of no greater than 3.5 dB/100 ft.

The antenna shall be mounted so as to provide a vertically polarized omnidirectional radio signal.

The antenna shall be mounted behind the Cab-end bonnet.
MOD 06

The power supply shall incorporate switching circuitry to provide isolation from the input and employ solid-state circuitry for developing regulated operating voltages necessary for operation from the low voltage power supply (37.5 volts DC) of the rapid transit car. The power supply shall provide protection against transient voltage spikes up to at least 2,500 volts at 80 watt seconds. The Contractor shall be responsible to ensure that transients encountered in the train will not damage components of the train radio equipment. The operating input voltage range is stated in Section 2.3. A regulated 13.8 Vdc output shall be provided.

A separate circuit breaker shall be furnished to serve the mobile radio assembly.

The crew intercom shall be continuously energized on the normal and emergency electrical system.

The on-board radio and the PA shall be active only in the cabs where the Master Controller is keyed in or where the Master Door Controller is zoned.

13.4.3.7 Arrangement and Packaging

Equipment housings shall be dust, moisture and splash proof and shall not incorporate external air ventilation. The housings shall be fabricated from heavy gauge metal or high-impact material as approved by the NYCT.

The control panels shall be module designed or equipped with maintenance hangers to allow access to all components and circuitry while retaining full use of all controls and functions on the panel face, without placing undue strain on cables and connectors.

The radio transmitter and receiver shall meet all vibration and shock stability requirements of the applicable paragraphs of EIA Standards TIA-603.

The control panel, the power supply and the antenna, shall continue to meet all technical and operational specifications after completion of vibration and shock stability tests as set forth for land mobile receivers in EIA Standard TIA-603.

All components shall be clearly labeled. All components behind the panel shall be clearly and legibly displayed in a prominent location and shall be in plain view upon removal of the unit from its enclosure. Wiring between equipment assemblies shall be tagged as approved by the NYCT.

The microphone shall provide an average discrimination of 12 dB against ambient noise.

The radio speaker shall be designed to provide good sound reproduction in the voice frequency range from 300 to 3,200 Hz under severe noise conditions and shall be rated for a minimum of 5 watts. The input impedance shall match the driver output.
13.5 Information Signs

13.5.1 General

The Contractor shall furnish and install a sign system of approved design and manufacture. The sign system for each car shall consist of two electronic Side Destination signs, two Interior Message Display signs and two Electronic Strip Maps. Each Cab Car sign system shall also include a motor driven mylar End Route sign (similar to the mylar display provided on the NYCT’s R62, R62A cars) for the No. 1 end of each Cab Car. Side signs shall be readable from the outside of the vehicle and shall be located in the split-vent portion of the side window. Destination signs must be able to be changed from the cab console in the active cab or the Conductor's position, on a trainline basis, for all signs on a train.

The portable and/or bench test equipment shall include a user interface to allow editing of text messages, creation of new messages and addition or deletion of messages without the need to understand programming or code. The special tools or test equipment shall also include software and hardware capability to digitize the audio portion of the messages either directly or from tape and control their placement in conjunction with other audio messages or corresponding text messages. They shall also provide capability to revise trigger points for any message, including revising the route, if necessary.

13.5.2 Side Destination Sign

The signs shall be all-electric, alphanumeric, LED or LCD display type meeting all other requirements of this Section and shall be completely self-contained. The LCD display shall be transflective and back-lighted showing a negative image font on a black background with the characters having rounded corners formed from a mosaic layout containing greater than 60 LCD segments.

The font character shall be similar to Helvetica style and capable of upper and lower case lettering.

The sign display shall be readable in direct sunlight or complete darkness. The readable viewing angle shall be a minimum of 170 degrees. The display shall have a minimum contrast ratio, in daytime or nighttime, of 35:1.

The display shall not require any external mask between pixels and shall not require any framing or support structure between characters which would give the sign a discontinuous appearance.

The side destination signs display shall consist of one alphanumeric character a minimum of 6 inches (152 mm) high followed by a space and 20 alphanumeric characters 2.50 inches (64 mm) high. All characters shall be mounted in the same housing and shall be readable from a minimum of 75 feet (22.86 m).

The destinations shall be selected from the Train Operator's Display (TOD) located on the cab console.

13.5.3 Interior Message Display

An all-electric alphanumeric, LED message display shall be installed in the low ceiling header panels in each end of the car. There shall be no glare from the mounting frame or from the car's interior which could affect the display's readability.
The display shall be comprised of a 16 x 224 matrix of pixels capable of displaying multi-color red, yellow, and green characters 2.3 inches (58.4 mm) high. The sign shall provide messages such as the next station stop, destination, Route, time of day, and other secondary messages.

Each side of the message display shall be pitched slightly downward to allow maximum visibility to passengers and minimize reflections on the ceiling.

### 13.5.4 Electronic Strip Maps

Two electronic strip maps shall be provided per car. The strip maps shall be located in the advertisement card area between the side passenger doors. Strip maps shall be capable of clearly displaying all stations and transfer points along an entire route. Strip maps shall also have the capability to automatically adjust to reroutes via trainlined commands or signals from an activated console screen. Strip maps shall include displays for "out of service" and "reroute change" indication.

### 13.5.5 End Route Signs

An enclosed dirt and dust tight, back lighted, electronic route sign shall be provided and located above the No. 1 End, body end door. The route sign shall be automatically controlled by the sign control system, see Section 13.5.7. The sign shall be designed to permit easy installation and removal.

The sign display shall contain one alphanumeric character, a minimum of 10 inches (254 mm) in height and be identifiable at a minimum distance of 300 feet (91.4 m). The sign display shall have the capability to display a NYCT line designation letter or number on a contrasting colored background.

### 13.5.6 Intentionally Blank

### 13.5.7 Sign Control

The destination and route sign messages shall be selected by the Operator or the Conductor from the cab console as described in Section 6.6.

The active cab control console shall transmit the message selection to all other cars in the train.

### 13.6 Closed Circuit Television (CCTV) System

Each car shall have provision for eventual installation of a Closed Circuit Television (CCTV) System to provide passenger area monitoring as well as viewing the platform via remote link-to-station mounted cameras. The system to be installed will consist of fixed position, fixed lens cameras mounted in the drop ceiling at each end of the car, and platform-mounted cameras. The system itself is not included within the Contract.
Provisions shall consist of identified space for carborne cameras and cab-mounted displays.
## SECTION 14

### LIGHTING SYSTEMS

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SECTION 14

14.0 LIGHTING SYSTEMS

14.1 General

All lighting fixtures shall be designed to provide ease of: cleaning lens; lamp and ballast change-out; adjustments; and housing removal. Lamp access shall be by gasketed enclosure covers secured by captive, tamperproof stainless steel fasteners or other approved tamperproof methods. Where possible, covers shall be retained by hinges. Hinges located on the vehicle exterior shall be made from stainless steel.

Fixtures installed on the vehicle exterior and in the interior below ceiling level shall be watertight. All fixtures shall be dustproof to minimize the accumulation of airborne dirt and dust within the fixture.

Power shall be provided to the fixtures through positive and negative leads. Both power feeds to the lamp fixtures shall be insulated from car body ground. Lighting systems shall not use the fixture housings or sockets as a ground return. All fixtures and their exposed metallic surfaces shall be grounded to the vehicle structure as described in Section 9.4.

14.2 Interior Lighting Systems

14.2.1 Main Interior Lighting Fixtures

The passenger areas shall be illuminated by two rows of high efficiency fluorescent fixtures mounted in the ceiling above the seats, to provide the light levels required below. Transverse mounted fluorescent fixture shall be provided adjacent to each body end door.

The light fixtures shall be dust and moisture proof. All portions of the fixtures (except lens and reflector) shall be powder-coated to match the ceiling panels. All visible portions shall match the finish of the ceiling panels. The reflector shall be painted glossy white on the inside of the fixture. The sockets shall be spring-type, designed to provide support at the end of the lamp in addition to that obtained from the terminal pin. The spring-type sockets shall be designed to preclude grounding of the terminal pins to the fixture. The socket shall provide an automatic engagement of the lamp on insertion. The use of lamp retainers that engage the glass portion of the lamp shall not be permitted.

The lamps shall be cool white in color, 32-watt, nominal 48-inch, T-8 lamps with bi-pin bases, unless otherwise approved by the NYCT. Lamps shall have an average rated life in excess of 20,000 hours.

The ballast shall be mounted on the outside of the light fixture housing. The ballast shall be accessible from the inside of the light fixture through a hinged plate. The hinged plate shall be retained by captive mounting screws.

Each fixture shall include a lens contained in a door with an integral, concealed hinge. The lens shall be manufactured from molded transparent polycarbonate, with a smooth exposed surface and patterned back surface designed to achieve specified illumination levels and even distribution of light. The lens mounting shall
preclude the lens from being pushed into the fixture housing by passengers and shall prevent the lens from vibrating under all operating conditions.

The lens door shall be secured in the closed position with tamper proof fasteners. The fasteners shall be stainless steel, captive, and of the quick acting type. Lens material shall meet the flammability and smoke emission guidelines of Section 15.25.

The average illumination intensity within the vehicle at elevations of 33 inches (838 mm) above the floor on a 45° plane centered on the front edge of any seat, and 55 inches (1,397 mm) above the floor on a 45° plane for passengers standing anywhere in the aisles shall be at least 35 foot-candles (375 LUX). The average illumination intensity on the floor in the passenger aisles shall be not less than 20 foot-candles (215 LUX). All specified light intensities shall be achieved at the nominal voltage of the low voltage system.

**14.2.2 Fluorescent Lighting Ballasts**

The fluorescent lights shall be powered from the LVDN described in Section 9.10. Rapid-start inverter ballasts shall be employed. The ballasts shall power two lamps wherever possible. The output power of the ballasts for starting and operating the lamps shall be optimized to allow energy savings at required light levels. A green indicating LED, visible from the lamp section of the fixture, shall be provided in the ballast cases to indicate the presence of output power. Ballast reliability shall be 500,000 hours MTBF, minimum.

The ballast shall have an over-temperature protection feature which automatically resets when the temperature drops to acceptable levels. Ballasts shall not be damaged by the intermittent or continuous application of reverse polarity direct current power up to 45 Vdc. The ballast shall withstand all low voltage system transients without damage or reduction in life.

All ballasts shall have an operating frequency of 25 kHz or greater.

For the protection of operating and maintenance personnel, a shutdown circuit shall be provided to prevent shock hazard when relamping and to prevent arcing at poor connections. The ballast shall automatically sense these conditions, turn off the power circuits and remove high voltage from the lamp circuit. Automatic reset shall occur when the condition is corrected. In the event of a damaged lamp or one that has reached the end of its useful life, the ballast shall not be damaged or fail prematurely.

In addition to the access requirements of Section 14.2.1, the ballasts and attendant wiring shall be configured mechanically and electrically so that they are easy to replace. Connectors meeting the requirements of Section 15.19.6 may be used for the wiring to satisfy this requirement.

Ballast emissions shall not exceed the specified EMI levels within Section 2.6. Lamps shall be operated at lamps manufacturer's recommended current levels.
14.2.3 Interior Lighting Control

The main interior lighting system shall be trainline-controlled from the Train Operator’s console in each cab. The interior lighting system shall be separated into three separate circuits. The emergency lights shall occupy one circuit while the remaining interior lights shall be divided into two circuits to be shut off in two stages. Separate circuit breakers shall be provided for each of the main interior lighting circuits to be shut off in two stages.

When the selector switch is in an active position, it shall be possible to turn the lights in the entire train on or off by operation of the control on the Train Operator’s console. The lights shall be turned off immediately.

When the auxiliary systems are shut down by operation of the selector switch, individual banks of light shall be controlled under load shedding as described in Section 9.10.4

14.2.4 Cab Lights

Each side of the cab shall be provided with a reading lamp, preferably fluorescent, powered from the LVDN. The right hand side reading lamp shall be suitably placed in the ceiling to illuminate the Train Operator's console. The left hand side reading lamp shall be suitably placed in the ceiling to illuminate the left hand side of the cab. Light beams shall be directed to avoid glare on the windshields. The illumination intensity measured on the Train Operator's controls shall be 20 foot-candles (215 LUX). The cab reading lamps shall be controlled from the Train Operator's console.

The body end door overhead fluorescent light in the cab shall be separately controlled from the Train Operator's console. The light shall automatically illuminate when the emergency lights are on, except when the local console is energized by the Master Controller Keyswitch. In addition, to provide a "night light" feature, the body end lights shall be illuminated when all consoles of the train are de-energized, with and without third rail power present. The "night-light" feature may be deactivated after one hour if third rail power is not present.

14.3 Exterior Lighting

Exterior lighting assemblies shall be set in waterproof enclosures. All bezels and trim shall be made of stainless steel, have captive stainless steel fasteners, and be consistent with good mechanical mounting principles. All exterior lights shall be incandescent or LED clusters and shall be powered from the LVDN with each lamp having its own voltage dropping resistor, if required. Lights at the coupled ends of vehicles in a train shall not function. The relamping of all exterior lights except those noted in Section 14.3.4 shall be from the exterior of the car.

Headlights and taillights shall be arranged on the cab end of the cab car as depicted on the NYCT front-end mockup. The taillight shall be located above the headlight.

14.3.1 Headlights

Headlights and taillights shall be arranged on the cab end of the cab car as depicted on the NYCT front-end mockup. The taillight shall be located above the headlight.
Two, 60 watt, 38 volt, 60PAR/1 sealed beam headlights shall be provided on the cab end of the vehicle. Headlight beams shall be set parallel to the longitudinal centerline of the car and at a 2° slope downward from
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the horizontal centerline. The centerline of the headlight beam shall strike the running rail at approximately 150 feet (45.72 m) in front of the car.

The headlights shall be powered from the LVDN. A separate circuit breaker shall be provided for the headlights. Headlights shall continue to be operable in the emergency power mode.

The headlights shall be illuminated at the leading (i.e., facing in the selected direction of travel) uncoupled end of the train as determined by the forward and reverse trainlines and coupler position whenever any Train Operator's console in the train is powered, including a console in an intermediate cab.

The headlight sockets and headlight and taillight wire shall be General Electric type AC 1619, or approved equivalent, except the wiring shall be #18 AWG stranded copper with type SF-2, 200°C insulation.

All lamp sockets shall conform to requirements of the National Board of Fire Underwriters.

14.3.2 Taillights MOD 02

Two, 60 watt, 38 volt, 60PAR/2/R sealed beam, taillights with an integral red filter, or equivalent LED cluster arrangement, shall be provided at each cab end of the cab car. Each lamp shall have a series dropping resistor rated 5 ohms, 20 watts for extended lamp life. Taillights shall be powered from the LVDN. A separate circuit breaker shall be provided for the taillights. Taillights shall continue to be operable in the emergency power mode. Wire shall be per Section 14.3.1.

The taillights shall be illuminated at each uncoupled end regardless of console status, except where headlights are activated.

14.3.3 Intentionally Blank MOD 02

14.3.4 Guard Light

A LED indicator, as detailed in Section 11.12.4, shall be furnished and located on each side of the car exterior to indicate passenger door closure status.
14.4 Emergency Lighting Systems

14.4.1 Emergency Functions

The following lights, powered by the low voltage system, shall remain functional and be powered by the storage battery under the loss of low voltage power supply (LVPS) output:

- A portion of the interior fluorescent lights,
- Cab lights,
- Headlights, and
- Taillights.

See Section 9.10.4 for additional details.

14.4.2 Main Light Power

In the event of a short interruption in LVPS output, such as would be caused by a third rail gap, the storage battery shall continue to power all main interior lights. Refer to Section 9.10.4 for load shed requirements.

14.4.3 Emergency Interior Lights

Fluorescent lights designated as emergency fixtures shall be energized from the storage battery when the LVPS output is not present. Emergency lighting shall be evenly distributed through the vehicle interior and arranged to include all side and body end doorway areas.

14.5 Lighting Sources

All LED lamps, unless otherwise specified, shall be standard type, and readily available. The Contractor shall make available sample fixtures, lamps, and ballasts during the design review period for NYCT evaluation.
# SECTION 15

## WORKMANSHIP, PROCESSES AND MATERIALS

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SECTION 15

15.0 WORKMANSHP, PROCESSES AND MATERIALS

15.1 General

15.1.1 Quality

Material and workmanship shall be in accordance with the requirements of this Section, unless approved by NYCT.

Inclusion of a material or method in this Section does not indicate approval for application or use in a specific situation. When a material or method is specified in this Section, this Section shall be applicable; however, specific requirements detailed in appropriate Technical Specifications take precedence over this Section.

Material Safety Data Sheets (MSDS) shall be submitted for all materials, including lubricants, used in the fabrication of these cars, except for non-hazardous metallic materials. Information shall be in a form compliant with ANSI B.1, B.1.2, B.1.3, B.1.5, and B.1.6.

15.1.2 Standards

The following domestic standards and specifications define materials for this contract: Federal or Military Specifications or Standards, the Specifications of the Aluminum Association of America, AAR, ANSI, ASME, ASTM, FRA, IEEE, and additional requirements, as specified herein. Where other or foreign standards are proposed by the Contractor, the Contractor shall submit documentation for NYCT review and approval demonstrating the proposed standards are the equivalent of the foregoing standards and specifications. Proposed substitute specifications shall be submitted in both English and the language of the country of origin.

15.1.3 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.

15.1.4 Cleaning Agents

A list of recommended cleaning agents shall be provided to the NYCT for all materials exposed to normal cleaning operations. This information shall also be included in the maintenance documentation for the vehicle. Contractor recommended cleaning agents shall be from the NYCT's list of approved cleaning agents (NYCT Cleaners and Related Material Qualified for Car Equipment Use, reference Appendix C), unless otherwise approved by NYCT.

15.1.5 Prohibited Materials

The following materials are prohibited from use on the cars:

- PVC
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- Asbestos
- Lead
- PCBs
- Carcinogenic materials
- Materials listed in 29 CFR Sec. 1910.19

In addition, reference Appendix C for NYCTA/MaBSTOA CCSS-003, latest revision, entitled "General Requirements-Restricted Chemical Substances".

15.2 Joining and Fastening

15.2.1 Joining

15.2.1.1 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 used at all times where these combinations exist.

15.2.1.2 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 not greater than 10 percent of the thinner material being joined, or 0.002 inch (0.05 mm), 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 NYCT. 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.

15.2.1.3 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 Federal Specification TT-P-664. Metal primer may be omitted for austenitic stainless steel to austenitic stainless steel joints.

For proper treatment of a connection involving aluminum, refer to Section 15.6.4.
15.2.1.4 Wood-to-Metal Connections

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 Federal Specification TT-P-664.

All bolts or rods passing through wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38.

15.2.1.5 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.

15.2.2 Fasteners

15.2.2.1 General

The Contractor and suppliers are 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.

Fasteners used throughout the car shall be inch standard fasteners, except that ISO Metric fasteners may be used in conformance with Section 15.2.2.2.1.

All fasteners used on this car shall be specified under one of three categories: electrical and electronic; structural and safety-related; or decorative. 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. Fasteners used to attach interior lining or trim and exposed to passenger view are specified under Decorative and Appearance Fasteners. All fasteners, in any category, which attach to car structure shall be in accordance with Section 3.3.3.

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 NYCT will be the final arbitrator on which fasteners are safety related.

15.2.2.2 Threaded 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 1970 Fastener Standards.

Prevailing-torque type locknuts shall be nylon insert type, ESNA or approved equal, conforming to IFI Fastener Standards or Military Standard MS-21044. Distorted thread 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°F (93°C).

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.

All screws or bolts used to secure access panels to the interior, undercar, or roof equipment shall be made captive to the panel in which they are used.

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 1½ screw threads shall be visible beyond all nuts. When used without elastic stop nuts, bolts shall not project more than 1½ threads plus 1/4 inch (6 mm) for bolts 1/4 inch (6 mm) diameter or less and shall not project more than 8 threads for larger diameter bolts, unless otherwise approved. With elastic stop nuts, bolt threads shall not project more than 1/4 inch (6 mm), regardless of bolt size. Undercar equipment shall not be supported by bolts in tension.

15.2.2.2.1 Metric Fasteners

Upon approval, specific components, control groups, or individual units that are supplied by a supplier or sub-supplier 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 assembly 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 assembled with or containing ISO-metric threads shall be indelibly identified, in an approved manner and in a conspicuous approved location, to signify that the unit was assembled using metric threaded fasteners or components. 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, latest edition.

15.2.2.3 Structural Fasteners

All structural fasteners shall have documentation identifying manufacturer and purchase specifications available for examination by the NYCT 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 sub-contractor, supplier, or the Contractor, the Contractor shall obtain and hold this documentation for a period of not less than termination of the last car's warranty period.
All safety-related fasteners shall either a): be manufactured, tested, and distributed in accordance with ASME FAP-1-1990, Quality Assurance Program for Fastener Manufacturers and Distributors, including the requirements of ASME accreditation or b): have a representative sample of each production lot of fasteners 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, and 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 NYCT. Tests conducted shall confirm that fastener material meets specified chemistry and strength requirements. The buyer shall obtain certified test results from the testing laboratory and hold the documents for a period of not less than the termination of the warranty period of the last car.

All safety-related fasteners that are plated or chemically cleaned shall have certifications showing freedom from hydrogen embrittlement. If non-standard, structural, or safety related fasteners are plated by other than the O.E.M., a representative sample of these fasteners shall be tested for hydrogen embrittlement by the 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 equipment shall be a minimum Grade 5 and the bolt diameter shall be no less than 3/8 inch (9.5 mm), regardless of design load. Stronger fasteners shall be used if the application requires. The mounting and attachment bolts for undercar-mounted equipment and equipment support structures or brackets shall be sized to the design strengths for Grade 2 bolts and Class A nuts.

15.2.2.4 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 fasteners used for stanchions shall be austenitic grade stainless steel. Bright finished interior fasteners may be either austenitic or plated martensitic stainless steel. Self-tapping screws are only permitted where they will not be removed for normal maintenance more than once in five years and shall be plated martensitic stainless steel.

All exterior fasteners visible to passengers shall be austenitic stainless steel for steel, LAHT steel, and stainless steel car bodies. Exterior aluminum shall be joined by austenitic stainless steel or aluminum alloy fasteners, as appropriate to the design and appearance requirements. 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 NYCT.

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 5 years, access panels shall be equipped with quarter-turn fasteners. Quarter-turn fasteners shall have a
minimum shank diameter of 1/4 inch (6 mm), be of adequate strength, and as manufactured by Southco, or approved equal.

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 NYCT to review for a period of not less than the expiration of the warranty on the last car delivered.

15.2.2.5 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 may be calculated from Industrial Fasteners Institute, Fastener Standards, 5th Edition, 1970 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 installation torque. For those nuts or bolts requiring "torque striping", the NYCT may require bolt torque-tension tests to verify that installed preload is equivalent to 75 percent of proof loads.

15.2.2.6 Washers and Lock Washers

Washers shall be used under the heads of all bolts and under all nuts. Where high strength fasteners are applied, washers shall be hardened and comply with IFI 1970 Fastener Standards.

Lock washers, when applied, shall conform to IFI 1970 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 the NYCT's approval.

15.2.2.7 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 with 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 (Huckbolt 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 NYCT shall be the final arbiter in determining whether an application is hazardous to maintenance personnel.

15.2.2.8 Plating of Fasteners

All carbon, alloy, and martensitic stainless steel fasteners shall be plated with zinc, unless specifically waived by the NYCT.

Grade 8, Metric 10.9, or stronger, fasteners shall not be plated if the OEM finish is other than plating.

Zinc plating shall conform to ASTM-B-633, Type II SC2, SC3 or SC4.

15.2.2.9 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. 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.

15.3 Stainless Steel

15.3.1 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.

15.3.2 Austenitic Stainless Steel MOD 02

Structural austenitic stainless steel components assembled by fusion or resistance welding shall be of AISI type 201L, 301L, 301LN or 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".

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.
15.3.3 Ferritic Stainless Steels

When specified, ferritic stainless steel conforming to ASTM A 176 may be used for sheeting up to 0.2 inch (5 mm) thickness. Ferritic stainless steel sheet shall have a ductile-to-brittle transition temperature (DBTT) or nil-ductility temperature (NDT) below 0°F (-18°C). Weld heat-affected-zones shall also have a DBTT or NDT below 0°F (-18°C). 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 car body, inhibit formation of martensite and limit chromium depletion in weld-heat-affected zones so that material shall meet ASTM A 763 requirements for resistance to intergranular corrosion.

General requirements for delivery of stainless steel shall be as required by ASTM A 480.

Where ferritic stainless steels are welded to other structural steels, the less-noble steel shall be painted with weld-through primer.

15.3.4 Testing

The Contractor shall prepare (or have prepared), submit, and receive approval 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 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 steels, the test and inspection plan shall include frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A 763.

15.4 Low-alloy, High-tensile Steel

15.4.1 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. 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 A 6. Welded LAHT steel shall develop 15 ft-lbs (20 Joules) Charpy V Notch impact strength in the CGHAZ (Coarse grain heat affected zone) 1 mm from fusion area at -20°F (-29°C).

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 steels shall be applied according to their specification properties.
15.4.2 Testing

The Contractor shall prepare (or have prepared), submit, and receive approval 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 NYCT for each shipment in accordance with the applicable requirements of Purchase Specification and specified CGHAZ impact tests.

15.5 Steel Castings

15.5.1 General

The Contractor is responsible for selecting casting grade, composition, strength and finishing. However, steel castings used in the car body structure shall meet AAR Specification M-201 latest revision, Grade "B", plus 2 percent nickel, minimum. These castings shall be heat treated to develop a minimum tensile strength of 75,000 psi (517 MPa), a minimum yield strength of 48,000 psi (331 MPa), elongation of not less than 25 percent in 2 inches (50 mm), 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" quenched and tempered.

15.5.2 Design Qualification of Structural Castings

One casting, selected by the NYCT 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.

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 NYCT before any castings are produced. Radiographs shall meet the requirements of ANSI/ASTM E 94 and E 142, and the quality level in the area of inspection shall be at least 2 percent (2-2T).

A qualification test report shall be prepared and submitted to the NYCT for approval. The production of any castings before receipt of the NYCT's approval of this report shall be at the Contractor's risk. All radiographs that resulted from the qualification test shall be made available to the NYCT for review. In case 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. Once a design is qualified and accepted by the NYCT, 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.

15.5.3 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. 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.

15.5.3.1 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 1/4 inch (6 m) in the direction transverse to the usual direction of loading, and 3/4 inch (19 mm) in the direction parallel to the usual direction of loading.

15.5.3.2 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. A sampling frequency shall be proposed by the Contractor and submitted for NYCT approval.

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 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 casting out of each ten produced. If no castings are rejected by radiographic inspection, this frequency may be extended to one casting in 25.

15.5.4 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 Section 15.23. Castings requiring repair or modification by welding after completion of heat treatment may be stress relieved locally by using electrically controlled heating to not greater than 1150°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 E 94 and E 142, 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.

15.5.5 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, and reinspected or destroyed at the Contractor's expense.
15.6 Aluminum

15.6.1 General

Aluminum alloy mill products shall be identified by 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, if used for door thresholds, shall conform to ASTM B-26, B-85, or B-108 for, respectively, sand, die, or permanent mold castings. 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 NYCT.

15.6.2 Design Stresses

All aluminum structural members shall be designed so that calculated stresses under the specified AW3 passenger load do not exceed the allowable stresses 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.

15.6.3 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.

15.6.4 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.

Aluminum alloy surfaces shall not be secured to or make direct metal-to-metal contact with the surfaces of copper, copper bearing aluminum alloy, brass, bronze, silver, nickel, nickel alloys, nickel plated parts, lead, tin, or wood.

The contact surfaces of aluminum alloy with aluminum alloy shall be painted with zinc chromate primer or approved equal before securing.
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-hygrosopic 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.

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.

15.6.5 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 (0.01 mm) and a minimum coating weight of 21 mg/square inch (32.55 g/m²), or approved equal process.

15.7 Elastomers

15.7.1 General

All elastomeric parts shall be of neoprene, unless otherwise specified. The elastomer shall be compounded and cured to perform satisfactorily in the temperature range specified in Appendix A. The elastomers shall have high resistance to ultraviolet radiation, weather, all NYCT car washing 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 resilient mounts shall be of natural rubber. Synthetic rubber compounds may be substituted for natural rubber only when approved for a specific application.

15.7.2 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 Section 15.25; the results of the testing shall be submitted to the NYCT.

The test specimens shall be cut out from the extruded material, and at least one tensile strength and elongation test and one 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 order, at least one test of each type shall be made for each different batch.
When testing the 6 inches (152.4 mm) by ½ inch (12.7 mm) ASTM "dumb bell" type test specimen (or smaller size if the size of the part necessitates) by the methods specified in ASTM D 3182, D 3183, D 3190, and D 412, the tensile strength shall not be less than 1,500 psi (10,343 kPa) 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 D 573, for a period of 96 hours in an air oven at 158°F (70°C).

The ozone resistance of the elastomer shall be tested in accordance with ASTM D 1149 using an ozone concentration of 100 pphm, an exposure time of 100 hours at 100°F (38°C), and a specimen elongation of 20 percent. The elastomer shall not exhibit any cracks during the test period.

15.7.3 Life Expectancy

For all parts made by vulcanizing an elastomer to metal, any premature failure (less than six years) 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 materials or workmanship.

15.7.4 Metal Parts

Metal parts to which elastomeric material is vulcanized shall be made of SAE 1020 or 1045 hot-rolled steel.

15.7.5 Bonding

The joining of elastomeric pieces shall be conducted by the hot vulcanization process. Bonding of elastomers shall not be allowed unless the Contractor submits the application, bonding procedure and bonding agent technical data for approval prior to the purchase of any materials.

15.7.6 Truck Parts

Truck bumpers, snubbers, 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, oil, grease, and acid.

15.7.7 Seals

CO 142

Glazing strips shall be of neoprene conforming to ASTM C 542, 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°F (21°C) to 90°F (32°C) shall be 70 ±5, except for side door mating edges where it shall be 80±5.
15.8 Glazing Materials

15.8.1 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 FRA 49 CFR 223 Type I or II test as appropriate for the application.

15.8.2 Glass Type

All safety glass shall be of the laminated type.

15.8.3 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.

15.8.4 Dimension Tolerance

The overall dimensions of individual lights as supplied shall be held within 0.60 inch (15.24 mm) of the dimensions ordered.

15.8.5 Overlap Tolerance

The overlap of one laminate of the light with respect to the other at an edge shall not exceed:

- 1/32 inch (0.8mm) for light construction of 3 or less plies of laminates (2 glasses + 1 PVB);
- 1/16 inch (1.6 mm) for light construction of 5 or more plies of laminates (3 glasses + 2 PVB).

Corners and burrs shall be ground smooth and all edges shall be treated in accordance with ANSI Z26.1, Section 6.

15.8.6 Color

The color of the glass shall be as required by Section 3.10. 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.

15.8.7 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.
15.8.8 Specks and Scratches

Occasional specks of foreign material and scratches are permissible, provided such specks do not exceed 0.020 inch (0.5 mm) in greatest dimension and scratches do not exceed a total of 3 inches (76.2 mm) in length and neither are within the central three-quarters area of the light.
15.8.9 Bond Separation

The bond between two 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.

15.8.10 Marking

All safety glass shall be marked with proper identification in accordance with ANSI Z26.1, Section 7, and appropriate FRA Type designation. The window light shall be installed so that the identification marking can be read from the inside lower right hand corner.

15.9 Floor Covering

15.9.1 Rubber Floor Covering

Rubber floor covering shall contain 44 percent (nominal, by weight of compound) Butadiene Styrene rubber, shall be non-staining, non-discoloring, and 100 percent non-oil extended. Only high quality, fine, hard clay shall be used as a filler. No whitening (limestone) shall be used in the compound. The rubber tile shall be free from reground rubber, natural rubber or coarse fillers.

At 68°F (20°C), the rubber flooring shall bend 180 degrees around a 3/4 inch (19 mm) diameter mandrel without breaking, cracking, crazing, or showing any change in color. The rubber flooring material shall be fully homogeneous throughout and shall meet the requirements of ASTM F 1344.

15.9.1.1 Inspection Criteria

This Section addresses defect items that may be cause for rejection, their allowable limits, and repair methods, where repairs are permitted.

15.9.1.2 Thin-Skinned Blister

A thin-skinned blister is a blister which, when finger_PUSHed, will collapse upon itself. Any thin-skinned blisters which exceed the limits listed below shall be cause for rejection of the floor sheet.

- Maximum Size - 0.030 inch (0.76 mm) high, 0.80 square inch (516 mm²) area with longest dimension of 2 inches (50.8 mm).

- Maximum Population - 3 blisters in a 12 inch by 12 inch (305 mm by 305 mm) area with only one other blister within 3 feet (914 mm) of this area.

- Repair Method - using a hypodermic needle, apply just enough Super Bond 420 or Bostik 1685 or equivalent, compress the blister and to bring to a flush surface.
15.9.1.3 Thick-Skinned Blister

A thick-skinned blister is a blister which, when finger-pushed, will collapse and then return to its original condition.

- Maximum Size - 0.030 inch (0.76 mm) high, 0.80 square inch (516 mm²) area with longest dimension of 2 inches (50.8 mm).
- Maximum Population - 3 blisters in a 12 inch by 12 inch (305 mm by 305 mm) area, and only one other blister within 3 feet (914 mm) of this area.
- Repair Method - no repair authorized.

15.9.1.4 Lump

A lump is a blister without a void, consisting of solid material.

- Maximum Size - 0.030 inch (0.76 mm) high, 0.80 square inch (516 mm²) area with longest dimension of 2 inches (50.8 mm).
- Maximum Population - 3 lumps in a 12 inch by 12 inch (305 mm by 305 mm) area, and only one other lump within 3 feet (914 mm) of this area.
- Repair Method - no repair required.

15.9.1.5 Hole

A hole is a defect which is 50 percent through the material. Any holes found in the floor sheet shall be cause for rejection of the sheet.

15.9.1.6 Thin Area

A thin area is a defect where the sheet is of reduced thickness locally.

- Maximum Size - 0.030 inch (0.76 mm) deep at the lowest point, 3 square inches (1,936 mm²) with the longest dimension of 5 inches (127 mm).
- Maximum Population - one thin area in a 40 inch by 40 inch (1.02 m by 1.02 m) area, and no other thin area within 3 feet (914 mm) of this area.
- Repair Method - rub with #00 steel wool to blend this area into the normal thickness material and then buff to a normal surface finish.
15.9.1.7 Color and Speckle Distribution

Color and speckle distribution is an appearance judgment and shall be subject to the approval of the NYCT. If the base coloring is not within 5 percent between production runs, or the speckling is not consistent over the entire surface, the roll shall be rejected.

15.10 Wood and Panels

15.10.1 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.

15.10.2 Plymetal

The term "plymetal" as used in this Specification means metal-faced plywood. All plymetal panels shall conform to Military Specification MIL-P-8053, Sections 3.1.2 and 3.1.3 and 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, 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>
<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 in accordance with Section 15.10.6. prior to the melamine-faced metal panel being laminated to the plywood core.

15.10.3 Plywood

All plywood shall be manufactured to conform with the requirements of Grade - Structural I of the National Bureau of Standards Voluntary Product Standard (American Plywood Association) PS 1-83, and then stored under cover. Scarf or finger jointed panels are not allowed. All plywood shall be sealed with two coats of an epoxy paint on all edges and cutouts as soon as possible after fabrication. All exposed edges of the panels, joints between panels, fastener heads, and openings of panels used in areas accessible to moisture shall be water-proofed and sealed with an approved coating prior to installation in the car.
15.10.4 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.

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 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 (2.68 kg/cm) 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 30 lb/inch (13.6 kg/2.5 cm) 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:

- Core shear yield at 200°F (93°C) 250 lbf/in² (1.72 MPa)
- Flatwise tension at 200°F (93°C) 250 lbf/in² (1.72 MPa)
- Beam flexure at 200°F (93°C) 75,000 lbf/in² (517.13 MPa)
- Core shear fatigue at R.T. 150 lbf/in² @ 10⁶ cycles (1.03 MPa)
- Flatwise tension at R.T. 250 lbf/in² @ 10⁶ cycles (1.72 MPa)
- Beam flexure at R.T. 50,000 lbf/in² @ 10⁶ cycles (344.75 MPa)

No other honeycomb materials are permitted.

15.10.5 Panel Contour Tolerance

Surfaces exposed to passengers shall not deviate from the specified contour by more than 3/32 inch (2.38 mm) in any 36-inch (914 mm) distance. The slope of any such deviation shall not exceed 3/32 inch (2.38 mm) in 12 inches (304 mm).
15.10.6 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°F (132°C) and pressure no less than 1000 psi (6.9 MPa). 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 (0.4 mm ±0.13 mm) thick. The aluminum sheets shall not be less than 0.025 inch (0.64 mm) in thickness when used as a facing on plywood. The aluminum sheets shall not be less than 0.081 inch (2.06 mm) 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 not acceptable.

The bond between the melamine and aluminum sheets shall, as a minimum, meet the following requirements:

- **Internal bond (ASTM D 952):** 2,600 lbf/in² (17.9 MPa)
- **Flexural strength - (S) (ASTM D 790)**
  - with grain: 26,500 lbf/in² (182.7 MPa)
  - crossgrain: 25,300 lbf/in² (174.4 MPa)
- **Modulus of elasticity - (E) (ASTM D 790)**
  - with grain: 2.8 x 10⁶ lbf/in² (19.3 GPa)
  - crossgrain: 3.1 x 10⁶ lbf/in² (21.4 GPa)
- **Tensile strength (ASTM D 638)**
  - with grain: 22,300 lbf/in² (153.8 MPa)
  - crossgrain: 20,300 lbf/in² (140 MPa)

15.11 Cab Seat Cushion

15.11.1 General

Cab seat cushion fill material shall be low-smoke flexible foam (see Section 6.4.1.2) constructed of inherently fire-retardant materials. The thickness shall be approved during design review. The material shall have a polymerized or vulcanized homogeneous (free from foreign material), cellular structure with a porous surface and open cells. The cells shall be interconnecting and uniform in size. Cellular material may be molded in one piece or may be assembled by laminating to achieve the required thickness. Laminated cushions shall be bonded together. Cushion material shall be properly cured to prevent any objectionable odor.

15.11.2 Physical Properties

Flexible foam shall meet the following physical property criteria when tested without upholstery material:

- **Tensile Strength** - 5.0 lbf/in² (34.5 kPa) minimum when tested to ASTM D 3574 Test E
- **Elongation** - 70 percent minimum when tested according to ASTM D 3574 Test E
- **Compression Set at 50 percent** - 15 percent maximum when tested according to ASTM D 1055
- **Flex Fatigue** - Thickness loss 5 percent maximum when tested according to ASTM D 1055
15.12 Cab Seat Upholstery Material

15.12.1 General

Fabric used for cab seat upholstery shall be made of woven, transportation grade fabrics of a 90 percent wool and 10 percent nylon blend with a minimum weight of 27 ounces per linear yard (0.84 kg/m), or approved equal.

15.12.2 Physical Properties

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>D-3776</td>
<td>Fabric Weight</td>
<td>16.5 oz./sq. Yd without back coating</td>
</tr>
<tr>
<td>D-3775</td>
<td>Fabric Count</td>
<td>Warp - (ends) 16 (picks) 23</td>
</tr>
<tr>
<td>D-5034</td>
<td>Breaking Strength and Elongation</td>
<td>Warp - 150 lbs. (672 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 200 lbs. (896 N)</td>
</tr>
<tr>
<td>D-2261</td>
<td>Tear Strength (Tongue)</td>
<td>Warp - 24 lbs. (107 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 24 lbs. (107 N)</td>
</tr>
<tr>
<td>D-1683</td>
<td>Seam Strength</td>
<td>Warp - 100 lbs. (444 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 100 lbs. (444 N)</td>
</tr>
<tr>
<td>D-3597</td>
<td>Color Fastness</td>
<td>Water - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solvent - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crocking - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light - Class 4 min</td>
</tr>
<tr>
<td>D-3884</td>
<td>Taber Abrasion Test*</td>
<td>700 cycles - no breaks</td>
</tr>
<tr>
<td>D-3597</td>
<td>Wyzenbeck Abrasion Test*</td>
<td>15,000 dbl. Rubs - no breaks</td>
</tr>
<tr>
<td>D-4966</td>
<td>Martindale Abrasion Test*</td>
<td>25,000 cycles - no breaks</td>
</tr>
</tbody>
</table>

*Only one of these test needs to be conducted
15.13 Fiberglass-reinforced Plastic

15.13.1 General

Fiberglass-reinforced plastic (FRP) shall be a laminated material, composed of a gel coated surface, fiberglass reinforcement, and a vinyl-ester or acrylic resin. FRP shall withstand, without any physical deformation or structural damage, the environmental conditions in Appendix A, and be resistant to acids, alkalies, and cleaning solutions recommended by the Contractor.

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 performed to confirm that the construction method chosen is adequate for its intended purpose and meets the strength requirements within Section 15.13.3. Finished gelcoated surfaces shall have a minimum gloss value of 85 when measured with a 60° glossometer and shall exhibit no print through of the reinforcements or have any appreciable orange peel.

FRP parts shall have a greater thickness at attachment points and edges. Exposed sharp edges will not be allowed on any parts.

15.13.2 Construction

15.13.2.1 Resin

The resin shall be of good commercial grade, thermosetting, vinyl-ester or acrylic material selected to meet the physical, flammability and smoke emissions properties of this Specification and molding process requirements.

15.13.2.2 Reinforcement

The fiberglass reinforcement shall be mat, fabric woven roving, continuous roving, chopped spun roving, or swirl mat as required to meet the physical properties of this Specification and the molding process requirements. The glass content shall be a minimum of 20 percent by weight.

15.13.2.3 Gel Coat

The gel coat shall be resistant to scuffing, fire, weather, water absorption and cleaning agents. The gel coat shall have a minimum thickness of 0.015 inches (0.38 mm). 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 Section 15.24. If the FRP panel does not receive paint, then the gel coat shall be pigmented to match the color scheme selected by the NYCT.

15.13.2.4 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 characteristics of Section 15.13.3, and the flammability requirements of Section 15.25. Antimony Trioxide shall not be used.
Mineral filler shall not exceed 28 percent of the finished weight for any preformed matched die molding process.

15.13.3 Strength Requirements

Independent laboratory test certificates shall be provided stating that the reinforced plastic material complies with the requirements of the following standards. Test specimens shall be conditioned in accordance with ASTM D 618.
### Minimum Requirements

<table>
<thead>
<tr>
<th>Mechanical Property</th>
<th>ASTM Test</th>
<th>Open Moldings</th>
<th>Matched Die Moldings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>D 638</td>
<td>10,000 psi</td>
<td>12,000 psi</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>D 695</td>
<td>18,000 psi</td>
<td>22,000 psi</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D 790</td>
<td>15,000 psi</td>
<td>22,000 psi</td>
</tr>
<tr>
<td>Impact Strength</td>
<td>D 256</td>
<td>6 ft-lb per inch of notch</td>
<td>8 ft-lb per inch of notch</td>
</tr>
<tr>
<td>Hardness</td>
<td>D 256</td>
<td>45 Barcol</td>
<td>45 Barcol</td>
</tr>
</tbody>
</table>

#### 15.14 Thermoplastic Sheet

##### 15.14.1 General

Thermoplastic sheet used in the construction of this vehicle shall not contain PVC vinyl and shall withstand, without any physical deformation or structural damage, the environmental conditions described in Appendix A, and shall be resistant to NYCT cleaning solutions. Thermoplastic sheet shall be used as extruded or vacuum-formed.

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 specified in Section 3.11. 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 approved prior to the production run of any parts.

##### 15.14.2 Quality

**MOD 02**

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 (0.25 mm), and the population of these defects is greater than one defect in four square feet (0.3716 m²).

##### 15.14.3 Strength Requirements

Independent laboratory test certificates shall be provided stating that the thermoplastic sheet complies with the requirements of the following standards. Extruded sheet in the surface finish specified shall be used for testing.
### Mechanical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>D 792</td>
<td>1.20 to 1.45</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D 638</td>
<td>5,500 lbf/in² (38 MPa) minimum</td>
</tr>
<tr>
<td>Elongation</td>
<td>D 638</td>
<td>50 percent</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D 790</td>
<td>8,000 lbf/in² (55 MPa) minimum</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>D 790</td>
<td>$3.3 \times 10^5$ lbf/in² (2.28 GPa)</td>
</tr>
<tr>
<td>Hardness Rockwell &quot;R&quot; Scale</td>
<td>D 785</td>
<td>90 to 110</td>
</tr>
<tr>
<td>Heat Shrinkage 15 minutes at 350°F (177°C)</td>
<td>------</td>
<td>10 percent maximum</td>
</tr>
<tr>
<td>Heat Deflection (annealed) @ 264 lbf/in² (1.82 MPa)</td>
<td>D 648</td>
<td>165°F (74°C) minimum</td>
</tr>
<tr>
<td>Impact Strength Fabricated Parts Gardener Dart Drop 0.5 inch (13 mm) dia. ball at 73°F (23°C)</td>
<td>D 3029</td>
<td>320 in-lb (36.16 N-m) minimum</td>
</tr>
<tr>
<td>-20°F (-28.9°C)</td>
<td></td>
<td>80 in-lb (9.04 N-m) minimum</td>
</tr>
</tbody>
</table>

### 15.15 Piping and Tubing

**15.15.1 General MOD 02**

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 must 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 specified by AAR Specification No. 2518, Standard S-400, or to an approved radius as used on existing Division A cars. Direction-change fittings are not permitted in the trailined 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 (3 mm).
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 car body 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 2 inches (50 mm) from the flexible elements. All pipe clamps shall be inherently rigid and shall be firmly attached to 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.

15.15.2 Air Piping, Tubing, and Fittings

The main reservoir pipe and brake pipe shall conform to ASTM A 53, Schedule 80 seamless pipe. Type "K" annealed copper tube per Federal Specification WW-T-799 latest revision may also be used, provided it is installed no lower than 2 inches (50 mm) 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. Where suitable protection in damage-prone areas is not possible or practical, approved steel piping sections shall be provided. The diameter of the main reservoir pipe and brake pipes shall meet the brake supplier's requirements; however, in no case shall these pipes be less than 7/8 inch (22 mm) O.D.

All air pipes shall be sized in accordance with the function intended and may be either ASTM A 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 must comply in all respects with the air brake supplier's design and installation requirements. Within 180 days of Contract Award and prior to manufacture of production cars, the Contractor shall provide the NYCT with a report containing written approval from the air brake supplier of the Contractor's air brake piping fabrication, installation, and design concept. The following information shall be contained in the report:

- All critical line sizes and materials including the main reservoir pipe, the emergency brake pipe, and the brake cylinder piping.
- The installation details of the above 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.
- Pipe processing details including welding, brazing, cleaning, and fabrication methods, as required by Section 15.23.
Locations of all major air brake control, relay, and emergency venting devices, and the proposed location and volume of all reservoirs.

An air consumption analysis justifying the proposed air storage system design.

Where ASTM A 53 piping is provided, its application shall also comply in all respects to AAR Specification No. 2518, Standard 400, latest revision. Approved copper tube shall also comply with any relevant requirements of AAR Specification No. 2518.

All air piping shall be installed in a manner to provide drainage away from devices, or branch pipes leading to devices, when the function of those devices could be impaired by the accumulation of water or ice.

All air hoses shall conform to the latest revision of the NYCT Specification 2086-PROD-96 and, except as that requires otherwise, shall also meet AAR Specification M-618 with AAR-approved reusable fittings meeting 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 Section 10.3.

Air piping on the trucks shall be ½ inch (13 mm) ASTM A 53 Schedule 80, or approved equal. Low spots (traps) are strictly prohibited on the trucks. 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.

15.15.3 Air Conditioning System Piping, Tubing, and Fittings

Air conditioning refrigerant lines and condensate drain lines shall be of seamless copper tubing, type "K", with wrought copper sweat type fittings. 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, but need not be type "K". Instead of elbows, tubing may be bent utilizing a bending tool designed specifically for bending of the tubing to be used.

Suction lines shall be designed and installed without traps. The suction line shall be sized for 3 psi (gauge) (21 kPa) maximum system pressure drop and the liquid line shall be sized adequately to prevent flashing due to pressure drop.

Lines subject to condensation shall be insulated with an approved insulation, 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, 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.

15.15.4 Brazing and Soldering of Piping, Tubing, and Fittings

All brazing and soldering shall comply with the applicable parts of Section 15.23, and the following requirements. All refrigerant piping and air system copper tubing shall be joined using silver solder conforming to Federal Specification QQ-B-654, Class 1 or 3. 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 written procedure prepared for each by the Contractor and approved by the NYCT.

15.16 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 document the test.

15.17 Wire and Cable

15.17.1 General

A 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, ICEA, ASTM, NEC, and MIL Specifications. 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.

All applications of shielded cable shall be approved.

The Contractor and each manufacturer of equipment through the Contractor shall submit samples (at least 12 inches [304.8 mm] long), specifications, and qualification test documentation of each size and type of wire and cable specified, for approval, before utilizing said wire and cable.

Three copies of notarized, certified test reports shall be furnished by the Contractor.
Only wire or cable shall be used for carrying electrical current. Exceptions are third rail shoes and other devices specifically designed to be electrical conductors. Where this Specification uses wire insulation trade names the use of an approved equal is acceptable.

15.17.2 Conductors

Conductors for wire AWG #12 and smaller shall be soft, annealed nickel-plated copper, constructed in accordance with MIL-W-22759/6B. Conductors for irradiated cross-linked polyolefin wire shall be soft, annealed tinned copper, in accordance with ASTM B33. Minimum stranding shall conform to AAR Standard S501, S502 (No. 589) or ASTM B-172 Class K or ICEA S-66-524, Table L-7, Class K for AWG #10 or larger, as appropriate for the application.

Stranding and conductor construction for wire sizes AWG No. 12 to AWG No. 16 shall be in accordance with ASTM B-174 Class K or ICEA S-66-524, Table L-8, Class M, as appropriate for the application.

Stranding and conductor construction for wire sizes AWG No. 18 and smaller shall be in accordance with ASTM B-174 Class L or ICEA S-19-81, Table L-8, Class M, or shall be 19 strand construction as appropriate for the wire size.

The use of solid wire is not permitted except for approved wire wrap applications.

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 the National Electric Code (NFPA 70) Table 310-16, 90°C column for wires in raceways or conduit, and 310-17 90°C column for wires in free air. Maximum wire ampacities for insulation rating of 110°C to 250°C shall conform to NEC (NFPA 70) Table 310-18 or 310-19, as appropriate for the application. 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 conductors are routed in a raceway or conduit, the ampacities shall be derated as detailed by Note 8 to Tables 310-16 through 310-19. 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 will be submitted for approval.

In no case shall wire smaller than the following sizes be used:

- Wire which is pulled through conduits or wireways - No. 14 AWG.
- Wire on electronic units, cards, and card racks - No. 28 AWG.
- Wire within control compartments - No. 18 AWG.
- Multi-conductor cables where current is not a factor in wire size selection - No. 18 AWG.
- All other wire, including that which is not pulled through wireways and conduits - No. 16 AWG.
The NYCT may approve smaller wire sizes for selected applications.

15.17.3 Insulation

15.17.3.1 General Wiring Insulation

Teflon, mineral filled, abrasion resistant insulation may be used on all sizes AWG #12 to AWG #28. Otherwise, all general car body wiring, the insulation shall be a flame retardant, flexible, irradiated cross-linked polyolefin material having a continuous temperature rating of 230°F (110°C). The insulation shall be rated at 2000 volts dc in the case of wires carrying a nominal voltage greater than 100 volts ac or dc, and rated at 600 volts dc in the case of wires carrying a nominal voltage of 100 volts or less, ac or dc. For wires carrying greater than 100 volts ac or dc, but less than 600 volts ac or dc, the Contractor may request a deviation to allow the use of wire rated at 600 volts, based upon the actual application. For wire sizes No. 6 AWG and larger, the insulation material shall be formulated for extra flexibility.

The irradiated cross-linked polyolefin wire insulation shall be constructed and tested in accordance with the requirements of NYCT Specification 3059-MATL-86 (TX, latest issue) and the following additional special requirements:

- **Flexibility Tests for Cables**
  
  Flexibility tests for cable sizes up to AWG#2/0 shall be performed in accordance with AAR Standard S501, paragraph 5.9.7.1, for the appropriate wire size.
  
  Flexibility tests for cable sizes AWG#2/0 and larger shall be performed in accordance with AAR Standard S501, paragraph 5.9.7.

- **Single Conductor Thermal Overload Test**
  
  A continuous current of 115 amperes shall be applied to an 18' length of 10 AWG test wire in 25°C still air. A 3000 volt dc potential shall be maintained between the test wire and an 18 AWG bare copper wire wrapped snugly around the outer insulation surface of the test wire. Failure shall be defined to 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.

- **Bundle Overload**
  
  A bundle overload using a seven-wire bundle shall be performed in accordance with AAR Standard S501, paragraph 5.9.1, and test results recorded.

- **Temperature Cycling Tests**
  
  This test shall be done on an 8 ft. length sample of AWG #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 about 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 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 125°C and -30°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 for other damage. After 250 cycles, the sample shall be immersed in water for 6 hours with both ends out, and then subjected to a dielectric test of 5 kvac for 5 minutes and also examined by microscope to verify that no cracks exist.

Flame-retardant, flexible, irradiated cross-linked polyolefin insulation rated at 125°C may be used, provided it meets all the above standards, modified to reflect the temperature rating related characteristics. The revised values, and the use of such wire, must be approved by the NYCT. Cross-linked polyolefin insulation is not permitted for use on wires connected to heater elements or any other high-temperature device.

All insulation other than irradiated cross-linked polyolefin shall meet the following test requirements based on MIL-W-22759 and using the following parameters:

- **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).**

- **Insulation Resistance - Test per ASTM D-470. Minimum accepted value shall be 1,000 megohms per 1,000 feet (304.8 m), using a 1,000 Vdc megohmmeter.**

- **Spark test - One hundred 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.**
**Impulse Test Voltage KV Peak** | **3 KHz Test Voltage KV RMS**
---|---
8 | 5.7
9.5 | 6.7
10 | 7.1

- **Air aging** - Test per ASTM D-638. Age sample for seven days at 302°F (150°C) in an 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 D-573 for extended life.

- **Cold Bend** - Test per NEMA WC3, except test temperature shall be -58°F (-50°C).

- **Weight Loss** - Weight loss of the insulation material shall not exceed one percent when subjected to an oven temperature of 266°F (130°C) for 500 hours.

- **Chemical Resistance** - An appropriate length of sample shall be measured for insulation diameter and total weight to record initial values. The wire shall be immersed to within 3 inches (76.2 mm) of each end in the test fluid for 24 hours at 149°F (65°C). During the immersion stage, the minimum bend radius of the wire shall be 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 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:
  - Humble No. 2214 Railroad Diesel Lubricating Oil and lubricants (100 percent solution);
  - Humble Diesel 260 or Railroad T fuel oil (100 percent solution);
  - Mineral oil (100 percent solution);
  - Hydrochloric acid, nitric acid, sodium hydroxide, sulfuric acid (0.1 percent solution);
  - Potassium hydroxide (0.1 percent solution);
  - Petroleum distillates and other graffiti removers and cleaning compounds listed in NYCT Cleaners and Related Material Qualified for Car Equipment Use within Appendix C (100 percent solution);
  - Kerosene solvents (100 percent solution);
  - Trisodium phosphate solution (50 percent solution);
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♦ Skydrol 500 B hydraulic fluid (100 percent solution); and
♦ Water.

Temperature Cycling Testing - The test shall be done on an 8-foot (2,438.4 mm) length sample of No. 12 AWG.

Thermocouples shall be attached to the outer jacket surface, and on the conductor under a small incision in the insulation about 12 inches (304.8 mm) from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

The sample shall be conditioned for 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 125°C and -30°C. The sample shall be subjected to a total of 250 cycles, with visual observation at the end of each cycle for cracks and for other damage. After 250 cycles, the sample shall be immersed in water for 6 hours with both ends out, and then subjected to a dielectric test of 5 kV ac for 5 minutes and also examined by microscope to verify that no cracks exist.

Single Conductor Thermal Overload Test - A continuous current of 115 amperes shall be applied to an 18-inch length of No. 12 AWG test wire in 25°C still air. A 1,000-volt dc potential shall be maintained between the test wire and a No. 18 AWG bare copper wire wrapped snugly around the outer insulating surface of the test wire. Failure shall be defined to occur when a short circuit is established between the copper wire and the test wire. Minimum time to failure shall be three minutes.

Seven-Wire Bundle Thermal Overload Test - A seven-wire cable bundle shall be formed by twisting six insulated No. 12 AWG conductors around a center insulated No. 12 AWG conductor.

A 120 ampere current shall be passed through the center conductor for seven minutes. After a test period the cable bundle shall be examined for visible damage to the outer six conductors. Failure shall be defined to occur if any of the outer conductors split, rupture or melt and adhere to the center conductor insulation.

Qualification and Production Tests - The tests required for this Specification concerning Qualification and Production shall be in accordance with tests required in MIL-W-22759 for all lots produced, as called for in this Specification.
All test reports covering Production and Qualification tests shall be furnished to NYCT with requested samples prior to any shipment of materials.

15.17.3.2 Wire Insulation for High Temperature Applications

High temperature insulation shall be used where connected to heat-generating apparatus, where the ambient temperature can exceed 125°C, or where Teflon is specified as a requirement. The insulation shall be rated at 1,000 volts dc in the case of wires carrying a nominal voltage greater than 100 volts ac or dc, and rated at 600 volts 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 150°C or above and be in accordance with the following requirements:

- For wire sizes No. 16 AWG 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 S503.

- For wire sizes No. 18 AWG and smaller: abrasion resistant Teflon (PTFE) meeting MIL-W-22759/6B or 10B, as appropriate. When used for interconnecting pieces 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 specifications for approval in a specific high temperature application, specifying the design ambient temperature, routing, RMS ampere value, worst-case ampere value, worst-case temperature rise, stranding, and insulation material specification.

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.

15.17.3.3 Wire Insulation Within Equipment

Insulation on wiring within replaceable modular units, electronic apparatus such as cards and card racks, and other equipment, as approved, shall be Tefzel (Ethylentetrafluoroethylene - ETFE) per ASTM D 3159 and insulation construction per Military Specification MIL-W-22759/16 (AS), irradiated cross-linked polyolefin per Section 15.17.3.1, or Teflon (Polytetrafluorethylene - PTFE) type EE per Military Specification MIL-W-16878/5.

15.17.3.4 Wire Insulation at Crowded Locations

Wire for connections to the control console, or in any other locations where there are equally crowded concentrations of low voltage control wiring, may be insulated with Tefzel (ETFE) per ASTM D 3159 and insulation construction per Military Specification MIL-W-22759/16 (AS), except the wall thickness shall be 0.025 inches (0.64 mm). When used for this application, these type wires shall be bundled with a protective covering of irradiated cross-linked modified polyolefin or similar, approved, high temperature rated, low smoke generating insulation.
15.17.4 Multi-Conductor Cables

15.17.4.1 General

Multi-conductor cables, where approved, shall be constructed using wiring as described in Sections 15.17.2 and 15.17.3. For high temperature applications, the cable shall conform to MIL-C-27072, with Type V connectors, Style 4 sheaths, Class D jackets, if needed, and shields, if needed. All conductors in multi-conductor cables shall be color coded or otherwise permanently identified as approved. Materials used in the construction of multi-conductor cables shall meet the requirements below. In applications where current is not a factor in wire size selection, such as LED indicator lights or status displays, No. 16 AWG may be used between repeater devices and displays. For multi-conductor cables carrying low-voltage, high-speed, serial data, exceptions to the wiring requirements may be submitted for approval, based upon availability of wire to meet the application requirements.

15.17.4.2 Fillers

Where required to obtain a circular cross-section, fillers shall be made of non-hygrosopic materials compatible with the wire insulation and jacket, and shall be of the same or of a higher temperature rating than the wire insulation.

15.17.4.3 Tape

A binder tape shall be employed over the assembly of conductors in multi-conductor cables if needed to assist in cable manufacture, or as required to permit the cable to function as intended in its application. The binder tape material shall be non-hygrosopic and shall be of the same (or better) temperature class as the wire insulation, and shall be of a compatible material.

15.17.4.4 Shield

The shield, if required, shall consist of either tin plated copper braid, concentrically served copper, or aluminum/polyester tape with a drain wire, as is appropriate for the application. Tape shields will be permitted for fixed installations only. The shields shall have the following minimum properties:

- Copper shield shall be made of either tinned, coated copper strands which conform to ASTM B 33, or silver-coated copper strands which conform to ASTM B 298, as is appropriate for the wire insulation. Shield coverage shall not be less than 85 percent. Shield strand size and application shall be as recommended by the cable manufacturer for the particular application, but shall not be smaller than AWG No. 38.

- Aluminum/polyester tape shields shall consist of a helical wrap of aluminum/polyester tape with a nominal thickness of 0.0004 inch (0.01 mm) aluminum on a backing of 0.001 inch (0.025 mm) polyester. The tape shall have a minimum overlap of 10 percent of the tape width to ensure complete coverage. In contact with the aluminum side of the shielding tape shall be a No. 22 AWG 7/30 tinned copper drain wire conforming to ASTM B 33 and B 174.
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15.17.4.5 Jackets

The overall jacket of multiconductor cables shall be of flame retardant, irradiated, cross-linked, modified polyolefin; Tefzel (ETFE); or Teflon (PTFE) to be fully compatible with the wire insulation and application as approved. The coupler cable shall have a jacket of low temperature arctic grade neoprene per MIL-C-13777, with a wall thickness suitable for 600 volts. The jacket shall be extruded and vulcanized over the cabled conductors, and shall be centered, with a smooth appearance without objectionable roughness or irregularities, consistent with good industry practice. The nominal jacket thickness for polyolefin, Teflon, Tefzel and Neoprene shall be that shown below, with the minimum wall not less than 80 percent nominal value.

### 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>

15.17.5 Wire Wrap

Wire wrap connections may be used in selected electronic applications, where approved. Where used, the following standards, as a minimum, shall be followed:

- Only soft or annealed oxygen-free solid copper conductor shall be used.
- Wire size shall be No. 28 AWG.
- A silver conductor coating, with a minimum coating thickness of 40 micro-inches (1 μm), shall be applied to the wire.
- Wire shall have "MIL-ENE" insulation, or approved equal manufactured to MIL-W-81822/1A. The insulation shall have a minimum 300 Vac/Vdc voltage rating and shall allow a 135°C maximum conductor temperature.
Wrapping shall be "modified" wrap, nominal 7-1/2 turns, including 1-1/2 turns for strain-relief.

15.17.6 Insulation Smoke Test

This test applies to all wire insulation in Section 15.17.3, except for irradiated cross-linked polyolefin. For testing of irradiated cross-linked polyolefin insulation refer to NYCT Specification 3059-MATL-86 (TX, latest revision).

15.17.6.1 Scope

This test method describes the equipment and the procedure for preparing insulated wire samples from which the specific optical density ($D_s$) of smoke generated can be determined in the Aminco-NBS Smoke Chamber. This method is used for wire sizes up to and including AWG #12. For wire sizes above AWG #12, the standard procedure outlined in ASTM E 662 shall be used. Equipment calibration, standardization, and operation are to be in accordance with ASTM E 662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.

15.17.6.2 Apparatus

- Aminco-NBS Smoke Chamber and Recorder.
- Aminco 6 tube, 90° burner assembly for flaming mode testing. Burners are all directed in one plane at the sample.
- Notchless wire frame (Aminco No. 20 AWG wire frame with notches machined off).
- Aminco troughless wire specimen holder assembly.
- Air oven.
- Humidification chamber.
- Heavy duty aluminum foil 0.001 ±0.0005 inch (0.0254 mm ± 0.0127 mm).
- Razor blade.
- Tape measure.

15.17.6.3 Procedure

- 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 (22,582 mm²).
Calculate the sample length as follows:

\[
\frac{35}{l = \frac{3.1416 \times d}{d}}
\]

Where:
- \( l \) = sample length
- \( d \) = diameter of insulated wire (inches)

Cut and identify a minimum of three samples of the required length.

Condition samples prior to testing by pre-drying in an air oven for 24 hours at 140°F ±5°F (60°C ±3°C) followed by humidification at 73°F ±5°F (23°C ±3°C), and a relative humidity of 50 percent ±5 percent, for a minimum of 24 hours.

After conditioning, wind a sample uniformly around the wire frame so that the frame opening is uniformly covered.

Cover the wire-wrapped frame with aluminum foil across the back, along the edges, and over the front surface's periphery with a single sheet of aluminum foil, with the dull side in contact with the wire.

Place the foil-wrapped wire in a troughless sample holder such that the wire is vertically oriented. Insert millboard backing, spring, and retaining clip.

Carefully trim the aluminum foil from the front opening of the sample holder.

Adjust wire turns, if necessary, to assure that the sample holder opening is uniformly covered.

Perform smoke testing in accordance with ASTM E 662, 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.

Report the sample orientation, test conditions, results, and observations made during the test.

15.18 Wiring

15.18.1 General

All car wiring shall be in conformance with 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, and except that all wire shall be as required in this Specification. Circuit protection shall be in conformance with Chapter 2 of NFPA 70, Article 240.
15.18.2 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 requirements of FAA Specification No. AC 43.13-1A, Section 449, "Stripping Insulation". Additionally, the following criteria applies:

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Maximum Number of Nicked Strands*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wires smaller than No. 10</td>
<td>None</td>
</tr>
<tr>
<td>No. 10 through 1/0</td>
<td>7.4 percent</td>
</tr>
<tr>
<td>Above 1/0 through 1600/24</td>
<td>4.4 percent</td>
</tr>
<tr>
<td>Above 1600/24</td>
<td>graduated scale</td>
</tr>
</tbody>
</table>

* Definitions:
  - A cutoff strand shall count as two nicked strands.
  - 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.

15.18.3 Wiring Layout and Installation

15.18.3.1 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 pre-fabricated into standard harnesses, wrapped or tied with spiral wrap or tie wraps. 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.
Alternative methods for fabricating and installing wiring, which are standard Contractor practice, will be considered for approval by the NYCT.

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 10 percent spares, but no fewer than two spares for each wire size.

15.18.3.2 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:

- CBTC circuits,
- High voltage circuits,
- ac circuits,
- Communication circuits,
- Battery voltage level circuits,
- Semiconductor gating voltage level circuits,
- 3rd Rail circuits, and
- Conductors carrying in excess of 100 amps.

Wires which are connected 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 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 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 a piece of 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.
Wire and Cable Runs

Wire runs shall be continuous and unbroken between connection points, shall be supported at no greater than 26 inches (660.4 mm) spacing, and 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 inch (25.4 mm) above the bottom of equipment enclosures.

All undercar wiring smaller than No. 6 AWG shall be run in closed wire ducts, conduits, or open wire mesh wireways in an approved manner. Wire and cable shall be secured within ducts or open wireways, including each entrance and exit point, to prevent chafing movement. Wire ducts and conduits shall be of waterproof construction. Permanently retained watertight strain relief bushings, with insulated throat liners, of an approved design, shall be used at locations where wires, cables or harnesses enter or exit conduit, ducts, apparatus and equipment enclosures. In addition, strain relief bushings on equipment enclosures shall include a permanently retained O-ring type seal.

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 car body 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.

Any wiring run through the floor shall be run in ducts or conduit. Wiring, even if enclosed in loom, must not be run through partitions without suitable bushings being provided 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.

Harness exposed, short cable runs or harness entering or leaving exposed raceways shall have approved, fire-resistant flexible dielectric sleeving over the raceway edges and grommet-type insulation of any penetration holes. Wiring shall be retained to the sleeving with tie-wraps.
15.18.3.3.1 Cable Cleating and Support

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All cable and wiring exiting wireways/wire ducts, or that which is not installed in conduit, shall be cleated using split-block cleats of molded neoprene rubber. Cables shall be cleated and bushed when passing through bulkheads and structural members. The cushioning material shall be non-conductive, fire retardant insulating material with a durometer of 50 to 60 meeting the requirements of Section 15.7. Each cleat shall have a
stiffener of at least 10 gage material 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. The Contractor shall minimize the quantity of different configuration cable cleats.

No. 6 AWG or larger insulated wire may be cleated in place without conduit, duct or open wireway. However, in the areas over the truck, in the wheel wash and not protected by underfloor-mounted equipment, the wire shall be mechanically protected by an open mesh, expanded metal or other type of approved guard. The guard may be attached to the bottom of each cleat with the cleat clamping bolts or other approved arrangement.

Cleats shall be designed to grip each cable individually and firmly, but without causing any damage to cable insulation, including cold flow of the insulation. Each cable in the cleat shall have its own cutout sized to the correct wire diameter. Cleated cables shall be routed and supported such that they cannot, under any combination of forces and car movement, touch each other or any other part of the car, except the cleat cushioning material.

Wire and cable runs shall be continuous and unbroken between terminations and shall be supported at not greater than 24-inch (610mm) intervals in ducts, open wireways or when cleated. The wire shall be protected at each support point against mechanical crushing and abrasion.

Wire splices will not be permitted, except with express written approval and in accordance with the wire splicing requirements of Section 15.19.9.

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 a potential chafing hazard.

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 any 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.

15.18.3.3.2 Wire Securement and Termination

All wiring shall be secured and protected against movement, chafing, and any contact with conductive, sharp, or abrasive objects including the inside surfaces of wire runs.

All wiring shall be located and secured such that normal equipment motions, 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 Section 15.19.2. 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 under any circumstances.

Wire and cable dress shall allow for sufficient slack at equipment terminals to provide for movements 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 and without splicing the wire, as follows:

- No. 10 AWG and smaller - Three reterminations
- No. 8 AWG and larger - Two reterminations

A drip loop shall be provided on all exposed wires and cables to prevent fluid runoff into connected equipment.

Wire tying devices shall be of such material and construction that they will adequately retain the wires for the life of the wiring and shall be resistant to ozone and ultraviolet light. Wire and cable ties shall be trimmed and located to eliminate any hazard to personnel from sharp edges. Wire tying devices shall be snug, but shall not be so tight as to cause indentation and cold flow damage to the insulation. Wire tying devices shall be mechanically fastened to a permanent structure. Adhesive-installed mounting bases shall not be used for ties or for cable support.

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 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 1 inch above the bottom of the box unless otherwise approved by NYCT. 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 will 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 a part of the permanent car wiring to enable the NYCT to conveniently maintain the equipment. This wiring shall terminate in approved connectors in the respective controls groups and cabinets.
The NYCT desires to have wiring and cabling 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, the Contractor shall submit a complete wiring plan for approval.

Wire and cables that are subject to high currents in fault conditions or normal operation must be secured against secondary damage due to the high magnetic forces that are developed. Propulsion inverter circuits are a typical example. This includes damage to bus bars or devices to which the cables terminate.

15.18.3.4 Circuit Shielding

Wire shields used in trainline circuits shall be continuous up to the car’s electrical coupler contacts. The wire shields shall be connected through all applicable connectors and junction boxes. Circuits shall be categorized. 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.

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 following three items shall be considered as guidelines and are not absolute requirements:

- 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.

- 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.

- 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.

15.18.4 Insulation Resistance

Refer to Section 17 for insulation resistance requirements.
WORKMANSHIP, PROCESSES AND MATERIALS

15.18.5 Marking and Designation

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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. 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. Each circuit shall be individually designated from point to point. Common designations for return circuits are not permitted.

Each wire and cable shall have printed on the outer surface, the manufacturer's identification, conductor size, temperature rating, and voltage rating. For wire size 1/0 and larger, stranding shall be given in addition to the other parameters.

Except for spares, TFE Teflon insulated wires and wires entirely within an equipment enclosure, each wire #8 AWG and smaller shall be permanently and legibly marked along its entire length. Wires larger than #8 AWG and TFE Teflon insulated wires may have wire markers applied at each end of the wire. Blank spaces between markings shall measure approximately 1.5 inches. Spare wires and wiring entirely within an equipment enclosure may have a single wire marker at each end, subject to approval by NYCT in lieu of continuous marking. Wires shall be marked with their alpha-numeric circuit designation. A circuit designation shall change only when it goes through an active or passive component such as a relay coil or relay contact, fuse or circuit breakers, lamp, motor or resistor. A circuit designation shall remain unchanged when it goes through a terminal strip or junction box stud regardless of how many wires of that circuit are common to that point. There shall be no duplication of wire codes in unrelated circuits throughout the car. Where there are more than one of a particular assembly per car, each assembly shall be wired identically to the other(s) and wire marking of harnesses shall be identical in each assembly.

For premanufactured multiconductor cables and for cases where individual circuit identification markers may be approved the following requirements apply:

- All wires and terminals shall be clearly identified. Wires attached to terminal studs shall also have a marker indicating the terminal stud to which it is attached.

- Identification of wires and terminals shall be by white or yellow permanent markers, with black printing or by continuous wire marking printed on the wire. All wires shall be marked every 6 inches (152 mm) within 12 inches (305 mm) of the end of the wire, every 12 inches (305 mm) within 10 feet (3.05 m) of the end of the wire, and every 24 inches (610 mm) over the remainder of the wire. Wire markers shall be stamped in two places, approximately 180 degrees apart, to facilitate readability of the marking. Wires in multiple-conductor cables shall be color-coded.

- Wire markers shall meet the adherence and solvent resistance requirements as specified by MIL-M-81531 Sections 3.4.2 and 3.4.3, latest revision, and shall withstand all combinations of ambient and equipment temperatures. Hand printing is prohibited.
For cable identification, the contractor shall use a basic identification system in conformance with ANSI/IEEE 200 and shall submit the system selected for review by the NYCT.
15.18.6 Pulling Compound

Pulling compound shall be non-conductive, non-hygroscopic, non-odorous, shall not support bacterial activity, and shall not attract vermin.

15.18.7 Solder

Solder shall be in accordance with ASTM B 32, Grade 60B. A flux of non-corrosive type shall be applied immediately before soldering.

15.18.8 Tape

Electrical tape shall be in accordance with AAR Standard S-540 of Section F of the AAR Manual Standards and Recommended Practices, or equivalent approved railway practice. Electrical tape shall meet or exceed the voltage rating of wire where the tape is applied.

15.19 Wire and Cable Connections

15.19.1 General

All equipment enclosures and junction boxes, except primary power circuits, shall be fitted with terminal boards or connectors. Primary power circuits shall be fitted with compression terminals and knuckle joint connectors as described herein.

The Contractor shall submit the proposed design and product line for all connections for approval. Terminal boards with M4 or Number 6 or smaller screws and quick-disconnect terminals, other than those stated herein, will only be permitted with approval.

15.19.2 Terminal Boards & Terminal Points

All electrical 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. 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 10 percent spares, but not fewer than one spare unless 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.
Wires connected to terminal boards shall have the terminal point location printed on the wire.

A maximum of two terminals shall be connected to any one binding screw. A maximum of four terminals shall be connected to any one threaded stud, provided that there is no interference between terminal barrels. On terminal boards, the wiring shall be arranged so that no more than two terminals are connected to a stud, from each side of the terminal boards.

15.19.3 Wire Terminations

Terminals and connections used throughout the car shall be the mechanical, solderless, crimp type made by AMP Incorporated or other approved manufacturer with a comprehensive line of terminals, connector pins, and application tools available. All terminals for the same wire size shall be crimped with the same model tool. The Contractor shall minimize the total number of crimping tool types needed for all crimp connections. Terminals fitting wire sizes AWG 10-22 shall require no more than three tool models to provide certified crimp connections. The Contractor shall submit the proposed product line for approval. Terminals to be approved shall be tested to Military Specification MIL-T-16366F for temperature rise, voltage drop, vibration, current overload, and corrosion. Test results shall be submitted for approval on a by part number basis.

Terminals and connections shall be attached to the wiring with proper crimping tools and dies as recommended by the manufacturer. The terminals used on conductors of size AWG 10 (5.3 mm²) or smaller shall be of the type which securely grips and holds the insulation of the conductor, unless approved. Terminals shall be ring lugs in accordance with Military Standard MS-25036; spade and hook-type terminals shall not be used. Corrosive protection shall be provided for all base materials.

Conductors subject to motion relative to the terminal shall be protected by suitable means to prevent breakage of the conductor at or near the terminal. Sufficient slack shall be provided in all wires and cables to prevent breaking or pulling out of bushings and terminals. A maximum of one wire shall be crimped in any one terminal.

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 double ring terminations which shall be screwed to an insulating fanning strip which shall serve to keep the terminations in the correct relative locations while removed from the device, unless otherwise approved by the NYCT.

15.19.4 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 terminal changes. 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.
15.19.5 Motor Lead Terminals

Traction motor terminals shall be of the glad-hand type or the two bolt type, with crimped or soldered tube type lug. The termination shall be covered by an approved insulated sleeve, such as Clark Equipment Co. Part No. M105. The sleeve shall be clamped with stainless steel worm screw-tightened hose clamps. A neoprene bushing shall be used between the cable and sleeve, if required, to make a good fit for a watertight seal between the sleeve and cable at the clamp.

15.19.6 Cable Connectors

All cable connector applications shall be approved.

All cable connectors shall conform to MIL-C-5015, or an equivalent standard as approved. They 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 (0.76 \( \mu \text{m} \)) of gold over a minimum of 0.000050 inch (1.3 \( \mu \text{m} \)) of low stress nickel. For high current applications, the connector contact area shall be plated with a minimum of 0.00010 inch (2.54 \( \mu \text{m} \)) of silver. Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections. One piece of all cable connectors shall be rigidly mounted.

All cable connectors used in exterior locations shall be of the environmental watertight variety. Cable connectors shall be equipped with sealing gaskets on the front mating surface and on the back where the cable enters. Bolts within the connector shall be long enough to ensure that there is sufficient room to terminate the cable wires within the connector body. The cable jacket shall be held by a clamp within the connector body. Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.

Plastic bodied connectors shall not be used in exterior locations. One-quarter (1/4) turn, bayonet-lock, quick-disconnect type connectors shall not be used on trainline jumper cables.

Except as provided above all cable connectors in exterior locations, shall be 1/4-turn, bayonet-lock, quick disconnect type CIR connectors as made by Litton-Veam SPA, or approved equal. One-quarter (1/4) turn, bayonet-lock connectors shall conform to all provisions in MIL-C-5015, or an approved standard, except for the screw coupling requirement.

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. The Contractor shall conduct an approved vibration test on these unitized assemblies.

In waterproof interior locations, the use of non-weatherproof connectors will be allowed as approved. All other connector requirements specified in this section which do not directly apply to weatherproofing shall be met.
15.19.7 Quick-Disconnect Terminals

Approved quick-disconnect terminals shall 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 will be permitted unless specifically approved by the NYCT.

15.19.8 Grounding Return Connections

15.19.8.1 Grounding MOD 02

Grounding connections to the car body and equipment shall be made through copper pads of an adequate area, silver soldered or brazed. Transition (base) plates if used, shall be made from the same alloy group as the respective car body and piece of equipment. The base plate shall be welded to the car body or equipment. Grounding connections shall not be made to aluminum alloy members. 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. An anti-corrosive grease shall be applied over the connection.

All equipment enclosures and shock-mounted equipment shall be grounded with flexible, grounding leads bolted between a car body grounding pad and the equipment's grounding pad. Braided strap-type leads shall be used where there is relative motion between the two items being connected. The ground strap termination method shall apply uniform pressure to the conductive surface and the current density shall not exceed the bonding requirements of Section 15.19.8.2.

The Contractor shall submit, for approval, a complete grounding scheme, which shall indicate the means by which it is proposed to prevent currents from passing through journal, motor, and truck-center bearings. Refer to other sections of this Specification for ground brush and related requirements. Low voltage and high voltage circuits shall not be grounded to the same ground.

15.19.8.2 Bonding

All grounding and bonding jumpers and straps 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 and bonding jumpers, and brazed shunt straps shall be "extra-flexible".
15.19.9 Wire Splicing

Splicing of conductors shall be avoided and shall be permitted only with approval on a case-by-case basis. Splicing of conductors in conduit will not be permitted. In the event a splice is approved, it shall be in a junction box and the spliced joint shall be mechanically as strong and have the same conductivity as any other part of the conductor. The splice shall be an insulated permanent crimp splice in accordance with Military Specification MIL-T-7928G, Type II, Class I, and shall be installed with the crimping tool and die of the splice manufacturer. All splices shall be 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.

15.20 Conduit

15.20.1 Types

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All conduit and conduit couplings shall be of an ANSI-approved type. All conduit shall be standard weight, galvanized steel with threaded fittings. All conduit ends shall be deburred inside and out to remove sharp edges and all pieces shall be blown out with compressed air and cleaned before installation to remove filings and other foreign material.

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 Standard C-80.1. The threads per inch and length of threading shall conform to ANSI Standard B-2.1 on Pipe Threads.

Steel fittings shall be used to assemble steel conduit. Elbows, nipples, and couplings shall be made of the same grade of steel as that employed in the conduit. All fittings shall be treated, coated, and threaded according to the requirements for zinc-coated, rigid steel conduit and shall conform to UL 6.

Flexible conduit, if used, shall be watertight and interlocking steel strip-protected, with an approved rust resistive coating. Flexible covering on conduit shall not contain polurethane or PVC vinyl.

Liquidtight flexible nonmetallic conduit, if required for special applications, may be used with NYCT’s approval. Liquidtight flexible nonmetallic conduit shall not be used where subject to physical damage or in lengths longer than 6 feet.

Conduit shall be color coded: red for those carrying circuits above 100 volts and yellow for under 100 volts.

15.20.2 Size and Fill

Conduit shall be sized such that the sum of the cross-sectional areas of the conductors and their insulation does not exceed 40 percent of the cross-sectional area of the conduit for three or more conductors. For two conductors, a limit of 31 percent shall be used, while for a single conductor, a limit of 53 percent will be permitted. Where conduit having a length not exceeding 24 inches (610 mm) without bends of more than 15 degrees are used between enclosures, a maximum fill of 60 percent will be permitted.

15.20.3 Installation

A run of conduit between junction boxes and/or pulling outlets shall not contain more than the equivalent of four quarter bends, 360 degrees total, including the outlet fittings. Bend radii at the inner surface of the bend shall be no less than eight times the nominal inside diameter of the conduit.
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 conduit 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 the end. The conduit arrangement and installation shall be subject to approval.

15.21 Conduit Fittings and Junction Boxes

15.21.1 General

The conduit fittings and junction boxes for car wiring shall be as manufactured by the Contractor or by a supplier of a comprehensive line of parts. The Contractor shall submit the proposed product line for approval. All conduit fittings and junction boxes shall be provided with gasketed covers as described in Section 15.21.4. All conduits and their connections to electrical equipment, shall be installed to make a continuous ground.

15.21.2 Boxes

All exterior junction boxes shall be fabricated of 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 Section 15.24.4.

15.21.3 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. All conduit entries into removable equipment boxes shall be secured by means of a bolt-on watertight access panel.

15.21.4 Covers

All junction box covers shall be 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. All covers shall be designed to accept or mate with a bulb-type clamp-on seal.
15.22 Wireways

All wireways shall be of rigid, stainless steel construction. Wireways shall be color-coded; red for those carrying circuits above 100 volts and yellow for under 100 volts. The trays shall be adequately supported throughout their entire length in an approved manner. The trays shall be completely de-burred, leaving absolutely no sharp edges, before installation on the vehicles. Grommet clamps shall be provided at all locations where cables or wires enter or leave the wireways. Under no circumstances shall leads be draped over the edge of the wireways, with or without wireway edge protection. Heads of screws or bolts inside the raceways shall be flush with the metal surface. Metal wireways, elbows, couplings and similar fittings shall
be flush with the metal surface. Points of screws or fasteners shall not be directed toward the interior of wire ways.

The wireways shall be routed such that they avoid:

- Sources of heat such as propulsion and dynamic brake grid resistors;
- Wheel splash areas; and
- Areas along the vehicle where the trays may be subject to foreign object damage.

Wireways shall be located to provide access to the harnesses contained within for maintenance action. They shall be provided with approved covers which may be interrupted wherever desired for entry and exit of wires and cables. Edges of such interruptions shall be completely covered with protective bushings.

Wireways shall be designed to prohibit the collection of dirt and debris, and shall be perforated, without compromising their requisite strength, to permit ventilation and drainage. They shall preclude water entrapment.

Metal raceways and the elbows, couplings, and similar fittings shall be electrically and mechanically coupled while protecting wires from abrasion and shall make a continuous ground with the car structure.

Bends in wireways shall be avoided; however, if they are required, approved protection shall be provided to avoid insulation chafing at the bends.

Wireways will be permitted in approved exterior and ceiling locations only. They will not be permitted in the car body sidewall area. Only conduit will be permitted in the car body.

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.

All wire and cable shall be securely fastened within wireways to eliminate movement and resultant chafing.

15.23 Welding and Brazing

15.23.1 General

The Contractor shall be responsible for the quality of its own welding and brazing and that done by its suppliers and subcontractors. Cleaning prior to welding shall be in accordance with applicable parts of Section 2, MIL-HDBK-132, "Protective Finishes".
15.23.2 Structural


Structural welding of ferritic and austenitic stainless steel shall be governed by ASME Section IX and ASME Section VIII, Part UHA. AISI 201L and 301LN stainless steels shall be treated as P-No. 8, Group-No. 3 category for reference to ASME requirements. Ferrite number for welds shall be between WRC4 and WRC10, or as proposed by the Contractor and approved by the NYCT. 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, Chapter 9, 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.

15.23.3 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 A 488/488M, or other approved qualifying procedures. Records of welder qualification tests shall be made available for review.

15.23.4 Inspection

The Contractor shall visually inspect all structural welds in accordance with AWS D1.1 requirements. A record of all NDT inspections shall be included in the car history book.

In addition to visual inspection specified for all welds, nondestructive 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 nondestructive inspection rate for all subsequent welds.

Test truck: The non-destructive surface inspection (dye penetrant or magnetic particle) shall be completed on all critical welds and the results submitted for review and analysis.

Additionally, all non-critical external welds of the test truck shall be examined by magnetic particle inspection and the results submitted for review and analysis.

On the first structure, all full penetration welds shall be nondestructively, 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. The minimum acceptable inspection plan shall require inspection of one portion of a full penetration weld for every 200 production welds made. The proposed test welds shall be selected from among welds that are most critically loaded as decided by calculations or load test results. 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 nondestructively 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. The minimum acceptable sampling plan shall require inspection of one ring weld sample for every 300 production ring welds made.

15.23.5 Post-Weld Cleaning Requirements

All welds exposed to passengers or on sliding contact surfaces of truck frames and bolsters shall be completely cleaned of all spatter.

15.23.6 Contractor Documentation

All welding procedures and documents, including Welding Procedure Specifications (WPS), Procedure Qualification Records (PQR), and Resistance Spot Welding Schedules (RSW), shall be submitted for approval before application. Specifications for purchase of welding electrodes, welding wires, and cover gases shall be submitted for approval before their application.

15.23.7 Special Welding

Procedures 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.

15.23.8 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. Contractor-proposed deviations from MIL-W-6858, including, but not limited to, weld nugget diameter, tension shear strength, and minimum spacing, shall be submitted and approved before application on production hardware.

Design strengths higher than standard certification and production strength requirements shall be qualified according to MIL-W-6858, Figure 11b for one thickness. This requires 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 macrosections. Twenty 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.

Surface indentation shall not exceed 20 percent of material thickness (t) or 0.01 inch (0.25 mm), whichever is greater. However, for exterior resistance-welded areas exposed to passenger view, indentation shall not exceed 10 percent of t or 0.005 inch (0.12 mm), 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 indicated, such as by a change in any of the following:

- Operator;
- Material, material thickness, or combination of thicknesses;
- Electrodes; or
- Settings.

15.23.9 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 inches plus twice the weld nugget diameter for any structural application, including car body side sheets. Intermittent fusion-weld spacing pitch shall not exceed five inches for 2-inch (50.8 mm) (minimum) weld lengths (40 percent minimum of length welded), unless otherwise approved.

15.23.10 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 (20.34 N m) of absorbed energy at the lowest specified operating temperature. The NYCT shall have the right to require impact tests to verify the specified toughness.

15.23.11 Torch Brazing

All brazing, defined as heating above 840°F (450°C), shall follow the recommendations contained in the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who do brazing work shall be qualified in accordance with AWS B2.2, Standard for Brazing Procedure and Performance Qualification.

15.23.12 Torch Soldering

All structural (not electrical) soldering, defined as heating below 840°F (450°C), shall follow the recommendations contained in the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who do 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.
15.24 Paints And Coatings

15.24.1 General

The portion of the car body, or any of its components, receiving paint shall be painted as required by the Specification and in accordance with the specified color scheme. Paints and coatings shall meet the requirements of NYCTA/MaBSTOA CCSS-002, entitled Paints and Coatings, within Appendix C. Any austenitic stainless steel portions of the car body shall not be painted, unless otherwise specified by the NYCT 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 to ensure adhesion.

All painting to be applied on the car body or any component is to be conducted in accordance with the paint manufacturer’s recommendations. The Contractor and its paint supplier shall supply 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 roller or by brush, will continue to be available in the United States.

15.24.2 Materials and Preparation

Preparation of the painted surface and application of painting materials for brushing or spraying shall be in accordance with the paint supplier's recommendations. 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 done by experienced labor, using proper equipment under competent supervision.

All painting materials for all surfaces shall be a two-part, high solids, low VOC, 2-part Desmodore polyurethane paint system. 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 car body not constructed of austenitic stainless steel shall, after fabricating, be prepared for painting by grit blasting, washing with an alkaline solution, properly rinsed, and then painted with a coat of wash (etch) primer. After application of the wash primer, all metal portions of the car, except the outside skin, which will receive the polyurethane paint system, shall be 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 match DuPont charcoal gray, Color #6334.

15.24.3 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 done in a clean, dry atmosphere at an ambient temperature as recommended by the paint manufacturer.
Before painting any car surface that is exposed to view, all dents, gashes, nicks, roughness, or other surface imperfections or depressions shall be removed so far as possible by straightening and shall be properly prepared to receive the 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 (3 mm).

15.24.4 Apparatus and Underfloor Equipment

All underfloor 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.

Traction motors shall be painted black and gear boxes shall be painted gray.

The exterior surfaces of undercar equipment enclosures and apparatus, other than propulsion, auxiliary power, and high voltage equipment, made from carbon steel shall be prepared, primed, and painted as specified in Sections 15.24.2 and 15.24.3. The interior and exterior surface of all propulsion, auxiliary power, and high voltage 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.

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. An exterior finish of polyurethane to match, DuPont charcoal gray, Color #6334, shall be provided for equipment control groups.

15.24.5 Painting Restrictions

Any equipment or parts of equipment which would be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant.

The following items shall not be painted:

- Copper tubing, piping, and fittings,
- Wire and cable,
- Power resistors,
- Heat transfer surfaces,
- Electrical insulators,
- Elastomeric portions of air and refrigerant lines, and
- Grounding pads.

The following truck-related items shall not be painted:

- Wheels,
- Axles,
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- Elastomeric parts,
- Grease fittings,
- Linkages,
- Threaded parts used for adjustments,
- Electrical equipment, and
- Wearing surfaces.

15.24.6 Interior Painting

All exposed interior surfaces, including molding and trim, shall be as specified in Section 3.11, or powder-coated 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.

The Contractor and its powder supplier shall supply 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.

15.24.7 Corrosion Protection

Concealed surfaces capable of rusting or oxidation shall be properly cleaned, receive a wash primer, then primed with an epoxy paint, and painted with an approved finish coat of paint. Where arc welding is performed on joints between stainless steel and other materials, the joint shall be de-scaled, cleaned, receive a wash primer coating, then painted in accordance with Section 15.24.3.

15.24.8 Acoustical Insulation

Acoustical insulating materials shall be applied to properly cleaned underframe, sides, ends, roof and floor sheets, as required in Section 3.7.3 to the supplier's recommendations. 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 No. 368 sound deadening compound, Aquaplas No. DL-10, or approved equal.

15.24.9 Paint Process Documentation

The Contractor shall prepare a paint coating and application document containing procedures for surface cleaning and preparation, priming, surfacing, and painting for the car body and all equipment that is painted or powder coated. A detailed paint schedule showing the equipment painted, paint type and manufacturers, recommended thickness, and other pertinent information 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.
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15.24.10 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 by blowing off 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 (a type which will not conceal cracks that may develop in service) and air-dried.

15.25 Flammability and Smoke Emission Requirements

15.25.1 General

All combustible material used in the construction of the car shall satisfy the flammability and smoke emission requirements cited in this Section.

NYCT approved, independent laboratory test results indicating successful compliance with these requirements are required for all materials. Testing must be conducted within the Contract duration period, and preferably on a production batch of material. Each laboratory must have tested a standard test sample no greater than 30 days prior to performing the tests which will be submitted to NYCT. The Contractor shall be responsible for complete conformance with these standards for itself and its subcontractors and suppliers. The NYCT may, at its discretion, require that the current batch of material being provided for this contract be retested for conformance with these standards.

As a minimum, all materials used in the construction of the car shall meet the requirements of this Section and the Urban Mass Transportation Administration's "Recommended Fire Safety Practices for Rail Transit Materials Selection - January 1989" as it appeared in the Federal Register, Volume 54, No. 10 of January 17, 1989, pages 1837 through 1840 inclusive, subject to the conditions cited in Section 15.25.3, and NFPA 130, latest version. In case of conflict, the most restrictive requirement shall prevail.

A matrix showing the total weight of all materials, where used, flammability and smoke emission test identity, test facility, test requirements, test results, and nature and quantity of the products of combustion shall be submitted by the Contractor during detailed design review.

Should the Contractor feel that the quantity of a particular material is such that it would not contribute significantly to a fire, the Contractor may request a waiver from testing for this material. The waiver shall be submitted in writing and shall include the total weight of the material to be used, the location and the distribution of the material in the car, and any previous test reports available. Waivers shall be accompanied by proper justification and will be reviewed on a case-by-case basis.

15.25.2 Combustible Content

The design of the vehicle shall minimize the total combustible material content of the vehicle. Each combustible material shall be specifically identified by supplier's name and type, use in the vehicle, total weight, and heating value in Btu/lb (Joules/kg) and Btu/hour (Joules/hour).
15.25.3  Flammability and Smoke Emission

Materials used in passenger vehicles shall be tested to demonstrate compliance with the requirements set forth in Section 15.25.1.

### REQUIREMENTS FOR PASSENGER VEHICLE MATERIAL FIRE RISK ASSESSMENT

<table>
<thead>
<tr>
<th>Function of Material</th>
<th>Test Procedures</th>
<th>Performance Criteria</th>
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<tbody>
<tr>
<td>Seat Cushion</td>
<td>ASTM D 3675</td>
<td>( I_s \leq 25 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (1.5) \leq 100 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 175 )</td>
</tr>
<tr>
<td>Seat Frame and Shroud; Wall, Ceiling, Partition, and Windscreen Panels; Exterior Non-metallic Shrouding and Equipment Box Covers; Battery Cases</td>
<td>ASTM E 162</td>
<td>( I_s \leq 35 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (1.5) \leq 100 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 200 )</td>
</tr>
<tr>
<td>Upholstery</td>
<td>FAR 25.853 (vertical)</td>
<td>Flame Time ( \leq 10 ) sec.</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>Burn Length ( \leq 6 ) in. (152 mm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( D_s (4.0) \leq 125 ) (cloth)</td>
</tr>
<tr>
<td>HVAC Ducting</td>
<td>ASTM E 162</td>
<td>( I_s \leq 25 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 100 )</td>
</tr>
<tr>
<td>Light Diffusers and Non-glass Window Glazing</td>
<td>ASTM E 162</td>
<td>( I_s \leq 100 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (1.5) \leq 100 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 200 )</td>
</tr>
<tr>
<td>Floor Assembly - Structural (See Section 15.25.4)</td>
<td>ASTM E 119</td>
<td>Pass (with a minimum 30-min. endurance period at AW3 loading)</td>
</tr>
<tr>
<td>Flooring (Covering)</td>
<td>ASTM E 648</td>
<td>CRF ( \geq 0.5 ) W/cm²</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (1.5) \leq 100 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 200 )</td>
</tr>
<tr>
<td>Thermal and Acoustical Insulation</td>
<td>ASTM E 162</td>
<td>( I_s \leq 25 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 100 )</td>
</tr>
<tr>
<td>Elastomers</td>
<td>ASTM C 542</td>
<td>Pass</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (1.5) \leq 100 )</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>( D_s (4.0) \leq 200 )</td>
</tr>
</tbody>
</table>
## REQUIREMENTS FOR PASSENGER VEHICLE MATERIAL FIRE RISK ASSESSMENT

<table>
<thead>
<tr>
<th>Function of Material</th>
<th>Test Procedures</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire Insulation</td>
<td>Flammability</td>
<td>Per Section 15.17.3.1</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>$D_s(4.0) \leq 200$ (flaming)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$D_s(4.0) \leq 75$ (non-flaming)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When tested in accordance with Section 15.17.6.</td>
</tr>
</tbody>
</table>

### NOTES:

- Materials tested for surface flammability shall not exhibit any flaming running or flaming dripping, except light diffusers.

- The surface flammability and smoke emission characteristics of woven or coated fabrics shall be demonstrated to be permanent in accordance with one of the following methods:
  - Washing, if appropriate, according to FED-STD-191A Textile Test Method 5830.
  - Dry cleaning, if appropriate, to ASTM D 2724.
  - Materials that cannot be washed or dry cleaned shall be so labeled and shall meet the applicable performance criteria after being cleaned as recommended by the manufacturer.

- ASTM E 662 test limits must comply with Specification limits in both modes.

- Seat cushion material that is to be tested for surface flammability and smoke emissions shall be first preconditioned in accordance with the procedures in ASTM D 3574, Test I2, Dynamic Fatigue Test by Roller Shear at Constant Force, Procedure B. After conducting the roller shear test, the same test sample shall be tested for flammability and smoke emission. Test reports for the roller shear test shall be forwarded for review with the flammability and smoke emission test reports.

The following information shall be supplied for all materials tested:

- Test Description,
- Test Facility, and
- Test Results.
15.25.4 Floor Assembly Fire Resistance Testing Criteria

The Contractor shall test the floor assembly in accordance with ASTM E 119 to demonstrate a 30-minute endurance rating. The test procedure, test facility, and test results shall be approved by the NYCT prior to the Contractor's procurement of any flooring material necessary for vehicle production.

The following test criteria shall be met:

- The test specimen shall be a full width vehicle section including side sills or that portion of the wall which extends below the floor. Specimen shall have a minimum exposed area of 96.8 square feet (9m²). 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 9 feet 10 inches (3m). No fewer than 2 typical penetrations, 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 specimen shall include typical floor splice configurations.

- Test specimen shall be loaded to simulate "crush" passenger loading conditions. Concentrated loads shall be applied to simulate underfloor equipment.

- Test specimen shall include at least three typical transverse supports.

- Test specimen shall represent the actual construction utilized in production. This includes the floor covering, floor boards, floor structure, thermal and acoustical insulation, and floor pans.

- Conditions of acceptance for this test shall be those required for unrestrained assembly.

15.25.5 Toxicity

Those 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.

- Carbon Monoxide (CO) 3500 ppm
- Hydrogen Fluoride (HF) 200 ppm
- Nitrogen Dioxide (NO₂) 100 ppm
- Hydrogen Chloride (HCL) 500 ppm
- Hydrogen Cyanide (HCl) 150 ppm
- Sulfur Dioxide (SO₂) 100 ppm
The tests are to be run 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.

15.25.6 Electrical Fire Safety

Electrical equipment shall conform to NFPA 130, Section 4-3, except where more restrictive requirements are imposed by this Specification.

15.26 Air Filters

15.26.1 HVAC and Equipment Ventilation Filters

Filters shall be selected in accordance with the manufacturer's recommendations for the specific equipment involved. All filters shall have an integral frame. Filters shall be the throw-away type, except reusable filters may be approved for specific applications where throw-away filters are not available. Filters shall be designed to meet the performance requirements of each installation, and shall be approved. All filters shall be freely accessible for maintenance. Filters shall not be ignitable by a burning cigarette.

15.26.2 High Pressure Air Filters

Air filter assemblies with replaceable filter elements shall be provided in the air line that connects each subsystem to the air supply system. The air filter filtering capability, flow rate capability, and overall size shall be appropriate for the application so that the filter replacement interval is greater than one year. It shall be possible to gain access to the filter element for replacement without requiring any pipe fittings to be disconnected or loosened. Filters shall be provided for each of the following systems and any others operated from the air supply system:

- Each air brake control assembly,
- Input and output of each height control valve,
- Coupler controls,
- Door controls, and
- Horn.

15.26.3 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 (89 mm). It shall be non-absorptive of fluids and gases, shall be processed in such a manner that material density increases progressively from air inlet to air exit side, and shall be coated with not less than 24 grams per square foot (258 g/m²) of a dust-retaining, viscous adhesive film. This film shall be stable at temperatures up to 150°F (65.6°C). The filter medium shall be cut not less than ½ inch (13 mm) oversize to ensure adequate sealing between the edge of pad and its integral frame.
15.27   Electrical and Electronic Designs

15.27.1   General

Except as otherwise noted herein, electronic equipment shall conform to IEC 571, Electronic equipment used on rail vehicles. All standard type tests shall be performed.

15.27.2   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 NYCT approval. Submittal of the reliability prediction shall be identified in the Reliability Program Plan. 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.

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 (e.g., Section 15.28.2) and the Reliability Toolkit, the more restrictive condition shall govern. Other service-proven devices may be submitted for approval.

Acceptance testing to eliminate infancy failures is required for all sub-assemblies containing electronic components. All such assemblies shall successfully pass a minimum 72-hour, temperature-cycled, burn-in test without failure. Testing shall be done with the equipment positioned as mounted on the vehicle, powered and connected to a simulator which shall duplicate the I/O (input/output) conditions seen in normal service. The equipment shall be placed in an environmental chamber and cycled continuously between -13°F and 158°F (-25°C and 70°C). Each cycle shall be 8 hours in duration, consisting of 3 hours and 40 minutes at 158°F (70°C), followed by a 20-minute return to -13°F (-25°C), followed by 3 hours and 40 minutes at -13°F (-25°C) and a 20-minutes return to 158°F (70°C). Alternative burn-in cycles will be considered, but must be approved by the NYCT. All outputs of the equipment shall be monitored for anomalous operation. Assemblies consisting exclusively of components rated at 50 amperes or greater, are exempt from this requirement.

15.27.3   Ability to Repair

All electrical assemblies, where practical, including such items as PC boards, shall be designed for repair by the NYCT, in their electronics laboratory.

Assemblies shall not be sealed, potted, or constructed to prohibit repair by the NYCT. Assemblies that must be potted or sealed by design shall have a minimum 10-year warranty.
15.27.4 Hardware

Refer to Section 15.2.2 for general hardware requirements. All hardware associated with electronic and electrical control systems shall be protected against moisture, oxidation, and common airborne contaminants. Hinges and latches shall be of stainless steel.

15.27.5 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 requirements in this document. 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 document.

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.

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 apply:

- The PC board must be protected from mechanical damage and hostile environments such as arc discharge or contact with high voltage.
- If the PC board is part of a high voltage circuit, special caution shall be used in its design with regard to strike distance and creepage in the transit vehicle environment. This includes between PC board components and with respect to any grounded mounting surfaces.
- Any test points required in routine testing or fault isolation to the user replaceable level, shall be easily accessible with no disassembly or tools.
- If replacement of the PC board is required (as part of secondary maintenance), no special tools or soldering shall be required.
- Each PC board use and application of this type is subject to NYCT approval.
15.27.6 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 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".

15.28 Semiconductor Standards

15.28.1 General

Semiconductors shall be selected to withstand all continuous and transient voltage and power demands present in the circuit application without damage or reduction in life. All circuit designs shall provide for the presence of high current switching equipment on the vehicle and the resultant induced voltages and currents in electrical equipment.

15.28.2 Ratings

Discrete semiconductors shall have the following minimum voltage breakdown ratings:

- Semiconductors, except diodes (see below), operated from the battery supply, or those connected to trainlines, shall have minimum breakdown ratings of four times the maximum achievable circuit voltage. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.

- 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.

- All discrete semiconductors operated from inverters or other isolating devices shall have a minimum breakdown rating of two 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 semiconductor junction temperatures shall be limited to 150°C (or to the maximum rated temperature for the device, whichever is less) or less at maximum ambient temperature and at maximum rated output power.

All semiconductors shall be operated at less than 50 percent of the maximum continuous current rating or 50 percent of the maximum continuous power rating, whichever is more restrictive. High power/current devices may be exempt from this requirement with prior approval, on a case-by-case basis. The Contractor shall submit complete device information, including all manufacturer's application recommendations, and calculated current and power demands with all waiver requests. If approved, such waivers do not reduce other requirements, including reliability.
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, 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 supplies to integrated circuits are 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.

Silicon semiconductors shall be rated for operation over the temperature range of -40°F to 185°F (-40°C to +85°C), and shall be hermetically sealed to the extent required by the application.

All Gallium Arsenide and similar optical semi-conductors shall be rated for operation over the temperature range of -40°F to 185°F (-40°C to +85°C).

15.28.3 Availability and Identification

All semiconductors shall be available from at least two manufacturers and available from U.S. distributors. Single source devices, such as high voltage power devices, microprocessors, ASICs, and related support chips may be used only if approved by NYCT. Such devices shall be essential to the proposed equipment, shall meet the proven service requirements, and shall be supplied by veteran manufacturers likely 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 NYCT.

15.28.4 Burn-in

Refer to Section 15.27.2.

15.28.5 Other Prohibitions

Electronic equipment shall utilize stock components and shall function properly with the component manufacture'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.

Germanium semiconductors shall not be used.
15.29 Printed Circuit Board Standards

15.29.1 General

Printed circuit boards shall be designed, constructed and inspected to ANSI/IPC-D-275, latest revision, except where more stringent requirements are noted here. Within ANSI/IPC-D-275, printed circuit board classes are designated. Printed circuit boards supplied under this Specification shall be Class 2, minimum, with the exception of wayside computers that are not utilized in vehicle operation. Class 3 requirements shall apply to all vital equipment.

Circuit board material shall be per NEMA Standard LI 1, Type FR-4 (MIL-P-13949, Type GF), for boards which have no components whose power dissipation is greater than two watts and when said board is not mounted adjacent to components dissipating greater than two watts. Otherwise, circuit board material shall be per NEMA Standard LI 1, Type FR-5 (MIL-P-13949, Type GH).

Printed circuit boards shall have a minimum thickness of 1/16 inch (1.6 mm) base material. All conductor material shall be copper and shall be firmly attached to the board and shall be resistant to blistering and peeling when heated with a soldering iron.

All printed circuit boards shall be designed for ease of testability per ANSI/IPS-D-275, "Testability design check list". Traces shall be made as wide as practical, with the minimum width being based on a 10°C temperature rise.

Components with pins shall be mounted only on one side. Connections shall be made to the other side or internal layers via plated through holes. SMT devices may be mounted on both sides if part of an approved existing design.

All circuit boards shall be inherently stiff or shall be reinforced to prevent damage due to vibration or handling. Circuit boards larger than 100 in² (64,520 mm²) shall be centrally stiffened unless otherwise approved.

All printed circuit boards with the same function shall be interchangeable between equipment groups without additional adjustment.

All printed circuit boards shall be of the "plug-in" type, with positive support against vibration. Single board applications, where approved by the NYCT, may be of a "non-plug-in" type.

Printed circuit boards shall be designed for insertion and removal with power applied, except where power is removed by a switch adjacent to the card rack and except where the mechanical construction would generally prohibit removal and insertion with power applied. Where a switch is used, it shall be labeled with a warning regarding its proper use.
15.29.2 Marking
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All circuit boards shall be labeled with a part number, serial number, and descriptive nomenclature.

All components shall be labeled on the board with component drawing references and such other information as may be required to repair and troubleshoot the board, except as otherwise approved by NYCT. The component and wiring sides of the board shall each be marked to indicate capacitor and diode polarity, and at least two leads or one lead and a graphic symbol indicating orientation of all transistors and thyristors.

Integrated circuits and other multi-terminal devices shall have an index mark on the component side of the board, visible with the component inserted, to indicate proper keying and insertion; the first pin on all IC packages shall be identified on the wiring side of the board. The labels used to identify components on the printed circuit board shall match those used in the schematic drawings for that particular component.

15.29.3 Component Mounting

Components shall be fastened to the board in such a manner as to withstand repeated exposure to shock and vibration. Large components shall be supported in addition to the solder connections. Power resistors shall be mounted on standoffs so that the resistor bodies do not contact the board, spaced far enough away from the board so that resistor-produced heat will not discolor or damage the board.

15.29.4 IC and Device Sockets

IC and device sockets are prohibited except for components that must be removed for reprogramming or initial calibration procedures or devices that are available only in mounting in sockets. All socket applications are subject to NYCT approval. All other components shall be soldered in place.

Where approved, IC sockets shall comply with approved standards such as MIL-S-83502 and MIL-S-83734, as is applicable for the device, and shall be made of the following materials:

- The bodies shall be molded from diallyl phthalate, PTFE Teflon, or approved equal.
- The contacts shall be fabricated from beryllium copper and shall be plated with a minimum of 0.000030 inch (0.76 μm) of gold over a minimum of 0.000050 inch (1.27 μm) of low stress nickel in the area of contact with IC pins.

15.29.5 Conformal Coating

Both sides of the assembled printed circuit boards shall be coated with a clear insulating and protective coating material conforming to MIL-I-46058 latest revision, or approved equal.

The coating shall be easily removed with a brush-applied solvent or penetrated by a hot soldering iron when a component must be unsoldered. The coating solvent shall not adversely affect board-mounted components.
All IC sockets, connectors, and test points shall be masked when the coating is applied.

15.29.6  Keying

All printed-circuit boards shall be mechanically "keyed" to prevent insertion into the wrong slot or in the wrong orientation. Further, circuit boards in safety related control systems, such as friction brakes, cab signal, ATC, ATS, and systems which can cause damage or unsafe train operation if the vehicle is operated with a card removed, shall be connected through a safety circuit to disable the vehicle if a circuit board is removed.

15.29.7  Circuit Board Connectors

Printed circuit board connectors shall be heavy duty, high reliability, two-part type with a history of successful service in rail applications and shall be approved by the NYCT prior to commencing design.

Connectors which comply with MIL-C-55302, latest revision, and which have plated contacts as described below, are considered to comply with the requirements of this section.

The connector contact area shall be plated with a minimum of 0.000030 inch (0.76 μm) of gold over a minimum of 0.000050 inch (1.27 μm) of low stress nickel.

Card edge connectors are prohibited.

15.29.8  Testing

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Sufficient clearance shall be provided between components to allow testing, removal, and replacement without difficulty due to lack of space.

Test points shall be provided in appropriate locations on modules and printed circuit boards, except as otherwise approved by NYCT. A negative return test point shall also be provided. The test points for manual testing shall either accept and hold a standard 0.080 inch (2 mm) diameter tip plug or shall be a turret lug similar to Cambion No. 160-1026-01-05, or approved equal, with sufficient clearance to permit it to accept a standard oscilloscope probe clip, and shall be identified by appropriate markings.

15.29.9  Extenders

Printed circuit board extenders (20 sets of each type) shall be provided by the Contractor for test purposes. At least two extenders of each type shall be available for use and evaluation throughout the design conformance and acceptance test programs. The interfaces between extender and enclosure and PC board must be positive and secure and must prevent malfunction and falling out during testing. Mechanical locking means shall be considered on large PC boards.
15.30 Electrical Devices and Hardware

15.30.1 General

All electrical devices shall be transit industry-proven.

15.30.2 Contactors and Relays

All contactors and relays shall meet or exceed the requirements of MIL-R-6106 and MIL-R-5757 respectively, with the following qualifications:

- Devices shall be tested for proper functioning in orientations up to 30 degrees from the orientation in which they are mounted in the vehicle, in each of the three possible rotations: pitch, yaw, and roll.

- If adequate documentation exists demonstrating that during functional and operational testing of the vehicle the contactors underwent normal duty cycle tests, it shall be considered as an acceptable alternative to a burn-in.

- In selected applications, contactors and relays shall comply with the requirements of MIL-R-6106 (for ratings of 10 amperes or greater) and MIL-R-5757 (for ratings of less than 10 amperes) but need not be qualified to these documents if all of the following requirements are met:
  - The device is service proven in the exact same application.
  - The device is service proven in transit service.
  - All other requirements of this Specification are met.
  - The NYCT approves of this application.

All devices shall be constructed and utilized in a fail-safe manner; that is, all failures shall be in a direction so that neither the passengers, the crew, nor the equipment are placed in jeopardy.

All devices shall be installed so that they are fully accessible for inspection, repair-in-place, or removal and replacement. All contactor terminals shall be fully accessible for trouble shooting purposes. Contactors and relays shall incorporate means of visually determining whether they are picked up or dropped out. Relays on printed circuit boards or within electronic assemblies may be exempted from the requirement for a visual indication, as approved by NYCT.

There shall be a maximum of two wire terminations on any one contact of the device.

The coils of all devices shall be suppressed to protect the low-voltage network from generated transients.

Under no circumstances shall either the main or auxiliary contact tips of the devices be placed in parallel for the purpose of carrying a current load at or above the manufacturers contact tip rating.
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Contact tip ratings shall be stated for the worst condition of reduced surface contact which may result from tip misalignment during normal operation of the device.

Contactor installation shall be such that the arc spray is directed by an arc chute away from ground and any other electrical devices proximate to the contactor.

Devices shall be constructed in a very heavy-duty fashion suitable for use in railroad service. The NYCT reserves the right to review and approve the design and selection of all contactors and relays.

Contactor tip replacement shall not exceed 10 percent of the total number of tips at 90-day intervals.

All contactors shall be constructed so that the main contact tips make and break with a motion (wipe) that prevents deposits and pitting.

All dc contactors shall be built with series-fed blowout coils. The Contractor shall demonstrate the ability of each contactor type to reliably interrupt current over the full design operating range.

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. The identification strip shall be mounted adjacent to the mounting of said device.

Bifurcated contacts shall be used in low voltage applications, whenever necessary due to dry contacts or low current switching requirements.

All time delay relays shall be of the R-C delay or solid state type. No mechanical or pneumatic time delay devices will be permitted.

Where plug-in relays are approved, the relay shall be positively retained by means of a retaining clip or bar. This device shall be captive, of rugged construction and shall be easily positioned for relay installation and removal without the need for special tools. When the relay is removed, the retainer shall itself be retained so that it cannot 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.

Adequate gap and creepage distances shall be maintained from high voltage contactor tips and low voltage coil and auxiliary contacts to prevent entry of high voltage arcs or transients into the low voltage circuits. The same applies to grounded mounting surfaces.

Relays shall not be affected by the accumulation of airborne dust.

15.30.3 Switches

Under no circumstances shall poles of switches be placed in parallel in order to carry currents in excess of the contact pole rating given by the manufacturer.
Switches shall be provided with a "keying" feature so that after installation, the body of the switch is constrained from mechanical rotation.

All switches provided shall be of the highest quality procurable and shall be fully suitable for the rigors of the NYCT's service environment. All control switches which are subject to water splash, which is defined to mean any switches mounted near windows or doors, or mounted on the Train Operator's control console, shall be environmentally sealed. Toggle and push button switches shall be per MIL-S-3950, MIL-S-8805, MIL-S-83731, or equal. All safety-critical switches, such as those that can cause door openings, shall be designed to withstand a high potential test of 1500 volts for one second, in a clean, dry condition, without false conduction. The design and selection of all switches shall be subject to review and approval.

There shall be a maximum of two wires connected to each terminal of the device.

Switches shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the switch to be replaced.

In addition to the above requirements, all switches and pushbuttons shall meet the following requirements:

- Contact resistance shall be less than 0.1 ohm at 3 Vdc and a 10 milliamp load.
- Open circuit resistance shall be 50 meg-ohms minimum.
- Resistance to case shall be 1000 meg-ohms minimum at 500 Vdc.

15.30.4 Circuit Breakers

15.30.4.1 General

All circuit breakers provided shall be extremely rugged and fully suitable for the service intended.

They shall be of the highest quality procurable. Design and selection of all circuit breakers shall be subject to review and approval.

All circuit breakers of the same rating shall be of the same manufacture and model throughout the vehicle.

The ON, OFF, and TRIPPED positions of all circuit breakers shall be permanently marked on the handle or the case of the circuit breaker. The circuit breaker, when tripped, shall assume a distinct position between the ON and OFF positions to permit determination of the fact that it has been tripped by either its overcurrent or shunt trip elements.

Circuit breakers shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the breaker to be replaced.

Electrical connections to circuit breakers shall either be threaded to accept machine screws or use a threaded stud. Wires to circuit breakers shall use ring terminals.
Circuit breaker terminals shall not be used as junction points.

Each and every input power circuit shall be protected by an individual circuit breaker. Separate circuit breakers shall be provided for major assemblies or functions. No circuit breaker shall protect more than one circuit, nor shall any one circuit be protected by more than one circuit breaker.

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 without causing nuisance tripping.

High voltage 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 marked and shall be completely visible after installation.

Electrically operated circuit breakers shall be arranged for operation from the low voltage dc supply.

15.30.4.2 High-Voltage Circuit Breakers

All high voltage circuit breakers shall be devices with not less than 3 poles connected in series.

All distribution-type, high voltage circuit breakers shall be Westinghouse Series C, FDB frame, Heinemann type GH, or approved equal.

The trip elements shall be thermal-magnetic, or magnetic, connected in series.

The circuit breaker handle shall protrude from the circuit breaker panel cover sufficiently to be manipulable in all positions.

15.30.4.3 Low-Voltage Circuit Breakers

Low voltage circuit breakers shall be either one-pole or two-pole devices depending on the intended function. Trip elements shall be thermal-magnetic, or magnetic, as is appropriate for the application.
All low voltage circuit breakers shall be:

- General Use - Westinghouse Series C, Quicklag C frame, Heinemann Series AM or approved equal, front connection or approved access arrangement, and approved labeling.
- Fast Operation - Airpax type IMLK, dust sealed, magnetic breaker, or Airpax type UP, hermetically sealed, magnetic breaker, or an approved equal.

15.30.5 Fuses

Fuses shall be used only where specifically called for in the Specification or where the use of circuit breakers is not technically feasible, and only with specific approval. Fuses may be considered in applications as follows:

- To protect solid state equipment from catastrophic damage, and
- Where current or voltage levels prohibit circuit breakers.

Fuses shall meet requirements of NYCT Fuse Specification 1139-C-78, where applicable. Reference Appendix C.

Fuses shall be permanently identified adjacent to the fuse. The rating of each fuse shall be permanently and clearly marked directly on each fuse.

Fuses shall be readily accessible. All fuses mounted in exterior equipment boxes shall be accessible without going under the vehicle.

Fuse holders shall contain fuse retention devices at both ends.

Air gap and creepage distances shall be as approved. Fuses used in nominal 600 Vdc circuits shall be rated for no less than 1,000 Vdc.

High voltage fuses shall be mounted in totally enclosed, dead front fuseholders, with no exposed high voltage connections. The fuse shall be extracted from the circuit when the fuse holder is opened and the exposed fuse shall be safely isolated from any circuit connection.

Where circuits use multiple fuses or fuses and circuit breakers, the coordination between the protective devices shall be discussed in design review.
15.30.6 Bus Bars

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Bus bars are to be fabricated from OFE (Oxygen Free Electronic) or ETP (Electrolytic Tough Pitch) copper (CDA 101 or 110). The 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 (1.55 A/mm²), and in any case shall not exceed a value which would cause a bus bar temperature rise greater than 30°C. Current densities in joints shall not exceed 150 amperes per square inch (0.23 A/mm²).

Bus bars shall be properly brazed together at joints unless bolted connections are found to be absolutely necessary for maintenance purposes and are approved. The overlap at bus bar joints shall be no less than 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 (1.38 MPa). Bolting hardware shall be plated steel with belleville washers to maintain connection pressure.

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.

15.30.7 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 a 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 lower 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°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 lower derating, on a case-by-case basis.

15.30.8 Transformers and Inductors

Transformers and inductors shall be derated 10 percent for current. Transformers shall:

- Have vacuum-impregnated windings.
Be rated to withstand at least twice the maximum peak-to-peak voltage that they shall be subjected to in operation.

Not emit audible noise in excess of 60 dB referenced to 20 micropascals at a distance of 2 feet (0.61 m) while operating at rated voltage and load.

Be designed to minimize radiated and induced EMI.

The location, orientation, mounting, cable connections and cable routing shall be in accordance to the overall EMI/EMC control plan for the vehicle.

15.30.9 Switch, Circuit Breaker, and Fuse Panels

All switch, circuit breaker and fuse panels shall be dead front types 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 live parts when operating the switches or circuit breakers. Furthermore, all live portions of the protected circuitry shall be completely concealed so that no danger of electrocution or shock exists from the touching of the panel or any appurtenances or devices mounted thereto.

All switches, breakers, fuses, and indicating lights shall be provided with a nameplate of raised or recessed lettering on the dead front, clearly identifying the circuit which each controls 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 and repair action 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 will not be permitted.

15.30.10 Battery Backup Circuits

Backup batteries are not permitted, unless specifically approved by NYCT.
SECTION 16
SOFTWARE SYSTEMS

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SECTION 16

16.0 SOFTWARE SYSTEMS

16.1 General

Many of the systems for this vehicle will use processors and hence software. The application requirements for those systems are detailed in other portions of the Specification and the software must be treated as an integral part of the total system design. Even so, there are sufficient unique requirements to warrant a dedicated section, within this Technical Specification, for software requirements. Selected hardware requirements are also included within this section. Refer to Section 15 and to IEC 571-3 for related requirements.

All computer hardware and software for this project, whether resident within a microprocessor-controlled intelligent subsystem or provided as part of test equipment or for the purpose of post-download fault log processing or incorporated within training technology, is subject to the same requirements, except as granted within this Specification.

16.2 Supplier Qualifications

Suppliers who are building processor based products shall have a mature software development process. To confirm its capability, the Contractor shall submit an independent Software Capability Evaluation (SCE) for each supplier. The independent evaluation shall include the use of a lead assessor who is certified by the Software Engineering Institute (SEI) and shall be conducted according to methodologies established by the SEI, or approved equivalent.

For all suppliers of custom software or transit specific software, the SCE must demonstrate that the supplier has the equivalent of a software capability maturity level of 2 or greater, as defined by the SEI. A supplier that fails to meet the requirements for level 2 will be allowed to perform remedial action and be re-audited, or may request a waiver based on meeting the requirements for level 1 and having a defined process that is commensurate with the complexity of the application. Waiver evaluations will be rigorous. Remedial action could be an improvement in in-house capability or software subcontract to a qualified supplier. A supplier that fails to meet the necessary requirements may not supply software for this procurement. Successful results of the software maturity audit must be provided prior to the preliminary design review for the equipment in question.

16.3 Design Process

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, using the documents listed below. Note that these documents are also addressed in Section 16.5, Software Documentation.

- System Functional Description
- Software Requirements Specification
- Software Design Description
- Software Verification and Validation Plan
Since software is part of a total system design, it will be reviewed as part of each design review. The correspondence between design reviews and software submittals shall be as shown below.

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### 16.4 Software Systems Functions and Features

#### 16.4.1 Hardware

**Platform**

Carborne and custom computer hardware shall be designed and constructed in accordance with the general electronic design principles of Section 15. The microprocessor based systems shall be based on an established family of microprocessors in wide use in the control system industry. They shall be supported by a full range of software development languages and diagnostic programs similar to that available for the Intel 80XXX, Motorola 68XXX and Echelon 31XX family of devices. Any use of commercially available computer boards must be specifically approved by the NYCT. Such approval will be based upon a technical review of the product, product documentation, and a commercial assessment of product availability.

The control system shall be powered by dedicated transformer-isolated power supplies driven from the vehicle battery circuit.

All control 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:

- Protect and isolate the control system from damage due to over-voltage, under-voltage, transients, shorts, and opens.
Perform necessary voltage translations.

Remove noise and undesired signals.

Limit, pre-process, discriminate and format those signals that would otherwise require excessive processor time.

Consist of optical isolators, transformer isolators, and other circuits appropriate to the application.

Program code and fixed data shall be stored in a form of PROM. All EPROM windows shall be covered with labels that are opaque at the UV erasing wavelengths. Flash PROM circuitry shall be configured so that reprogramming can be disabled via a semi-permanent hardware mechanism. After the software design has stabilized in revenue service, flash PROM reprogramming shall be hardware-disabled. If a system does not disable flash PROM reprogramming in the equipment itself, then it is acceptable to use a PTE where both a password and an approved hard key (dongle) are necessary for the PTE to download software. The same hard key shall be used for all systems and for both R142 and R142A cars. One hard key shall be provided for each PTE.

Other than the main car battery, batteries are restricted as follows: One battery per A Car for the purpose of maintaining a clock and calendar, one battery per Event Recorder System, and any others only with NYCT approval. Rechargeable batteries shall be sized to retain data for at least six months without charging and shall be located such that leakage cannot damage any control system components. Battery life shall be no less than five years, regardless of type. The system 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. Batteries shall not be connected by soldering. Upon detection of the loss of input power to non-battery backed systems, the processor system shall store all necessary RAM control data to non-volatile memory.

The hardware shall be designed to allow program expansion without hardware modification. The memory needs of the installed software shall not utilize more than 70 percent of the installed memory. This requirement applies individually to each type of memory installed, whether it be EPROM, EEPROM, Flash PROM, RAM, or other type. Peak processing time demands shall not be greater than 50 percent of the available processor time, except as indicated below. The Contractor may petition for relief from the 50 percent requirement, based on product maturity and the lack of potential for expansion or modification. In no case may more than 75 percent of the peak processor time be utilized, and generally, more margin will be required. The hardware shall include spare input and output channels, of each type used within the system, except for major output drivers, the quantity of which is fixed by the overall system design (e.g., traction motor semi-conductors and sign character drivers). In addition, the architecture and assembly construction shall allow for the installation of additional I/O hardware. Simple singular functions performed by dedicated embedded processors may utilize up to 75 percent of the available processor time and do not have to provide spare I/O capability.
16.4.2 Operating Systems and Languages

Software may be written in a high or low level language. The language, and its implementation for the selected microprocessor system, shall be commercially available in English. No proprietary languages are allowed. C++ is the preferred language. All languages and operating systems must have an acceptable installed base and be Approved by the NYCT.
16.4.3 General Features

Software shall perform the following basic functions:

- Implement the desired control scheme such that the specified performance is achieved;
- Monitor all inputs for unsafe, erroneous, or unknown conditions or combinations of conditions;
- Sample all input conditions 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. All software shall be designed to insure that the timing requirements for safety-related tasks are always met;
- Limit all output commands to safe levels regardless of any combination of input conditions;
- Perform self-diagnostic routines and respond promptly, safely, and predictably to detected faults. The self diagnostics shall include tests for program corruption and integrity in read/write memories;
- 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 re-initialize all affected routines and temporary data. Detection of power interruptions may be by hardware; and
- Permit thorough interrogation of all input, output, and internal conditions by external diagnostic equipment.

Software version numbers shall be included within the code and shall be accessible to the Monitoring and Diagnostic System. Multi chip programs must self-test to assure that the correct compliment of chips is installed.

Processor system parameters shall be adjustable via PTE. Appropriate parameters shall be suggested by suppliers, in design review, for approval by the NYCT.

16.4.4 Testability

All features and functions of software systems shall be testable on a systems level. Specific approval by the NYCT is required for any feature which is not testable on a systems level. For features which are only testable with special equipment, all such equipment shall be supplied by the Contractor as test equipment, and become the property of NYCT. 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 Portable Test Equipment.
Type tests of all processor systems shall verify the proper operation of all software features, including diagnostics.

16.5 Software Documentation

16.5.1 General

For non-commercially available software, thorough and accurate software documentation submittal and NYCT approval is required. The NYCT shall be provided with sufficient documentation to fully comprehend and analyze the operation of the equipment in which the software is to be installed; and to enable NYCT 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 subcontractors to comply with same. The methodology shall be submitted for NYCT approval. The Contractor shall provide descriptions to enable the NYCT's design reviewers to understand the documentation methodology. Software documentation training shall be included within the formal Training Program. Submissions also shall conform to the requirements of Article 105 of the Terms and Conditions of the Contract.

Documentation for non-commercially available software shall fall into two categories. First, the documentation must include all form, fit, and function information for use by the NYCT for the Specification purpose as set forth in Article 105 of the Terms and Conditions of the Contract. Second, documentation must include all implementation details as set forth in and for the use by the NYCT for the approved purposes spelled out in Article 105 of the Terms and Conditions of this Contract. The placing of software documentation details in an escrow account, in lieu of submittal to NYCT, will not be permitted.

16.5.2 Software, Specifically for Custom Applications

As described in Section 16.5.1, all software documentation from all suppliers shall be in a common format. This format shall use a consistent set of graphical and textual techniques to fully describe the software functionality and implementation. The Contractor shall submit, for approval, a software Quality Assurance Plan in accordance with ANSI/IEEE Standard 730. The plan shall include the submittal and approval of the documents listed below.

- System Functional Description
- Software Requirements Specification
- Software Design Description
- Software Verification and Validation Plan
- Software Verification and Validation Report
- User Documentation

With the exception of the System Function Description, these documents are those required by ANSI/IEEE Standard 730.
The Software Design Description (SDD) shall be in accordance with ANSI/IEEE Standard 1016. The final Software Design Description shall include details required by ATA Specification No. 102, through all levels to Level 6. Level 4 shall be interpreted to mean all source code, including operating systems. The levels defined in ATA No. 102 are summarized below only for information:

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<tr>
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<td>4</td>
<td>Annotated compiler/assembly listing</td>
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<td>5</td>
<td>Detailed memory map and listing</td>
</tr>
<tr>
<td>6</td>
<td>Input/output port map</td>
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After original approval, changes to the software shall be formally submitted for approval by the NYCT, prior to implementation. The Software documentation shall be revised concurrently with software changes.

16.5.3 General Market 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 data base software for wayside fault analysis. The Contractor shall submit a list of software which is commercially available to the general public. The NYCT shall determine which software will be classified as commercially available.

For commercially available software, software documentation requirements are limited to: the original data storage/transfer media (CD-ROM or diskette), functional and usage details, all provider manuals, and licenses required for NYCT 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. For all other software, as deemed by the NYCT, the documentation requirements of Section 16.5.2 apply.

16.5.4 Configuration Control

The Contractor shall develop a configuration control plan for tracking software changes relative to cars on NYCT property. This plan shall be submitted for approval by the NYCT.

All software shall be identified by a name and a version number. 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.

16.6 Software Maintenance and Related Tools

The NYCT retains the right to modify the performance of its equipment, at its own risk. Since this involves software modifications, all software for this vehicle shall be delivered to the NYCT on CD-ROM or diskettes.

The Contractor shall provide software workstations in accordance with Section 20.4.3, including 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. Development tools and software which are provided to the NYCT must be the same version as used by the suppliers. The system shall allow software modifications and tests of all transit related software on this procurement. The complete complement of software development/modification tools shall be delivered such that software modifications can, if desired, be made on-site during warranty. PROM re-programming equipment shall allow re-programming of 16 PROMs per hour.

The workstation and software documentation equipment is to be delivered, demonstrated, and proven to perform its function six (6) months before the expiration of the warranty period of the first two (2) operating units. The demonstration shall consist of NYCT 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.

16.7 Portable Test Equipment Software

For custom software that is resident in test computers, the NYCT shall be given a license for use of the software for the approved purposes, such license shall meet the requirements of Article 105 of the Terms and Conditions of this Contract. In addition, portable test equipment software documentation, compliant with Section 16.5 and with Article 105 of the Terms and Conditions of the Contract, shall be furnished.
## SECTION 17
### COMPLIANCE PROGRAM

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SECTION 17

17.0 COMPLIANCE PROGRAM

17.1 General

The Contract shall include a comprehensible compliance program to assist in assuring Specification compliance of Contractor furnished designs and equipment. The program shall include development and supply of mock-ups as detailed within Section 17.2, and a Test Program as detailed within Section 17.3.

17.2 Mock-Ups and Models

Full-size mock-ups shall be constructed and furnished for the purpose of evaluating preliminary design work, spaces, accessibility, and the human interface. Mock-ups shall provide early identification of potential problem areas and development of alternative solutions.

The mock-ups shall be complete with regard to both exterior and interior details, and shall show the location and arrangement of all devices including, but not limited to, the windshield, control console, doors, lockers, windscreens, windows, windshield wipers, destination signs, sun visors, handholds, stanchions and seats. Operable interior and exterior lighting, and air distribution systems shall be included.

Final mock-ups shall be constructed from the actual production materials and hardware and shall be dimensionally and functionally accurate. The construction technique shall permit modifications quickly, easily, and economically following the NYCT's review.

Mock-ups shall be used to demonstrate Specification compliance, design practices, and material selection.

Mock-ups shall depict the following:

- Operator's Cab
- Cab Car Front End
- Non-Cab Car End (Cab Car No. 2 End, Non-Cab No. 1 and 2 End)
- Passenger Area
- Side Doorway Area
- Undercar Equipment for Cab Car
- Undercar Equipment for Non-Cab Car
- Intercar and Between-Car-Barrriers

As an alternate to providing individual mock-ups, the Contractor may combine the Train Operator's cab, Cab Car front end, passenger area, side doorway area, intercar barriers and between-car-barriers into one mock-up.

Selected mock-ups may be used as training aids. All mock-ups shall be kept up-to-date with all car design modifications.

A model as specified within Section 17.2.9 shall be furnished.
The Contractor shall construct a detailed, full-scale mock-up of the No. 1 End of the Cab Car, extending a minimum of 25 feet (7.6 m) from the face of the anti-climber. The mock-up shall include a fully detailed cab. The mock-up shall be available before cab and interior arrangements are finalized. The mock-up shall contain sufficient detail to enable NYCT to fully visualize and critique the final design concept and details.

The mock-up shall be complete with regard to both exterior and interior details, and shall show the location and arrangement of all devices including, but not limited to, the windshield, control console, Train Operator's Display (TOD), doors, lockers, partitions, windscreens, windshield demisters, windows, windshield wipers, information signs, sun visors, and seats. Operable interior and exterior lighting, and air distribution systems shall be included. Substitute materials, as approved by NYCT, may be used in construction of the mock-up provided that their use does not substantially alter the configuration of the intended full design. The side door system included with the mock-up shall be complete, operable, accurate in all mechanical details, and representative of all the actual components.

The mock-up shall be constructed in phases: The mock-up shall be initially available for review using simulated arrangements in place of unavailable equipment. The simulated arrangements shall be replaced as the functional equipment becomes available so that the mock-up fully complies with the description in this Section.

The mock-up shall be inspected by the NYCT at the Contractor's facility throughout its construction phases. NYCT comments generated during inspections shall be incorporated into the mock-up. The Contractor shall demonstrate on the mock-up that, as a minimum, the following requirements are met before the represented designs are finalized and prior to production:

- General industrial design of represented portions of the interior are acceptable to NYCT.
- Glare and reflections on the windshield have been minimized so that light sources inside and outside of the Unit do not obscure the Train Operator's vision through the windshield.
- Indicators and displays are clearly legible and readable under all conditions including bright sunlight.
- The cab equipment is functionally designed with all cutouts, bypass switches, and circuit breakers logically zoned and grouped. The maintainability aspects of all cab equipment should be thoroughly investigated and defined.
- The cab console inclusive of the TOD, other displays and controls normally available for Train Operator and Conductor's use shall be developed with proper consideration for function and ergonomics.
- Proper operation of windshield heater.
The sun visors properly shade the Train Operator from bright sunlight without compromising safe visibility through the windshield or side windows.

Exterior lighting levels.

Destination signs are clearly legible on both bright, sunlit days and dark nights from 5 feet (1.5 m) above the car floor at a distance of 150 feet (45.7 m) from the sign surface for an angle of ±50° from a line perpendicular to the sign surface.

The mock-ups shall then be shipped to NYCT for final approval by additional personnel and interested parties before the represented designs are finalized. The mock-ups shall be delivered to a location designated by NYCT in the New York area and become the property of NYCT after delivery of the first Unit.

17.2.2 Cab Car Front End

The Contractor shall construct a full-size mock-up of the exterior of the No. 1 End of the Cab Car. The mock-up shall be constructed of the identical materials to be used on the production car. The mock-up will be used to evaluate the equipment arrangement and industrial design of the No. 1 End exterior.

The mock-up shall accurately depict the exterior features of the car including end windows, anti-climber, coupler, grab irons, intercar barriers, lighting, end route sign, end door and door hardware, and color scheme.

The mock-up shall incorporate finalized intercar and between-car-barriers resulting from the development requirements of Section 17.2.5.

The mock-ups shall be inspected and approved by the NYCT before the represented designs are finalized and prior to production.

17.2.3 Passenger Area(s)

A full-size mock-up of the passenger area of the Cab Car shall be constructed to represent the area from the cab wall to the second set of side doors. A full-size mock-up of the passenger area of the Non-Cab Car shall be constructed to represent the area from the end wall to the second set of side doors. These mock-ups shall be used to evaluate ergonomics, space utilization, accessibility for maintenance and cleanability. Actual production materials shall be used in the construction of the passenger area model.

The Contractor shall place emphasis on the following design features:

- Seat layout and seat design,
- Standee area including stanchion and handhold placement,
- All interior linings including windscreens, end panels, cab wall, and electrical lockers,
Lighting, air distributors, destination signs, electronic message displays, and strip maps,

Wheelchair parking area and seating for the disabled,

Floor covering, side entrances and thresholds,

Doorways, door pocket panels,

Window design and arrangement, and

Compliance with ADA requirements and usability of passenger area by passengers with disabilities.

The mock-ups shall be inspected and approved by the NYCT before the design of the cab and passenger area is finalized and prior to production.

17.2.4 Side Doors

The Contractor shall construct a full-size mock-up of a side passenger door entrance including both door panels, door pockets, and any overhead transom panels which may cover door operators.

Production doors, hardware, and materials, including door pocket and access panels, door operators, and door control and threshold heaters, shall be used and shall functionally demonstrate compliance with the Specification requirements.

This mock-up shall be used to demonstrate door operation, obstruction detection, cycle times, closing forces, visual and audible door closing warnings, accessibility for maintenance and threshold heater operation. Upon completion, the mock-up may be used for the door accelerated life test.

17.2.5 Intercar and Between-Car-Barriers

Full-size mock-ups of the intercar and between-car-barriers shall be constructed. The materials used for all barrier models shall be production material and the models shall be fully functional.

The intercar barriers shall protect the passengers while passing from car-to-car or Unit-to-Unit, independent of car speed and relative alignment. The Contractor shall demonstrate effectiveness, storage and deployment of barriers.

The between-car-barriers shall warn, deter, and protect individuals from inadvertently walking off the boarding platform between cars. They shall also discourage passengers from attempting to enter the car ends directly from the platform. The between-car-barrier shall be either chains or gates.
17.2.6 Underfloor Equipment Arrangement

The Contractor shall construct full-size mock-ups of the underfloor equipment arrangement for each type of car. Actual undercar devices and materials shall be used. All subsystems, equipment boxes, components, wiring, raceways, conduit, piping hoses, trucks, and couplers shall be included.

The mock-ups shall demonstrate subsystem and component placements; methods of attachment; accessibility for maintenance; equipment interfaces; and clearances at the trucks, couplers, other components and structure.

If the Contractor desires, a single underfloor structure may be utilized and then fitted to represent each car type.

17.2.7 Samples

Samples of all interior materials, passenger and Train Operator's seats, glazing, decorations, and signs shall be furnished during the design for NYCT evaluation and approval. Samples shall be submitted for quality, color, and finish evaluation by NYCT, and shall be generally 10 inches (254 mm) by 10 inches (254 mm) in size. An interior finish schedule, giving actual samples identified with the manufacturer's name and ordering reference for each material, shall be furnished before delivery of the first Unit. Three sets of samples shall be provided. The samples are to be delivered during the in-process design review meetings and may be retained by the NYCT.

17.2.8 Sample Cars

The first production car of each type shall be designated as the Sample Cars. They shall precede all other cars in the construction and assembly process. The Sample Cars shall be evaluated at every stage of construction and assembly to insure Contract compliance prior to undertaking this work on the remaining cars to be manufactured.

The NYCT shall inspect the sample train at the following stages of completion:

- Car shell complete, including all structure, but without equipment, insulation or liners installed;
- Car shell with floor insulation installed;
- Car shell water test;
- Car shell with wall and roof insulation, all interior wiring and piping in place and connected, side doors installed and operating, overhead air conditioning apparatus in place and connected, car interior lighting installed, but without liners installed;
- All liners installed, but without seats installed;
- Train Operator's cab complete;
The NYCT may also perform other additional inspections of the Sample Cars at other points during the manufacturing process.

17.2.9 Models

Within thirty days after acceptance of the exterior configuration design, the Contractor shall commence building two scale models of a complete five-car train. The models shall be built to one-fiftieth scale, shall be complete with a mounting base, clear plastic cover and carrying case. The completed models shall be delivered to the NYCT no later than nine months after NTP.

17.3 Test Program

A comprehensive testing program shall be conducted on raw materials, components, subsystems, cars, Units, and 2-Unit trains to substantiate the design and performance requirements, to assure conformance to the Specifications; inclusive of reliability and maintainability requirements.

The Contractor and its subcontractors and suppliers may perform additional testing as deemed necessary, and shall perform additional quality control testing as necessary to assure Specification compliant, high-quality material and parts.

Unless otherwise indicated, all costs associated with testing shall be borne by the Contractor. All instruments, personnel, and apparatus required for testing shall be provided by the Contractor.

If an item fails a test it shall be modified and retested at the Contractor’s expense. If the design of an item is changed after a test is conducted, the Contractor shall perform a complete retest of the item to demonstrate Specification compliance.

The Contractor shall give at least 15 working days' written notice to the NYCT prior to the start of any specified test. All specified tests shall be arranged to facilitate witnessing and verification of parameters thereof by representatives of the NYCT and shall be conducted in the presence of such representatives unless the NYCT directs the Contractor to proceed without them.

The tests specified herein are considered to be an absolute minimum by the NYCT. The Contractor shall be responsible for assuring that each design and performance requirement of this Specification is assigned to a specific test effort. The Contractor shall furnish a comprehensive test plan as described in Section 17.3.2.1. The Contractor and its subcontractors may perform additional testing as they deem necessary.
17.3.1 Classification

Tests are to be performed on 2-Unit trains, Units, cars, systems and components and generally fall into the following test categorizes:

17.3.1.1 Qualification Tests

Qualification tests are typically one-time tests conducted to demonstrate compliance with Specification design requirements at operating and environmental extremes. These tests shall be performed on initial production components, assemblies, subsystems, cars, Units, and 2-Unit trains. These test requirements are detailed in Section 17.3.3 Component Qualification Tests; Section 17.3.4 System Qualification Tests; Section 17.3.5 Car Qualification Tests; and Section 17.3.6 Unit Qualification Tests.

17.3.1.2 Conformance Tests

Conformance tests shall include all efforts necessary to demonstrate that each equipment item to be delivered operates within specified limits and is in compliance with its applicable design requirements. Conformance test requirements may vary from an inspection and functional demonstration for a simple component to a full system demonstration of a Unit. These tests are routinely performed at ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation. These tests are described in Section 17.3.7.

17.3.1.3 Unit Pre-Shipment Tests

Each Unit shall be tested prior to shipment to the NYCT. Tests shall include static and dynamic testing as required within Sections 17.3.8 and 17.3.9.

17.3.1.4 Unit Acceptance Tests

The Contractor shall complete Acceptance testing to demonstrate that each Unit has been completely and correctly constructed in accordance with Specification requirements, and is suitable for NYCT's revenue service.

Unit Acceptance testing shall be conducted on the NYCT property as part of the Unit Acceptance Program. Tests shall include static and dynamic testing as required within Section 17.3.10.

17.3.2 Test Plans, Procedures, and Reports

17.3.2.1 Test Plans

The Contractor shall submit to the NYCT, for approval, a Master Test Plan covering all tests and adjustments listed in this Section and otherwise required in this Specification. The Test Plan shall identify all tests by reference to the appropriate number of this Section and the applicable design Section. The Test Plan shall contain a detailed schedule showing the time and place of each test to be performed. Unless otherwise approved by NYCT, the Test Plan shall cover
all suppliers' and subcontractors' tests to be completed at the suppliers' or subcontractors' plants, all Contractor's tests to be completed at its plant, and all testing to be conducted by the Contractor on NYCT property. The Vehicle Master Test Plan shall be submitted to NYCT for review and approval no later than five months after the Contractor Notice to Proceed.

17.3.2.2 Test Procedures

The Contractor shall prepare a detailed test procedure for each test described in this Section, and for any other tests conducted by the Contractor in connection with its own Quality Assurance Program. Each test procedure shall be submitted to NYCT for review and approval. The Contractor shall submit, as part of each test procedure, forms to be used to record data accumulated in the performance of that test. Such forms shall also contain a step-by-step format for data reduction, formulae used in deriving the format, criteria for acceptability, and justification for the criteria set forth.

Unless otherwise provided, each detailed test procedure shall be submitted to NYCT in advance of the planned test date so as to provide at least 15 working days to review and approve the procedure.

17.3.2.3 Test Reports

The Contractor shall retain a written report of each test, including copies of all test data, at the manufacturer's facility for NYCT review when requested. These test reports will be kept at the manufacturer's facility for a minimum of 5 years after the test are performed, except for truck conformance test, which shall be included in the appropriate Car History Book. In case of tests which are performed on all cars, or all components, the reports of those tests shall be included in the appropriate Car History Book or equivalent data base. In every case, the report shall include a description of the test, all raw data collected in the test, all data reduction forms, and a summary of the results in a manner that can be directly compared to the Specification without further calculations.

A final test report for each test shall be prepared documenting the results obtained and submitted for approval. The report shall be identified by a Contractor document number and shall refer to the Contractor part number and serial number of the test hardware. All pertinent test results (as well as a discussion of any deviations from the approval test procedure) shall be included. The test report shall also include any photographs and any additional data necessary to support the test results. Test data shall be presented as approved by NYCT. Supplier test reports shall be approved by the Contractor prior to submittal to the NYCT. Three (3) copies of the report shall be submitted for approval to the NYCT within 15 days after completion of testing.

Except as otherwise specified, all tests specified herein shall be performed by the Contractor and its subcontractors. When the Contractor can furnish a test report for a required qualification (design verification) test which has been performed on equipment identical to the equipment to be provided for this Contract, and when, in the NYCT's judgement, the test report demonstrates that the requirements for this contract are met, the NYCT may accept the prior test report in lieu of new testing.

Test reports for tests classified as commercial (quality assurance) tests shall not be submitted for approval but shall be made available to the NYCT upon request.
17.3.2.4 Test Components

Items to be used for testing shall be production items. The items shall be manufactured according to the latest revision of manufacturing documentation and shall have been subjected to all prescribed quality control procedures. Any deviations from these requirements shall be subject to approval from the NYCT. Components used for testing shall be clearly identified as test components, and disposed of in accordance with the directions of the NYCT at the completion of testing.

17.3.2.5 Test Failure and Discrepancy Analysis

In the event that failures occur during any testing, a failure report shall be submitted to the NYCT. This report shall identify the unit being tested, identify the cause(s) of failure, indicate what corrective action is necessary, and the extent of such action. Where the Contractor recommends that no change be made, justification for the recommendation shall be provided. When a failure occurs during a test, the test shall be suspended pending evaluation as to the bearing of the failure on the testing completed and as to the need of additional testing using new or reworked parts.

17.3.2.6 Equipment Manufacturer's Representatives

Representatives of the manufacturers of equipment such as motors, traction control, air brakes, door operating equipment, and other equipment specialties shall be available at the site of each test of such equipment as the Contractor and/or the NYCT may require.

17.3.2.7 Test Instrument Calibration

Calibration information for all test equipment utilized for any and all tests shall be traceable from each Test Report. Each Test Report shall contain a statement that all test equipment used was properly calibrated.

A copy of the Certificate of Calibration shall be supplied for each piece of test equipment utilized to obtain data pertinent to any and all of the tests performed. (It is understood that some equipment does not require calibration such as power supplies utilized strictly to provide source power for other equipment.) Additionally, test equipment shall be available for examination by NYCT to allow for the inspection of calibration stickers and that calibration seals, where required, are intact and in place.

A copy of the calibration procedure utilized, particularly if the test equipment was calibrated in house, and/or the manufacturer's recommended calibration procedure shall be provided. The reason for supplying both, if the test equipment was calibrated in-house utilizing an in-house calibration procedure, is to ensure that the test equipment is calibrated to manufacturer's specifications. If the in-house procedure does not require calibration to the same specifications as the manufacturer of the test equipment, then a review of the actual accuracy of the test equipment must be performed and a decision made if the actual specifications were of sufficient accuracy to have been utilized for the particular test performed.

A list of all Calibration Standards shall be provided if the Contractor utilizes their in-house lab. Copies of the Calibration Certificates for all Calibration Standards in an in-house lab shall be provided to ensure traceability.
to the NIST (National Institute of Standards and Technology). Inspection of all Calibration Standards shall be performed to ensure that all calibration stickers and/or calibration seals are in place. Additionally, any certifications the lab may have for calibrating equipment shall also be provided. Copies of the manufacturer's specifications for each of the Calibration Standards shall be obtained to ensure that all of the standards used for the calibration of the test equipment utilized during any test is of sufficient accuracy to have been put to use as the standard of record.

The Contractor shall provide documentation attesting to the traceability and accuracy of all test equipment calibrated in-house, and utilized, meets NIST standards. If an outside lab performed any of the calibration on test equipment used, a copy of the lab's certification by the NIST shall be provided.

Where NIST is specified above, a higher international standards body may be substituted, where approved by NYCT.

### 17.3.2.8 Tests at NYCT

NYCT will provide a non-signaled, dedicated test track for general use by the Contractor in its testing program. Revenue tracks shall be used for EMI tests, regeneration tests, wayside systems interface tests, higher speed tests, and such items as cannot be reasonably tested on the test track. Revenue tracks shall also be used during periods of test track maintenance and repair. Inasmuch as the test track may be utilized for purposes beyond this contract, the Contractor shall assume no more than 80 percent availability during qualification testing and acceptance testing, with regard to sharing.

### 17.3.3 Component Qualification Tests

#### 17.3.3.1 General

**MOD 02**

Components to be supplied shall be given a Component Qualification Test. The following design Qualification tests shall be performed by the Contractor, or under its direction, to demonstrate conformance to the requirements of this Specification:

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammability, Smoke Emission &amp; Toxicity</td>
<td>All materials for tests listed in Section 15.25</td>
<td>17.3.3.2</td>
</tr>
<tr>
<td>Door Panel</td>
<td>One door panel of each type</td>
<td>17.3.3.3</td>
</tr>
<tr>
<td>Windows</td>
<td>Two windows of each type</td>
<td>17.3.3.4</td>
</tr>
<tr>
<td>Seat</td>
<td>One seat of each type</td>
<td>17.3.3.5</td>
</tr>
<tr>
<td>Fluorescent Lamp Ballast</td>
<td>Two of each type</td>
<td>17.3.3.6</td>
</tr>
<tr>
<td>Motors:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Frequency</td>
<td>Reference</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Traction</td>
<td>First motor, one at random, and one of every hundred, selected by NYCT</td>
<td>17.3.3.7</td>
</tr>
<tr>
<td>All others</td>
<td>First motor and one other selected by NYCT</td>
<td>17.3.3.7</td>
</tr>
<tr>
<td>Traction Gear Unit</td>
<td>Two as selected by NYCT</td>
<td>17.3.3.8</td>
</tr>
<tr>
<td>Auxiliary Power Supply</td>
<td>First supply and one as selected by NYCT</td>
<td>17.3.3.9</td>
</tr>
<tr>
<td>Low Voltage Power Supply</td>
<td>First supply</td>
<td>17.3.3.10</td>
</tr>
<tr>
<td>Battery</td>
<td>One set as selected by NYCT</td>
<td>17.3.3.11</td>
</tr>
<tr>
<td>Truck</td>
<td>One of first three</td>
<td>17.3.3.12</td>
</tr>
<tr>
<td>Coupler and Draft Gear</td>
<td>First supply</td>
<td>17.3.3.13</td>
</tr>
<tr>
<td>Unit Interior Link</td>
<td>First supply</td>
<td>17.3.3.13</td>
</tr>
<tr>
<td>Equipment Noise Tests</td>
<td>First supply of each equipment type</td>
<td>17.3.3.14</td>
</tr>
<tr>
<td>Car Body Structural Tests</td>
<td>First car body of each type</td>
<td>17.3.3.15</td>
</tr>
</tbody>
</table>

**17.3.3.2 Flammability, Smoke Emission & Toxicity**

All materials supplied for these cars shall be tested to the Flammability, Smoke Emission and Toxicity requirements of Section 15.25.

**17.3.3.3 Door Panel**

One door of each type shall be tested to verify the strength requirement of Section 3.12.2. The maximum load shall be applied for a minimum period of five minutes. Upon removal of the load, the door shall not show any permanent set.

**17.3.3.4 Windows**

Two windows of each type shall be tested to illustrate compliance with the requirements of Section 3.10.1. Window types to be tested will be selected from the production lot at random by NYCT.

**17.3.3.5 Seat**

One seat frame, seat, seat installation/attachment, material of each type, selected at random by NYCT, shall be tested to confirm compliance with the requirements of Section 3.14.
17.3.3.6 Ballasts

Two fluorescent lamp ballasts of each type used in the vehicle, selected at random by NYCT, shall be tested to confirm compliance with the requirements of Section 14.2.2. Note that it is not necessary to perform testing to verify compliance with MTBF requirements. Compliance with MTBF requirements can be demonstrated by calculation.

17.3.3.7 Motors

17.3.3.7.1 AC Traction Motors

The first motor, then one other, and one for every hundred traction motors, selected at random by NYCT, shall be given an IEC Publication 349-2 "type" test, by the manufacturer.

Motor balance shall be dynamically tested to meet the requirements of Section 10.2.8.

17.3.3.7.2 AC Auxiliary Motors

The first motor of each type and an additional one of each type, selected at random by NYCT, shall be given an IEC Publication 349-2 "type" test, or equivalent standard including a heat run, by the manufacturer, to demonstrate its capabilities and power rating. Both motors of each type tested shall be tested at their continuous rating.

17.3.3.7.3 Low Voltage DC Motors

A motor of each type used as selected by NYCT shall be load tested at maximum application load and maximum ambient temperature conditions. The motor external temperature shall be within the manufacturer’s recommended limits for a 30 year motor life.

17.3.3.8 Traction Gear Unit

Two traction gear units, selected at random by NYCT, shall be subjected to a 100-hour test. The gear units shall be tested with torque load simulation. The test shall subject the units to conditions that are, in general, 20 percent more severe than would occur under the most extreme operating conditions (i.e., power and torque increased by 20 percent at maximum speed and power and speed increased by 20 percent at maximum torque). Torque load shall include the effects of dynamic braking.

The test shall be started with the unit at a temperature from 60°F to 90°F (15.6°C TO 32.2°C). In-service air flow conditions may be conservatively simulated if cooling is critical. The temperature rise measured in the oil sump shall not exceed the gear oil supplier's recommendations for maximum temperature consistent with the life between oil changes, as stated in the Contractor's maintenance manuals. The direction of rotation shall be reversed at intervals not greater than every 8 hours until the 100-hour test is completed. Noise and vibration tests shall also be performed to verify the requirements of Section 2.7.
After completion of the test, the gear units shall be disassembled and all parts examined. Gear tooth mesh and tooth pattern shall be checked and recorded before and after the test. Any sign of deterioration of any part shall be investigated jointly with NYCT. The test report shall include test records of running time, oil temperatures, and vibration and sound level readings taken at such intervals as required to verify compliance with this Specification.

17.3.3.9 Auxiliary Power Supply

Auxiliary power supply tests shall be performed on the first production unit, and one additional production unit selected at random by NYCT. These tests shall include all aspects of the following for the environmental ranges in Appendix A and supply voltages given in Section 2.3.1.

If the auxiliary supply system on a car is made up of multiple converters (e.g., distributed auxiliary inverters, intermediate voltage power supply with one or more inverters), each separate converter shall be tested separately and then the working combination tested.

- All output and control requirements
- Performance and capacity requirements
- Fault detection and annunciation requirements
- Insulation, isolation, and transient rejection requirements
- Heat run, designed to test the system for the worst case heat loadings for maximum rated output current at the lowest operational input voltage; and lightest possible load, at the highest operational input voltage

17.3.3.10 Low Voltage Power Supply, LVPS

Low voltage power supply tests shall be run on the first production low voltage power supply. The unit shall first have successfully completed the conformance test outlined in Section 17.3.7.9. The design qualification tests shall include the following:

17.3.3.10.1 Heat Run

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 rises over ambient shall be within Contractor's limits as set forth in the test plan.

17.3.3.10.2 Upper and Lower Limit Operation

The LVPS under test shall be run for one hour at an input voltage just below the upper limit of the specified operating range.
The LVPS under test shall be run for one hour at an input voltage just above the lower limit of the specified input range for which rated output voltage and current is to be delivered, at rated output voltage and current.

17.3.3.10.3 Supply Step Input Operation

The LVPS shall be subject to 5 successive cycles of step changes in the supply voltage between the minimum and the maximum values given in Section 2.3.1. The output voltage and current shall not vary with supply voltage changes.

17.3.3.10.4 On/Off Cycling

The LVPS, when connected to its rated load, shall be cycled OFF and ON by interruption of the source voltage supply external to the power supply. Rate of cycling shall be approximately one second on, one half second off, and shall continue for 2 minutes.

17.3.3.10.5 Open Circuit Starting

The LVPS shall be started into an open circuit 5 times in succession. Stable operation shall be demonstrated.

17.3.3.10.6 Short Circuit Starting

The LVPS shall be started into a short circuit five times in succession. Automatic protective current limiting and shut-down shall be demonstrated. Automatic restart shall be demonstrated upon removal of the short circuit.

17.3.3.10.7 Overload Starting

The LVPS shall be started while connected into an overload of 120 percent of rating. The overload shall then be removed and the unit shall automatically provide rated output voltage.

17.3.3.10.8 Noise Measurements

Noise measurements shall be made sufficient to demonstrate compliance with Section 2.7.

17.3.3.10.9 Output Wave Form Monitoring

At operating points representing the full range of conditions for delivery of rated output voltage and for routine current limit operation, output voltage and output voltage wave forms shall be monitored by an oscilloscope to determine compliance with the specified regulation and levels of ripple.

17.3.3.11 Battery

A battery sample, selected from the production lot at random by NYCT, shall be tested to establish that the batteries will meet sizing in accordance with IEEE 1115 Recommended Practice for Sizing Nickel-Cadmium
Batteries for Stationary Applications and all the other requirements of this Specification. Battery testing and rating shall be in accordance with IEC 623, Vented Nickel-Cadmium Prismatic Rechargeable Single Cell.

17.3.3.12 Truck
MOD 02
MOD 04

One of the first three truck frames, complete with bolster and all motor and gear unit mounting provisions as selected at random by NYCT, shall be subjected to static and fatigue tests described in Sections 17.3.3.12.1 and 17.3.3.12.2. This truck frame and bolster shall be radiographically inspected as required by Section 17.3.3.12.6.

The primary suspension test described in Section 17.3.3.12.4 shall be done during the same time period as the static and fatigue test.

The truck dynamic test described in Section 17.3.3.12.3, shall be completed after the static load and fatigue tests, unless the Contractor chooses to meet the specified options.

One of the first three motored cars and one of the first three non-motored cars assembled shall be used in the performance of the equalization tests described in Section 17.3.3.12.5.
The Contractor is responsible for determining appropriate test loads and conditions that will illustrate the adequacy of the truck design to meet Section 4. Test loads and conditions specified herein are minimums. Greater test loads and more severe test conditions may be imposed by the Contractor. The Contractor shall determine actual loads by instrumenting and measuring loads which will be incurred while operating on the existing NYCTS.

A test procedure shall be prepared for each test. The procedure shall include a description of the test, the purpose, how and with what equipment the specimen is to be loaded and in what load increments, the type and location of strain gauges, the location of deflection gauges, complete description of all instruments, and details of the data acquisition system. Drawing and sketches shall be included to clarify the text. Also included shall be the drawings showing the test fixture, the specimen installed in the fixture, and location of load application points. Test procedures shall be submitted not less than 60 days in advance of the test date, and approvals of the test procedure and stress analysis are necessary prerequisites for testing.

The test procedure shall include a copy of the current certification for every instrument and gauge to be used during the test. Typical logging sheets, print-outs, plotting forms, and examples of any other data sheets which will be used during the test or in the final report shall be submitted as part of the test procedure. Tables shall be included which show the maximum allowable gauge reading for each gauge and loading condition. Other tables, showing the allowables for all other test criteria, shall be included in the test procedure.

The Contractor shall conduct a stress coat test of the entire truck frame and bolster by either the brittle lacquer or photo-elastic method. Each component shall be tested to confirm areas of high stresses and orientation of principal stresses. A test procedure shall be prepared for stress coat testing and submitted for NYCT's review and approval. Analytical method may be permitted as an alternative to the stress coat test as approved by NYCT.
If the Contractor elects to perform the stress coat test, not less than 75 strain gauges shall be applied to each test truck frame and bolster for the tests described in Sections 17.3.3.12.1 and 17.3.3.12.2 at locations of expected high stress and other areas of interest. If the Contractor elects to use analytical methods, in lieu of stress coat test the Contractor shall apply not less than 100 rosette strain gauges to each test truck frame and bolster for the tests described in Sections 17.3.3.12.1 and 17.3.3.12.2 at locations of expected high stress and other areas of interest. Location of strain gauges shall be based on the stress analysis, the Contractor's experience, the stress coat test results, and the direction of NYCT. Drawings and sketches showing the location of every strain gauge shall be prepared by the Contractor and submitted as part of the test procedure. NYCT will review and approve strain gauge locations. The strain gauges shall be SR-4 type, or other approved gauges suitable for the application. The gauges shall be compensated for temperature. A load cell shall be installed at each point of load application. All load cells shall be recorded simultaneously with all strain gauges.

All gauges and instruments shall be in current calibration. The method of calibration and time period for recalibration shall be in accordance with the laboratory's national standard or ISO. The laboratory shall have on file a current certification of calibration traceable to the laboratory's national standard.

The Contractor shall prepare a color photographic record of the tests. This record shall include photographs of the trucks in the several test fixtures, installation of critical strain gauges, repairs or modifications, deviations from the drawings, and any areas that were found non-compliant. The Contractor shall prepare and submit a final test report within 30 days after successful completion of the structural tests. It is the approval of this test report that constitutes the acceptance of the truck structural tests. The test report shall include:

- A table of contents.
- The complete test procedure.
- A narrative describing the conduct of the test, with dates and locations of test elements.
- Tables showing stresses and deflections which are 85 percent or more of the allowable.
- Description and explanation of any value that exceeded the test criteria.
- Appendices containing all data; i.e., output from each gauge for each load step. These data shall be identified with the date that they were recorded.
- The record photographs shall be mounted on pages the same size as the report pages.
- Stress (or strain) vs. load curves for the 10 greatest tension stresses and the 10 greatest compressive stresses for each test series.

17.3.3.12.1 Static Load Test

The purpose of this test is to verify that the maximum allowable static stresses selected by the Contractor and approved by NYCT are not exceeded under maximum expected static loads. The truck and bolster shall be loaded twice, with complete release of the load between applications. Strain gauges shall be re-zeroed after the first load application and the offset from zero recorded and reported. All required data shall be taken.
during the load applications. The methods and points of test load application and reaction shall simulate as closely as possible the actual loading conditions to which the truck will be subjected in service.

The vertical test load shall be the truck's share of completed vehicle plus an AW3 passenger load minus the weight of the truck. The lateral load shall be 25 percent of the vertical component. The longitudinal load shall be the maximum possible instantaneous braking effort with perfect adhesion at the wheels at AW3 load. The lateral and longitudinal loads shall act as if they were applied at the center of gravity of the completed vehicle plus an AW3 passenger load. Accessory loads, such as brake units, and traction motors, shall represent maximum steady state conditions; for example, maximum motor torque and brake unit weight, and maximum brake unit reaction and motor weight. All loads shall be applied to produce the worst stress conditions on the truck.

If the truck bolster is used as part of the air suspension volume, the bolster pressure during the static test shall be the maximum possible service pressure (the setting of the safety valve in the compressor discharge).

The truck will be compliant with this Specification if all of the following are met:

- Stresses calculated from strains measured at critical locations do not exceed fatigue allowables. Critical locations and fatigue allowables shall be as selected by the Contractor and approved by NYCT. This stress range shall be within the allowable fatigue endurance limit for non-redundant structures obtained from AAR C-11, Section 7.4 or AWS D1.1, Section 9.

- Maximum stresses calculated from strain readings in any gauge during the second load application do not exceed 50 percent of the material's yield stress.

- There are no permanent deformation, fractures, cracks, or separations in the truck.

If any of the above criteria are not met, the truck design shall be corrected and the truck retested at the Contractor's expense, and this process shall continue until these criteria are met.

17.3.3.12.2 Fatigue Test

To demonstrate that the truck has adequate fatigue strength under dynamic loading, the static test truck frame and bolster shall be subjected to not less than six million cycles of dynamic loading as specified below. The truck shall be tested as a unit and may contain its internal elastomeric cushioning and springs or an approved substitute thereof, but not shock absorbers.

Prior to the test, the test truck shall be given a wet, fluorescent magnetic-particle or fluorescent dye-penetrant inspection for cracks and other defects which might impair the performance of the truck during the test. Magnetic particle and dye penetrant inspections shall be in accordance with the requirements of Section 15.23.4. Any such defects found shall be recorded, and if required, repaired using an approved procedure in accordance with, as a minimum, the requirements of Section 15.5.4 and Section 15.23. The type,
size, location and repair of each defect shall be documented by photographs and drawings, and all such
documentation shall be included in the truck fatigue test report.

The mean vertical load shall be the truck's share of completed vehicle plus an AW3 passenger load minus the
weight of the truck, and the applied vertical load shall vary about the mean vertical load ±25 percent. The
lateral load shall vary between 15 percent of the mean vertical load acting towards one side of the truck and
15 percent of the mean vertical load acting towards the other side. The longitudinal load shall vary between
15 percent of the mean vertical load acting towards one end of the truck and 15 percent of the mean vertical
load acting towards the other end. The lateral and longitudinal loads shall act as if they were applied at the
center of gravity of the car body at the AW3 load, with resulting vertical loading applied to the bolster.

If the truck bolster is used as a part of the air suspension volume, the bolster pressure during the fatigue test
shall be the maximum service pressure required for a load equivalent to the truck share of full load on the
suspension.

Accessory loads shall be of the greater of:

- ±100 percent of the maximum load applied by the mounted equipment during service: motor
  under maximum torque and brake unit under full cylinder pressure with 25 percent adhesion;
  or

- A dynamic load range determined from a dynamic simulation of the truck in accordance with
  Section 4.1.5 or from a test of prototype trucks on representative portions of the NYCTS in
  accordance with Section 17.3.3.12.3.

The phasing of the loads shall be selected by the Contractor and approved by NYCT, and shall be such as to
produce the worst case stresses at critical locations.

During the fatigue test, the truck shall be visually inspected periodically to detect possible crack initiation and
progression. If evidence of crack progression or failure is found, the test shall be halted, the appropriate
corrective action taken, and the test rerun from the beginning, (on another truck if desired). All load cells and
strain gauges shall be recorded for both maximum and minimum loadings.

The truck will be compliant with this Specification if all of the following are met:

- Indicated residual strains at strain gauges on principal structural elements following removal
  of all loads do not exceed the maximum error resulting from the accuracy of the
  instrumentation.

- There is no permanent deformation, fractures, cracks, or separations in the truck.

- At the conclusion of the test, a magnetic particle or dye-penetrant inspection shall be made
  for cracks. The post-test inspection procedure shall duplicate the pre-test inspection
  procedure. If cracks are found which were not present before the test, or cracks have
  propagated from
17.3.3.12.3 Truck Dynamic Test

After the specified static load test and fatigue test, the first-available pair of trucks shall be subjected to a dynamic test on representative portions of the NYCTS. The NYCT will make the R110A train available to the Contractor for the purpose of conducting this test, if so desired by Contractor. The purposes of the test shall be to validate and calibrate the truck static and dynamic analyses required by Section 4.1.4, and to validate the accessory dynamic load ranges used to determine the applied fatigue load ranges for the fatigue test required by Section 17.3.3.12.2.

One of the two trucks shall be instrumented for acceleration and strain data. Tri-axial acceleration shall be measured on two diagonally-opposite journal bearing adaptors, on one gear box, one traction motor, one brake unit, and the truck frame transom. Not less than fifteen of the most critical locations shall be instrumented with linear or rosette strain gauges as appropriate. These locations shall include the motor/gear box, mounting brackets and the brake unit mounting bracket.

The test shall be considered as having been successful passed if:

- Processed accelerometer data confirms that the loads used during the fatigue test are conservative with respect to the actual measured loads. This shall be demonstrated on the basis of rain flow counting of the measured data, frequency-domain analysis of the data, or other approved method. Filtering used during data analysis shall have a band pass of not less than 1 to 200 Hz.

- Stresses calculated from the processed strain data is below the allowable fatigue stresses selected by the Contractor and reported in the truck stress analysis for each location instrumented for strain.

At the Contractor's option, the truck dynamic test may be performed prior to the fatigue test required by Section 17.3.3.12.2. If the Contractor selects this option, approval of the test procedure by the NYCT, and NYCT permission to perform the test shall depend on:

- Completion by the Contractor and review by the NYCT of the truck stress analysis required by Section 4.1.4, and

- Satisfactory resolution of NYCT questions on the truck stress analysis. Approval of the stress analysis shall not be a prerequisite for performing the truck dynamic test.

If this option is selected by the Contractor, pre-production truck frames and bolsters may be used, one truck instead of two may be used, and the test article may be non-powered and unbraked, with simulated drive and brake unit masses. Pre-production truck frames and bolsters, if used, shall be configured in accordance with
the NYCT Approved Contractor drawings, but may be assembled by expedient means without jigs, fixtures, and tooling that may eventually be developed for truck production.

17.3.3.12.4 Primary Suspension Tests

A deflection test and accelerated aging tests shall be performed to demonstrate that the spring rate of the primary suspension system and the creep rate for the materials used are within the design limits for the suspension's design life. The purpose of these tests shall be to prove that the primary suspension system performance meets design requirements and will not produce excessive deflections under any service load or allow the truck to infringe on the minimum clearance to the top of the rail as specified in Section 2.1.3 of this Specification. Data from previous tests on the same primary suspension elements may be submitted within 90 days of NTP, and if acceptable to NYCT this test may be waived.

17.3.3.12.5 Equalization Test MOD 02

To verify the equalization provided by the truck design, the first car of each car type making up a Unit, with air springs inflated, shall have one wheel first raised and then lowered 2½ inches (63.5 mm) with respect to the plane formed by the three other wheels as they rest on level, tangent track. Contact between the other three wheel treads and the rails shall be verified for both conditions. In addition, one wheel shall be first raised and then lowered 2 inches (50.8 mm) with respect to the plane formed by the other three wheels as they rest on level, tangent track without resulting in a change of more than 50 percent in the weight on any wheel with respect to its null-position weight in either condition. In the event that the required equalization is not demonstrated by these tests, the truck suspension shall be modified, and the truck retested at the expense of the Contractor.

17.3.3.12.6 Truck Radiographic Inspection Test

One of the first three production trucks for each type, including the frame, bolster, and any other primary structural members shall be qualified by radiographic inspection of all critical welds. Critical welds shall be defined as:

- All full penetration welds;
- All welds subject to tensile stresses in excess of 50 percent of the weld's rated fatigue life;
- All non-redundant load path welds whose failure could cause truck failure or derailment; and
- All welds whose failure could impair brake performance.

Radiographs shall be made in accordance with AWS D1.1 for welds. Inspection quality level shall be selected by the truck manufacturer to be consistent with the truck design, but shall not be of lesser quality than that required by Section 9 of AWS D1.1 for welds. Any defects found shall be repaired and the truck re-inspected. This process shall continue until a truck passes the inspection. Production variables shall be corrected for welds that continue to fail inspection. Critical areas may be sectioned and etched to demonstrate weld
soundness. In this case, there shall not be less than three etched sections at each critical area, and the location of each shall be approved by NYCT.

17.3.3.13 Coupler, Draft Gear, and Link Bar

Coupler, draft gear, and link bar design qualification tests shall include tests which validate the performance and capacities of the following:

- Coupler draft and buff loading,
- Link bar draft and buff loading,
- Draft gear deflection and emergency release,
- Coupler anchor static loading,
- Link bar anchor static loading,
- Gathering range, and automatic mechanical coupling and uncoupling,
- Electrical automatic coupling and uncoupling,
- Pneumatic automatic coupling and uncoupling,
- Centering, and
- Vertical strength capability.

These tests shall be done using two completed cars where appropriate.

17.3.3.14 Equipment Noise Tests

Noise design qualification tests conducted on equipment prior to its installation shall be performed early in the production phase. Test conditions shall be those applicable to pre-installed equipment as stated in Section 2.7.

17.3.3.15 Car Body Structural Tests

Structural testing, including all reports, shall be designed and developed to confirm that the analyses of each car body type structure specified in Section 3.4 are accurate, and that the car body structures meets the requirements of Sections 3.3, 3.4 and 3.5. The tests shall be sufficient for long-term use as part of the permanent information to be used to maintain, repair and modify the car throughout its life.

17.3.3.15.1 General

The first car shell of each type which is structurally unique shall be tested by the Contractor to show that the critical portions of the car body structure comply with this Specification. If there are no major structural differences between car types, one shell may be tested. The tests shall be made at an NYCT-approved facility. The tests shall not begin until the car body stress and energy absorption analyses have been approved.

The test specimens 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 paid to recording flatness and straightness.
The test shells shall be structurally complete, consisting of all car shell structure and fiberglass front end mask (if part of the design), but excluding such items as exterior and interior trim, windows, doors (except those used in the vertical load test), seats, lights, interior lining, insulation, or other parts that would obscure any structural member from view or that would interfere with the performance of the test. Underfloor equipment shall be simulated by equivalent weights at their respective locations. All structural tests shall be conducted on the same specimen.

The car shells 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. The method of calibration and time period for recalibration shall be in accordance with the test laboratory's national standard or ISO. 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 must be verified after the Contractor tests and before the official test begins. The official test (test of record) shall be witnessed by NYCT. A copy of all recorded data shall be given to the NYCT witness 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 output 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 NYCT representative for review. The Contractor shall obtain approval from the NYCT representative after every load step before proceeding with the next step. The Contractor shall not break down the test fixtures until the NYCT representative has reviewed all the 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 that were found to be non-compliant.

The entire procedure shall be videotaped by the Contractor with at least three sound-equipped VHS color video cameras. One camera shall be roving and the others shall be arranged in approved locations to view and record key areas. All video tapes taken during this test shall become the property of NYCT.

NYCT 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 NYCT unless the tests prove the design is non-compliant in any structural area. If non-compliant, the Contractor shall then be responsible for the test expenses and for all of NYCT-associated costs to NYCT, and the cost of modifications necessary for the car and all other cars to comply with the Specification. The Contractor (at its own expense) shall also perform a complete set of structural tests to qualify the modified car.
17.3.3.15.2 Test Procedure

A test procedure shall be prepared for each test. The procedure shall include a description of the test, the purpose, how and with what equipment the specimen is to be loaded and in what load increments, the type and location of strain gauges, the location of deflection gauges, complete description of all instruments and gauges, and details of the data acquisition system. Annotated copies of catalogue cuts may be used to provide some of this 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 be a step by step instruction describing how load is applied, the load at each step, when to record data, and the place where authorization to proceed is to be obtained from the NYCT representative. Test procedures shall be submitted not less than 60 days in advance of the test date, and approvals of the test procedure and stress analysis are necessary prerequisites for testing.

The test procedure shall include a copy of the current certification for every instrument and gauge to be used during the test. Typical logging sheets, print-outs, plotting forms, and examples of any other data sheets which will be used during the test or in the final report shall be submitted as part of the test procedure.

Tables shall be included which show the maximum allowable gauge reading for each gauge and loading condition. Other tables shall be included which show the requirements for all other test criteria.

Each test procedure shall contain a table of predicted strain (or stress) at selected strain gauge locations. This table shall list the strain gauge number, predicted strain (or stress) from the stress analysis, the location of the strain, a space to enter the actual strain (or stress) and a space to enter the calculated percent difference, defined as:

\[
\text{Percent Difference} = \frac{\text{Actual} - \text{Predicted}}{\text{Actual}} \times 100
\]

17.3.3.15.3 Strain Gauges

A minimum of 200 strain gauges shall be applied to the car structure for the compression tests. A minimum of 200 strain gauges shall be applied to the car structure for the vertical tests. A minimum of 200 strain gauges shall be applied to the car structure for the diagonal jacking tests. Some of the gauges may be used for more than one test if their location on the structure is appropriate for both tests, but readings from at least 200 strain gauges in locations where the stress may be critical shall be obtained for each test. The location of the strain gauges shall be based on the Contractor's experience, the stress analysis, and NYCT recommendations.

Drawings and sketches showing the location of every strain gauge shall be prepared by the Contractor and submitted as part of the test procedure. These drawings shall dimension the location of every gauge showing the distance from edges, connections and bends. The location 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.

For each post load test, there shall be a minimum of 100 strain gauges applied to the post and car structure. Some of the gauges may be for more than one test if their location on the structure is appropriate for both tests, but readings from at least 100 strain gauges in locations where the stress may be critical shall be obtained for each test.

17.3.3.15.4 Deflection Gauges

Vertical deflection of the car body shall be measured along the side sill during all tests. At least 11 gauges shall be used per side. Gauges shall be located at the end sills, at the bolsters, and half-way between the bolsters. The remaining gauges shall be evenly spaced between the five 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 this point.

During the vertical load test, the change in car body width at the belt rail, and at the top of the center door opening posts due to bending shall be measured and recorded. Two additional deflection gauges shall be applied in one center door opening in order to measure the change in the diagonal dimensions of the opening during the tests.

The deflection gauges shall have electric output 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, five dial indicators of sufficient stroke shall be employed to measure the vertical deflection at the center of both side sills, the longitudinal deflection at the anti-climber next to the ram and next to the reaction at the opposite end of the car. The fifth indicator shall be located next to the lowering jack during the diagonal jacking test. These dial indicators shall be read and manually recorded at every load step.

To measure the bending of the collision posts during the post tests, deflection gauges shall be applied to the post at a minimum of four places on each post being tested: top, bottom, middle, and load application point. These gauges shall be mounted to measure the deflection of the post in the direction of the applied force. In addition, a dial indicator shall be mounted at the middle of the post in each test.
17.3.3.15.5 Load Cells

In order to verify the accuracy of the applied vertical and compressive loads, load cells shall be provided at the appropriate location for each test. Each load cell shall be calibrated to 1 percent accuracy and certified within two months before commencement of these 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 electric output compatible with the data logging apparatus used with the strain gauges. All loads shall be recorded simultaneously with the strain gauge recordings.

A single load cell shall be placed at the end of the ram for the compression test. A load cell shall be placed at each secondary spring location for the vertical test. A load cell shall be placed at each jack location for the diagonal jacking test. Load cell readings shall be taken and recorded at each step of the vertical, compression and diagonal jacking load application and removal process.

17.3.3.15.6 Vertical Load Test

17.3.3.15.6.1 Test Description

The car body specimen supported on trucks or a simulation, shall be subjected to a vertical load test. A test load equal to the static vertical operating load specified in Section 3.4.4.1, shall be applied to the specimen. The load shall be applied in four approximately equal increments resulting in a total of five vertical load increments. One of these increments shall be equivalent to a ready-to-run car body 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 that it was loaded, in reverse order. Strain gauge and deflection readings shall be taken at each load increment. The vertical load test procedure shall provide for the anti-climber combined load test as required by Specification Section 17.3.3.15.10.

During the vertical load test, a measurement of car body vertical deflection shall be made along both car body side sills at each test load applied.

All side doors on one side of the car shall be installed. The doors shall be complete with operators, thresholds, and all sealing and weather-stripping. All door equipment shall be production equipment installed in accordance with production drawings and procedures. At each increment of test load, the doors shall be opened and closed electrically by means of the door operators simulating actual operating forces. The opening and closing time of each door leaf shall be measured and recorded electrically. Failure to operate at the prescribed speed specified in Section 11.2.2, or any indication of binding shall require corrective action to be taken by the Contractor. The vertical load test must then be repeated in its entirety.

17.3.3.15.6.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- Stresses are in accordance with the requirements of Section 3.4.4.
Vertical deflection 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 that point which represents the measured deflection for maximum vertical load.

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.

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.

Recorded residual vertical deflection between bolsters following removal of the maximum vertical test loading does not exceed 0.04 inch (1.0 mm).

Recorded residual car transverse width and/or opening diagonal dimensions following removal of the maximum vertical test load do not exceed 0.04 inch (1.0 mm).

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.

Car body 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 car body bolsters.

There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and NYCT to determine if the failure is the result of weld quality or stress.

The flatness and straightness of structural members meet the requirements of Section 3.3.4.

The side doors open and close at the specified speeds without binding at all test loads.

17.3.15.7 Compression Load Test at the End Sill

17.3.15.7.1 Test Description

The ability of the car body structure to resist the end sill compression loads specified in Section 3.4.4.2 shall be tested.

During the compression test, the car shell shall be supported on trucks or a simulation thereof to allow free longitudinal movement. The car shell shall be loaded with sufficient dead weight to bring the total body weight
The test load shall be applied to the anti-climber. The load shall be distributed over an area not to exceed the height of the anti-climber by 12 inches (305 mm) in width.

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. Cushioning means, such as lead sheets, shall be provided to assure uniform bearing. The test load shall be applied horizontally on the car longitudinal centerline. 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 2 percent of full load. 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.

17.3.3.15.7.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- Stresses are in accordance with the requirements of Section 3.4.4.2.
- The vertical deflection of each side of the test structure shall be within a ±10 percent of the value determined by the analysis.
- Vertical deflection 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.
- 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.
- 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.
- Recorded residual vertical deflection between bolsters following removal of the maximum vertical test load does not exceed 0.04 inch (1.0 mm).
- The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 inch (1.0 mm).
- 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.
There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and NYCT to determine if the failure is the result of weld quality or stress.

The flatness and straightness of structural members meet the requirements of Section 3.3.4.

17.3.3.15.8 Compression Load Test at the Coupler

17.3.3.15.8.1 Test Description

The ability of the car body structure to resist the coupler compression loads specified in Section 3.4.4.3 shall be tested.

During the compression test, the car shell shall be supported on trucks or a simulation thereof to allow free longitudinal movement. The car shell shall be loaded with sufficient dead weight to bring the total body weight (of test specimen) up 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. Cushioning means, such as lead sheets, shall be provided to assure uniform bearing. The test load shall be applied horizontally on the car longitudinal centerline. 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 2 percent of full load. 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.

17.3.3.15.8.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- Stresses are in accordance with the requirements of Section 3.4.4.3.
- The vertical deflection of each side of the test structure shall be within ±10 percent of the value determined by the analysis.
- Vertical deflection 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.
- 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.
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.

Recorded residual vertical deflection between bolsters following removal of the maximum vertical test load does not exceed 0.04 inch (1.0 mm).

The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 inch (1.0 mm).

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.

There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and NYCT to determine if the failure is the result of weld quality or stress.

The flatness and straightness of structural members meet the requirements of Section 3.3.4.

17.3.3.15.9 Primary Collision Post Load Tests

The ability of the car to resist the primary center and side collision post loads shall be tested, see Section 3.4.4.5. These tests shall be conducted in two parts. The first part shall be all tests which have a pass-fail criterion equal to or less than permanent deformation (elastic tests). These tests shall be performed on the same test specimen as used for the car body compression and vertical load tests. The second part shall be a test of the primary center collision post loaded at 18 inches above the floor, sufficient to cause permanent deformation (elastic-plastic test). The second part will require the construction of a model of the front end of the car up to the bolster. The model shall be a duplication of all structure which supports or influences the support of the post(s).

17.3.3.15.9.1 Primary Center Collision Post Elastic Load Tests

17.3.3.15.9.1.1 Test Description

The ability of the car body structure to resist the primary center collision post longitudinal loads specified in Section 3.4.4.5.1 shall be tested.

During the primary center collision post test, the car shell shall be supported on trucks or a simulation thereof to allow free longitudinal movement. The car shell shall be loaded with sufficient dead weight to bring the total body weight (of test specimen) up to that of an AW0 loaded car body. 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 collision post in Section 17.3.3.15.3, Section 17.3.3.15.4 and Section 17.3.3.15.5. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the model to the car body can be resolved.

A longitudinal test load as specified in Section 3.4.4.5.1 shall be applied to the collision 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 primary center collision post by 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 cushioning means, 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 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 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.

17.3.3.15.9.1.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- Deflection 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.

- 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.

- 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.

- 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.

- There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and NYCT to determine if the failure is the result of weld quality or stress.

- The flatness and straightness of structural members meet the requirements of Section 3.3.4.
17.3.3.15.9.2 Primary Side Collision Post Elastic Load Tests

17.3.3.15.9.2.1 Test Description

The ability of the car body structure to resist the primary side collision post longitudinal compressive loads specified in Section 3.4.4.5.3 shall be tested.

During the primary side collision post longitudinal test, the car shell shall be supported on trucks or a simulation thereof to allow free longitudinal movement. The car shell shall be loaded with sufficient dead weight to bring the total body weight (of test specimen) up to that of an AW0 loaded car body. 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 collision post in Sections 17.3.3.15.3, 17.3.3.15.4 and 17.3.3.15.5. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the model to the car body can be resolved.

A longitudinal test load as specified in Section 3.4.4.5.3 shall be applied to 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 primary side collision post by 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 cushioning means, 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 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 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.

17.3.3.15.9.2.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- Deflection 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.

- 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.

- 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.
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- 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.

- There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and the NYCT to determine if the failure is the result of weld quality or stress.

- The flatness and straightness of structural members meet the requirements of Section 3.3.4.

17.3.3.15.9.3 Primary Side Collision Post Transverse Load Test

17.3.3.15.9.3.1 Test Description

The ability of the car body structure to resist the primary side collision post transverse loads specified in Section 3.4.4.5.3 shall be tested.

During the primary side collision post test, the car shell shall be supported on trucks or a simulation thereof. Transverse restraining apparatus may be attached to the car body bolsters. The car shell shall be loaded with sufficient dead weight to bring the total body weight (of test specimen) up to that of an AW0 loaded car body. 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 collision post in Sections 17.3.3.15.3, 17.3.3.15.4 and 17.3.3.15.5. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the model to the car body can be resolved.

A transverse test load as specified in Section 3.4.4.5.3 shall be applied to 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 primary side collision post by 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 cushioning means, 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 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.
17.3.3.15.9.3.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- Deflection readings plotted against load do not vary by more than $\pm 5\%$ 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.

- Strain readings plotted against load do not vary by more than $\pm 5\%$ 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.

- 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.

- 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.

- There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and NYCT to determine if the failure is the result of weld quality or stress.

- The flatness and straightness of structural members meet the requirements of Section 3.3.4.

17.3.3.15.9.4 Primary Center Collision Post Elastic-Plastic Test

The ability of the connections between the primary center collision post and the car body structure to withstand a longitudinal load equal to the ultimate load carrying capacity of the post as specified in Section 3.4.4.5.1 shall be tested.

The test specimen shall be a full scale structural model of a cab end of a car. The structural model shall contain all structural elements required to support the primary center collision posts including the end underframe and roof extending from the forward end of the end frame to the bolster. All connections shall be the same as on 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 will be the same as it would be in a car subjected to the same load.

The specimen shall be instrumented as required for the car and collision post in Section 17.3.3.15.3, 17.3.3.15.4 and 17.3.3.15.5. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the model to the car body can be resolved.
The longitudinal test load shall be applied to the collision 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 primary center collision by 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 cushioning means, 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 primary center collision post elastic load test, Section 17.3.3.15.9.1.1. The load shall be reduced to not more than 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 percent of the gauge readings for the same load and location measured during the primary center collision post elastic test, Section 17.3.3.15.9.1.1. If difference between the two tests are obtained, the fixture and/or the model will be corrected until 5 percent agreement between the two tests are obtained.

After agreement between the two tests is demonstrated, the collision post will continue to be loaded in increments of 25 percent of the full load specified in the primary center collision post longitudinal load test until the load carrying capacity of the collision post is obtained. At each 25 percent load increment, all load cell(s), strain gauges, and deflection gauges shall be recorded. The load need not be relaxed at each step.

The ultimate load carrying capacity of the post is defined as the condition where the post cannot support an increased load and the center of the post has deflected more than its full depth. This deflection is measured at the middle of the post from a line connected between the top and bottom of the beam.

17.3.3.15.9.4.1 Test Criteria

The collision post will be compliant with this Specification if all of the following are met:

- All strain gauges and deflection gauges have the same readings for the same loads at the same locations as the primary center collision post elastic load test for 0 to 100 percent of the loads specified in Section 3.4.4.5.1.

- The connections between the primary center collision post and all other structural members are not broken.

17.3.3.15.10 Compression Test Anti-Climber Load

The anti-climber and car body structure shall be tested under the loads of Specification Section 3.4.4.8. There shall be two tests; one a test of the anticlimber and its attachment to the end sill, and the other a test to permit, by superposition and extrapolation, validation of the anti-climber combined load case analysis.
A loading test of the anti-climber and its attachment to the end sill shall be performed by the Contractor. The test shall be performed on an actual production anti-climber, which may be mounted in a special test fixture, as long as the method of attachment to the test fixture is the same as production, so that the connection will be subjected to the test loads in a realistic manner.

In addition, as part of the vertical load testing required by Specification Section 17.3.3.15.6, a test shall be performed on the car body structural test article to permit validation of the analysis of the anti-climber combined load case of Specification Section 3.4.4.8. At a convenient time during the vertical load testing, the test article shall be loaded by placing a jack under the cab end sill with an intervening load cell. The jack shall be raised until the test article is supported on the jack and the truck at the far end of the test article, and strain a deflection data shall be recorded relative to the normal vertical load condition, or other appropriate condition which will permit the test data to be referenced to zero load for the test support condition. The contractor shall propose a test method for this purpose in detail in its test procedure, including procedures for data extrapolation and superposition to produce data which can be compared with the analytical results for the corresponding anti-climber combined load case. Alternate procedures for accomplishing the intended purpose will be considered as long as the results are based on data from a test or tests of the car body structural test article.

17.3.3.15.11 Diagonal Jacking Test

17.3.3.15.11.1 Test Description

The car shell shall be loaded to its AW0 weight, with all trucks (or an equivalent weight) hanging from the body bolsters. The car shell shall be supported symmetrically at the jack pads at the four corners of the car. One of the jacks shall be lowered in five equal increments until the load on the jack is 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.

17.3.3.15.11.2 Test Criteria

The car will be compliant with this Specification if all of the following are met:

- 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.

- 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.

- Indicated residual strains at strain gauges following return to original level do not exceed the maximum error resulting from the accuracy of the instrumentation.

- There shall be no permanent deformation, fractures, cracks or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and NYCT to determine if the failure is the result of weld quality or stress.
The flatness and straightness of structural members do not exceed the requirements of Section 3.3.4.

17.3.3.15.12 Structural Changes

Any structural changes or modifications made 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 these structural changes or modifications. These tests and modifications shall be at the expense of the Contractor.

17.3.3.15.13 Test Report

The Contractor shall prepare and submit a final test report within 30 days after successful completion of the structural tests. Approval of the test report constitutes acceptance of the car structural tests. The test report shall include:

- A table of contents.
- The test procedure (with all its appendices).
- A narrative describing the conduct of the test.
- Tables showing stresses and deflections which were 80 percent or more of the allowable.
- Description and explanation of any value that exceeded the test criteria.
- 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.
- The record photographs shall be mounted on pages the same size as the report pages.
- The video record of the tests formatted for VHS-North America.
- Side sill deflection curve for each load step.
- Stress (or strain) vs. load curves for the 10 greatest tension stress locations and the 10 greatest compressive stress locations for each test series.
- Tables comparing the stresses computed in the analyses with stresses computed from the strain gauge readings for each test. These tables shall be annotated to explain differences between the predicted and test values.
17.3.3.15.14 Crush Energy Tests

17.3.3.15.14.1 Elemental Energy Tests

In order to demonstrate the energy absorption properties of structural elements, a series of crush tests shall be performed. These tests shall measure the force required to compress (crush) a structural element a measured distance in order to develop a force-displacement curve for every member which contributes to the total energy absorption of the car required by Section 3.4.2. Members which are designed not to contribute to the total energy absorption will also be tested to demonstrate that these members do not interfere with the energy absorption elements. Full-size elements shall be used.

The specimen shall be manufactured in the same manner as the part to be used on the car. It shall have a grid pattern appropriate to the specimen size marked over its entire surface. It shall be connected to a fixture in the same manner it is connected in the car assembly. The specimen and fixture shall be mounted in a calibrated test machine. A combination of elements may be tested together for economy.

The specimen shall be continuously compressed (crushed) slowly, approximately 3/4 inch/sec (19 mm/sec), or at a different rate proposed by the Contractor and approved by the NYCT. The force and deflection shall be continuously recorded (plotted) during the test. At the same time, the test shall be recorded on two (2) color video cameras. The cameras shall be situated to best show the crushing of the specimen. One of the cameras shall be set up to show the force-deflection plot and the specimen in the same frame. All tests shall be witnessed by a representative of NYCT.

Prior to testing, a test procedure shall be submitted for approval. The procedure shall include a description of the test, test specimens, and test apparatus; the purpose of the test; location of video cameras; and complete descriptions of all instruments, gauges and data acquisition system. Drawing(s) showing the specimen with grid pattern, the fixtures, the attachment of the specimen to the fixture, and test apparatus shall be included. The procedure shall be a step-by-step instruction describing how the load is applied, and how it is recorded. The procedure shall contain detailed steps, calculations and tables for the correlation of analysis results with test results. The test procedures shall be submitted not less than 60 days in advance of the scheduled test date. The procedure shall be approved before testing can commence.

A test report shall be submitted for approval. It shall contain the raw data as well as reduced data. It shall include the force-deflection curves and photographs of the specimens before, during and after the tests. A copy of all the videos formatted in VHS-North America shall be included with the original report. The report shall contain correlation of test and analysis data. Approval of the energy absorption analysis report will depend on the approval of the crush energy test report.

17.3.3.15.14.2 Car Body Energy Test

Full-scale crash testing of a car end will be required if the Contractor cannot establish the accuracy of its crashworthiness analysis from prior programs where a test was performed and the results were in substantial agreement with the analysis. It must be shown that the analysis model used previously and the model to be used for the program are substantially the same.
The purpose of the test is to show that the car body meets the requirements of Section 3.4.2, and to verify the crashworthiness analyses specified in Section 3.4.2.

The test procedure will follow the format as required by Section 17.3.3.15. The procedure shall be developed by the Contractor and approved by NYCT.

The test report shall meet the requirements of Section 17.3.3.15.

17.3.3.15 Equipment Support Test

The strength of equipment supports subject to stress analysis as required by Section 3.4.3.1 shall be tested. The three heaviest items of equipment, and a fourth selected by NYCT shall be subjected to the required tests.

Each item of equipment required to be tested shall be subjected to loading in both senses on all three principal axes in accordance with the requirements of Section 3.4.4.13 with all supports active. The tests shall then be repeated with one less than the total number of supports in accordance with the requirements of Section 3.4.4.13.

The test shall be considered as having been successfully passed if the failure criterion of Section 3.4.4.13 are met.

17.3.4 Systems Qualification Tests

The following systems qualification tests shall be performed by the Contractor, or under its direction, to demonstrate conformance to the requirements of this Specification:

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<td>Network System</td>
<td>One Train Set</td>
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17.3.4.1 Information Signs

One of each type of information sign within Section 13.5 shall be tested to meet the performance requirements of that Section and the environmental requirements within Appendix A.

17.3.4.2 Communication System

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The Contractor shall conduct a test of the communication equipment to verify compliance with Section 13. Tests shall include specific elements for the amplifier, digitized audio, and digitized message generation. With NYCT approval, this test may be waived.
17.3.4.3 Propulsion System

A combined systems laboratory test shall be conducted on one complete set of propulsion equipment, including motors, power conditioning, protection devices, logic and controls using a dynamometer which simulates vehicle inertia by means of flywheels or programming of a motor-generator, and which simulates train resistance by means of a motor-generator. The physical layout of car components and cabling for this test shall simulate actual car conditions. This test is for the purpose of demonstrating that the propulsion equipment functions properly and meets all requirements of Section 2.4.

For the purpose of the test, the trainlines and control network shall be exercised by the actual or an appropriate emulation of the trainline and network drive apparatus (Master Controller, console, etc.). In order to demonstrate the compatibility requirement of Section 1.3, the logic and control part of the test shall be performed with both the R142 and R142A trainline and network drive apparatus if they differ.

This set of propulsion equipment shall also be tested for electromagnetic emissions, conductive and inductive, according to the methods referenced in Section 2.6.

17.3.4.4 Friction Brake System

The friction brake system qualification testing shall include the following tests on one of the first three production systems or system components as appropriate.

17.3.4.4.1 Response

The friction brake system shall be tested in combination with the propulsion control logic to determine conformance to the specified requirements for output force, time, and magnitude, and stability of response to all control inputs.

17.3.4.4.2 Linearity

A set of dynamometer test runs shall be made with the friction brake system, to determine conformance to Specification requirements for accuracy and time response. Test runs shall be made corresponding to a car loading of AW0, AW2, and AW3 at 10, 30, and 50 mph (16, 48, and 81 km/h). For each entry speed, input signals calling for 25, 50, 75, and 100 percent of full service friction braking effort, and friction emergency braking effort shall be used. All tests shall be run with brake elements (shoes and wheels) initially at ambient temperature and also with hot elements as defined below. Results shall be plotted to show both the instantaneous and average relationship between input signals and output braking effort over the speed and weight ranges for both motor and trailer trucks. "Hot" element temperature is defined as a minimum of 250°F (121°C) and a maximum of 450°F (232°C) for the wheel braking surface.

17.3.4.4.3 Brake System Capacity

The brake elements shall be tested on a dynamometer or flywheel to verify the brake system capacity with brake elements initially at ambient temperature and also hot (as defined in Section 17.3.4.4.2). The test shall be run.
using the friction brake duty cycle specified in Section 2.4.5. The elements (wheel and shoe surface temperatures shall be measured and recorded throughout the test and shall not exceed 450°F (232°C). At the completion of this test the brake unit shall remain in an undamaged, fully operable condition. Production elements, actuator, wheel and shoes shall be used for this test.

17.3.4.4 Pressure

All pneumatic brake system components shall be pressure tested at 150 percent of the main reservoir safety valve operating pressure. No component damage shall occur.

17.3.4.5 Brake System Endurance Test

A complete friction brake system including the electronic control unit shall be subjected to an endurance test of one million cycles of normal apply and release applications. Brake reaction forces shall be simulated on the actuators. Failures which occur shall be within the specified reliability values.

17.3.4.6 Brake System Environmental Test

A complete car set of friction brake equipment including the electronic and pneumatic control units, shall be subjected to an environmental test as described in this Section. If it is impractical to test a complete system at once, duplicate parts of the system may be simulated, with the requirement that at least one representative assembly of each type is subject to the test conditions. If it is impractical to place the pneumatic system in the test chamber at the same time as the other equipment it may be tested separately.

The environmental test shall be conducted over the temperature and humidity ranges found in the New York City Metropolitan Area (reference Appendix A). The test shall consist of cycling the temperature and humidity that the equipment is exposed to between the minimum and maximum temperature and humidity conditions according to the following test schedule while recording performance parameters for the equipment at minimum, nominal, and maximum vehicle power supply voltages for the system.

The test schedule shall start with an overnight (8 hours minimum) soak at the maximum temperature with the power on. The equipment shall then be tested. After which the equipment shall be subjected to eight (8) temperature and humidity cycles between minimum and maximum with each cycle to last twelve (12) hours, including holding at the minimum and maximum temperatures for at least one (1) hour each during each cycle.

No system or component failure shall occur.

17.3.4.5 Door System

Door, door operator, control, and obstruction detection design qualification tests shall include an accelerated life test of 2.0 million cycles for one complete set of door hardware. These tests shall be completed before the first car is delivered to NYCT. 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.
17.3.4.6 Air Conditioning

17.3.4.6.1 General Requirements

One air conditioning unit complete with all controls shall be given a dual chamber climate room test by the manufacturer to verify the capacity and functioning of ventilation and air conditioning according to the temperature schedule of Section 12.5.4 and at test conditions specified in Sections 12.4.2 and related requirements. This test shall be successfully completed prior to the vehicle climate room tests required by Section 17.3.5.4.

Appropriate test log sheets and calculation forms shall be generated and included with the Qualification Test Procedure which shall become a part of the Qualification Test Report.

Equipment qualification testing shall be conducted at nominal supply and control voltages except where otherwise specified.

17.3.4.6.2 Test Methods and Standards

The air conditioning equipment shall be tested according to ANSI/ASHRAE Standard 37, Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment. In additional to test "A", the secondary applicable test method "B" shall be selected by the manufacturer from Table 3 of the Standard. All ventilating and cooling apparatus and controls shall meet the safety requirements of UL Standard 465, Sections 33, 70, 78, and 85, except that the wind velocity during Section 85 test shall be simulated at 80 mph (130 km/h) from the front, 65 mph (105 km/h) from the sides, or the worst combination of the two velocities and directions.

Sound and vibrations levels shall be tested to assure conformance with the requirements of Section 2.7 and the recommendations of AMCA Bulletin No. 300. All ventilating, and cooling apparatus and controls shall also meet the applicable requirements of the AAR RP-037, Air Conditioning Recommended Practice.

In the event of conflict between the referenced standards and this Specification, the Specification shall govern.

17.3.4.6.3 Instrumentation

- The accuracy and tolerances of all instrumentation and tests shall comply with Sections 5 and 9.2 and Table 4 of ASHRAE Standard 37. All temperature measurements and measurement techniques shall comply with ASHRAE Standard 41.1.

- Proof of the calibration of all instruments, traceable to a master at the national standards organization of the applicable country, shall be submitted to the NYCT for approval prior to testing.

- An event recorder shall be provided to monitor operation of relays and contactors.
All data (temperature, pressure, voltage, current, speed, and event) shall be continuously recorded by an approved data acquisition system using appropriate transducers. The data acquisition system shall be capable of providing the graphical representation (strip chart) of the selected channels while test is in progress.

17.3.4.6.4 Data Requirements

All data recordings shall be conducted according to ASHRAE Standard 37, Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment. The data listed below shall be the minimum recorded by the Contractor during the testing.

- Temperatures:
  - Unit mixed air inlet (dry bulb & wet bulb)
  - Unit air outlet (dry bulb & wet bulb)
  - Condenser air inlet
  - Condenser air outlet
  - Discharge at compressor 12 inches (305 mm) away from compressor
  - Suction at compressor 12 inches (305 mm) away from compressor
  - Liquid leaving condenser
  - Liquid at TXV - each circuit
  - Suction at evaporator - each circuit
  - Compressor crankcase oil
  - Condenser fan motor windings - two at each motor end
  - Evaporator blower motor windings - two at each motor end
  - Air adjacent to the High Limit Switch
  - Air adjacent to the Shunt Trip Circuit Breaker Activating Device

Note: All refrigeration system thermocouples shall be soldered to a metal surface and insulated.

- Pressures, psi (kPa):
  - Discharge at compressor
  - Suction at compressor
  - Liquid leaving condenser
  - Liquid entering evaporator coil - each circuit
  - Suction at evaporator - each circuit

- Air Flows
  - Evaporator coil
  - Condenser coil(s)

- Pressures, inch of water (mm of water)
  - Evaporator fan total or evaporator fan static
  - Air supply plenum - static
Evaporator coil air pressure drop
Static pressure difference across nozzle inside air tunnel
Condenser coil pressure drop

Barometric pressure, inch of mercury (kPa)

Electrical - Compressor, Condenser and Evaporator motors and heater section separately
Volts - each phase
Amps - each phase
Watts
RPM (all motors)
Power factor (except heater)

Event Recorder shall be used for the operation of the following components:
Compressor
Solenoid valve - main liquid line
Solenoid valve - modulation
Duct Temperature Sensor (OHDS)
Overhead heat
High Limit Switch
Back-up Protection Activating Device

Miscellaneous
Refrigerant oil flow rate (if required) - L/s (cfm)
Ratio of refrigerant in refrigerant-oil mixture (if required) - ft3/ft3 (m3/m3)

17.3.4.6.5 Test Requirements

17.3.4.6.5.1 Scan Test

The temperature control components shall be exposed to the temperature environments they will experience on the car. All points of temperature control shall be verified on temperature rising and temperature falling, including a demonstration of the pump-down cycle. The temperature shall be varied slowly to reflect natural temperature lags as experienced in actual installation.

The simulated vehicle interior and ambient rooms shall be instrumented with temperature measuring devices to determine when various control switching points are reached. A light panel shall be used to determine which contactors are picked up to verify control response, and the LED operation mode lights shall be observed to monitor operation of the system. The simulated vehicle interior and ambient temperatures shall be cycled up and down, at least 20 times, through the operating range of the temperature sensors.

Any malfunction of the system or components at any temperature shall constitute a failure of the test. The use of test switches to control the unit independent of the temperature sensors is not permitted.
17.3.4.6.5.2 Control Stability Test

Under steady state operation at design conditions, the 37.5 Vdc nominal control voltage shall be varied between the limits allowed by Sections 2.3.3 to show the effect of such change.

17.3.4.6.5.3 Cooling Capacity

Cooling capacity shall be verified at the design conditions listed in Section 12.4.2, following the procedure of the ANSI/ASHRAE Standard 37, Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment.

17.3.4.6.5.4 Maximum Operating Conditions

A system functional test shall be performed at 110°FDB/80°FWB (43°CDB/26.7°CWB) ambient and evaporator air mixture based on this ambient and interior car temperature at 83°FDB (28.3°CWB) with 50 percent RH.

A successful test shall consist of continuous operation of the system at design conditions for one hour without shutdown due to high pressure, modulation, circuit breaker trip, compressor motor overload, or any device failure. A shutdown for any reason while operating at these conditions shall constitute a failure of the test. All data shall be recorded every five minutes during the steady state of operation.

At the end of one hour of operation, the system shall be momentarily stopped and then restarted. The system shall continue to function properly with all components safe from malfunction. There is no capacity to be met. This test shall be conducted at nominal supply voltage, 10 percent overvoltage and 10 percent undervoltage.

17.3.4.6.5.5 Modulation Pressure Switch Test

A test with air entering the condenser at higher than 110°F (43°C), and at the evaporator air mixture based on the conditions of Section 17.3.4.6.5.4 shall be used to demonstrate pressure modulation capability. As the condenser outlet air dry bulb temperature rises, pressures and temperatures shall be recorded and the system shall be allowed to cycle due to the modulated operation. The frequency of pressure switch cycling shall be recorded. All system pressures and temperatures, and the state of compressor oil in its sight glass shall be recorded.

A successful test shall consist of one hour of continuous operation of the system without shutdown due to high pressure, cutoff, circuit breaker tripping, compressor motor overload, or any device malfunction.

17.3.4.6.5.6 High Pressure Cut-Off Switch Test

Upon conclusion of the modulation pressure switch test, the condenser air temperature shall be slowly increased to 125°F (52°C). The system shall operate at least one hour continuously at this condition while maintaining the interior mixture conditions defined in Section 17.3.4.6.5.4 without operation of the high pressure cut-off device. Following this, the condenser/fresh air ambient shall be slowly raised to the point when the high
pressure cutoff switch activates and shuts off the system. Record pressures and temperatures of the pressure switch cutoff and reset conditions. This test shall be repeated four times.

17.3.4.6.5.7 Low Temperature Operation Test

A low temperature operation test shall be conducted at air temperature entering evaporator coil based on the mixture of the recirculated air at 70°FDB (21°CDB), 50 percent RH and ambient conditions determined from the control chart to be 2°F (1°C) higher than the compressor lock-out point. After attainment of the specified temperature conditions, the unit shall be operated continuously for a period of four hours. During the test, the unitized air cooling system shall operate without damage to the equipment and without the formation of any ice or frost on the evaporator coil or piping. Proper oil return to the compressor shall be verified. The data shall be recorded every 10 minutes during steady state operation.

17.3.4.6.5.8 Insulation Efficiency and Condensate Carry-Over Test

The unit insulation efficiency shall be tested with ambient and evaporator entering air temperature at 80°FDB (27°CDB) 75°FWB (24°CWB). The unit shall be operated continuously for a period of four hours at the specified conditions. During the test, no condensed water shall drop, run, or blow off the unit's casing.

All condensation from the evaporator coil shall be retained inside the drain pan. No condensate shall spill from the drain pan.

17.3.4.6.5.9 Refrigerant Sample Test

A sample of refrigerant and oil shall be taken from the air conditioning system of the tested unit and analyzed for contaminants by an approved laboratory. Test results shall satisfy the requirements of ARI Standard 700.

17.3.4.6.5.10 Watertightness and Water Eliminator Test

The HVAC equipment system shall be watertightness tested as specified in Section 17.3.5.1. The testing shall be conducted without power to the unit (blowers inoperative) and with power to the unit (blowers functioning). Water eliminator performance shall conform to the requirements of Section 12.2.6.

17.3.4.6.5.11 Noise Test

The HVAC equipment shall be noise tested to determine conformance to the requirements of Section 2.7.

17.3.4.6.5.12 Abnormal Heating Condition, Restricted Air

During this test, the ambient temperature shall be maintained at approximately 70°F (21°C) with the system heaters activated independent of the thermostat and with the air conditioning compressor not operating, and with the air flow switch bypassed. The test shall be conducted by slowly restricting the mixed air inlet so that heater unit temperature rises 2°F (1°C) per minute, but not faster, until the high limit switch cycles off. The restriction shall be eased to the point where the high limit switch stays closed. The heating test shall continue
to simulate a dirty filter condition. The system shall operate until a steady condition is reached. Temperature readings shall be recorded every 5 minutes.

The test shall be performed at nominal, low, and high supply voltage specified limits. The test shall be successful when the following criteria are met:

- The back-up protection did not activate during the test.
- The temperature inside the unit did not cause damage to the equipment and components.
- There was an absence of any smoke and odors.
- The high limit switch opened at the design set point ±18°F (±10°C).

17.3.4.6.5.13 Abnormal Heating Condition with No Air Flow

The ambient temperature shall be maintained at approximately 70°F (21°C). The air conditioning compressor shall not be operating and the air flow switch shall be bypassed. Power shall be applied to the heaters with no air blowing over the heaters. The system shall be operated as the high limit switch cycles.

The criteria of Section 17.3.4.6.5.12 shall apply for supply voltages at nominal, low, and high specified limits.

17.3.4.6.5.14 Back-Up Protection Test

The ambient temperature shall be maintained at approximately 70°F (21°C). The air conditioning compressor shall not be operating. Prior to power application to the heaters, the high limit switch and air flow switch shall be bypassed. The heaters shall be energized and the activation temperature of the back-up protection device shall be observed. The equipment interior temperatures shall be measured and recorded, at least once per minute, from the start of the test until all recorded temperatures start decreasing.

The test shall be performed at nominal, low, and high supply voltage specified limits. The test shall be successful when the following criteria are met:

- The temperature inside the unit did not cause any damage to wiring, electrical components, motor, and unit insulation.
- There was an absence of any visible smoke.
- There was an absence of any detectable odors.

17.3.4.7 Network System

The Contractor shall conduct a laboratory simulation test of the train and car network system. The simulation equipment shall be representative of an actual train. It shall include representative nodes of each type, network
management computers, coupler contacts and wire lengths that are equivalent to the actual application. The test shall include, but not be limited to the following:

- Proper point-to-point addressing,
- Error Rate versus Data Rate,
- Replacement of nodes,
- Replacement of management computers,
- Reversing coupled Units,
- Direction and side Determination,
- Proper Priority for Real Time Control, and
- Response to faults.

This simulation equipment shall remain intact and available for additional testing until one year after acceptance of the first car.

17.3.5 Car Qualification Tests

The following tests shall be performed by the Contractor on the indicated cars or Units prior to shipment to NYCT, unless otherwise approved by NYCT. The selection of cars to be tested shall be approved by NYCT.

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watertightness</td>
<td>First car each type</td>
<td>17.3.5.1</td>
</tr>
<tr>
<td>Air Leak</td>
<td>First car each type</td>
<td>17.3.5.2</td>
</tr>
<tr>
<td>Door Operation</td>
<td>First two cars each type</td>
<td>17.3.5.3</td>
</tr>
<tr>
<td>Climate Room</td>
<td>First Cab Car</td>
<td>17.3.5.4</td>
</tr>
<tr>
<td>Lighting</td>
<td>First car each type</td>
<td>17.3.5.5</td>
</tr>
<tr>
<td>Weight Distribution</td>
<td>First car each type</td>
<td>17.3.5.6</td>
</tr>
<tr>
<td>Coupled Car Clearance</td>
<td>First car each type (in conjunction with</td>
<td>17.3.5.7</td>
</tr>
<tr>
<td></td>
<td>appropriate adjacent cars)</td>
<td></td>
</tr>
<tr>
<td>Parking Brake</td>
<td>First car each type</td>
<td>17.3.5.8</td>
</tr>
<tr>
<td>Noise and Vibration</td>
<td>First car each type</td>
<td>17.3.5.9</td>
</tr>
<tr>
<td>Horn</td>
<td>First A Car</td>
<td>17.3.5.10</td>
</tr>
<tr>
<td>Car Networks</td>
<td>First car each type</td>
<td>17.3.5.11</td>
</tr>
</tbody>
</table>

17.3.5.1 Watertightness Test

The fresh air and electric equipment ventilation intake ducts in the all the car type roofs shall be water tested with the ventilating fans running at full speed, to determine the effectiveness of the water-excluding features of the duct work. At the conclusion of the test, there shall be no evidence of moisture in the ducts downstream of the water excluding features or evidence of water in any equipment.

The watertightness test shall be performed on each of the first car types as part of the car qualification test.
Exterior equipment enclosures or interior equipment enclosures which have access to the outside, are required to be watertight. Enclosures shall receive a water test at the point of manufacture. During test of the boxes, the required spray is to be directed at the exposed sides and ends of the boxes as would normally occur during car washing operations, as a simulation of water spray from the wheels, or as wind driven rain on exposed elevated trackage. At the conclusion of the test, there shall be no evidence of moisture in the boxes.

17.3.5.2 Air Leakage

To assure a positive internal car body pressurization, the first car of each type shall be given an air leak smoke bomb test with the interior positively pressurized. All openings related to ventilation shall be sealed during this test. All apparent leaks shall be corrected by the Contractor.

17.3.5.3 Door Operation

Before delivery, the first two cars of each type and two other cars of each type, selected at random by NYCT, shall have all doors operated for 1,000 continuous trouble-free cycles. One of the four cars of each type shall be loaded to AW3, uniformly distributed, for the cycle test.

Any door or door control failure occurring prior to completion of the test on each car will nullify the test, and the test shall be re-run completely after the fault has been corrected.

17.3.5.4 Vehicle Climate Room

17.3.5.4.1 General

A complete climate room test shall be performed on the first Cab Car. The climate room test shall demonstrate the heating, ventilation and air conditioning system's ability to comply with the temperature control and operational requirements of Section 12. Testing on the cab (A) car must technically compensate for the waiver of no cab (B) car testing analysis to be submitted for NYCT review and approval. Testing shall include a functional check of all apparatus including temperature sensors and controls, an air balance test, a pressurization test, and a temperature and relative humidity check to show compliance with the specified cooling requirements with all apparatus operating at nominal voltage except when specified otherwise.

The heating, ventilation and air conditioning system shall be powered by the unit power systems, i.e., the auxiliary IVPS and/or ac inverter power supply and low voltage systems. During the air cooling tests, the following auxiliary ac power supply test points shall be monitored, recorded and incorporated into the test report:

- Input power,
- Output voltage each phase,
- Output current each phase, and
- Temperature of the most sensitive temperature critical component/components of the inverter, if used.
17.3.5.4.2 Test Facility Requirements

The climate room for the vehicle level heating, ventilation and air conditioning testing shall be capable of achieving and maintaining any test temperature from 0°FDB (-17.8°CDB) to 126°FDB (52°CDB) and any relative humidity throughout that range between 25 percent and 90 percent.

Temperature in the facility shall be uniform throughout. There shall be no more than 5°F (3°C) variation from 24 inches (610 mm) above the running rail to 24 inches (610 mm) above the vehicle roof and from end to end of the car. Fans may be used to circulate the air in the facility. Passenger load shall be simulated by means of heaters and humidity generating equipment inside the car. Solar and equipment loads shall be simulated by means of heaters inside the cars. Humidity introduced into the car to simulate the latent heat load shall be carefully metered to assure the accurate proportioning of sensible and latent design loads. Load simulating equipment shall be evenly distributed throughout the car such that it as closely as possible represents the actual operating conditions.

17.3.5.4.3 Instrumentation Requirements

- A proof of the calibration of all instruments, traceable to a master at the national standards organization of the applicable country, shall be submitted to the NYCT for approval, prior to testing.

- Relative humidity of the car interior and fresh air shall be measured with an approved sampling device in accordance with ASHRAE Standard 41.1 at each return air grille and fresh air inlet.

- A minimum of 28 representative car interior temperature locations, including the operating compartment, shall be provided, as agreed between the Contractor and NYCT.

- Refrigerant pressure measurements shall be taken with one or more of the following instruments:
  - Bourdon tube gauge
  - Electronic pressure transducers

- The accuracy of the refrigerant pressure measuring instruments shall permit measurements within ±2.0 percent of value being measured. In no case shall the smallest scale division of pressure measuring instrument exceed 2-1/2 times the specified accuracy.

- Air pressure measurements shall be made with manometers, or approved equal, having an accuracy of ±0.01 inches of water (2.5 Pa).

- Electrical instruments used for measuring the electrical input to heaters shall be accurate to ±1.0 percent of the quantity measured. Instruments used for measuring the electrical input...
to fan motors, compressor motors, or other equipment accessories shall be accurate to ±2.0 percent of the quantity measured.

- Rotational speed measurements shall be made with either a revolution counter, tachometer or stroboscope having an accuracy of ±1.0 percent.

- The air flow measurements shall be made with a "Flow Hood 8410", as manufactured by Shortridge Instrument Company or approved equal. Adaptor ducts may be used when required.

- An event recorder shall be used to monitor operation of relays and contactors.

- All data; i.e., temperatures, pressures, voltage, current, and speeds, shall be continuously recorded by an approved data acquisition system using appropriate transducers. The data acquisition system shall be capable of providing the graphical representation (strip chart) of the selected channels while test is in progress. Alternative methods of measuring pressures and speeds shall be approved by the NYCT.

- For each of the specified steady state cooling test requirements, all data shall be recorded every minute for 30 consecutive minutes in order to determine temperature variation as the air conditioning apparatus cycles.

17.3.5.4.4 Data Requirements

The following test data shall be taken during each test run. Only the pertinent data shall be selected and recorded which reflect the type of test in progress.

- **Air Temperatures**
  - Return Air - 9-point grid
  - Fresh Air - 9-point grid
  - Mixed Air - 9-point grid
  - Air leaving evaporator - 9-point grid
  - Condenser inlet - 9-point grid
  - Condenser outlet - 9-point grid
  - Climate Room
  - Car interior: 28 thermocouples, minimum

- **Refrigerant System Temperatures**
  - Discharge at compressor (12 inches (305 mm) away from compressor)
  - Suction at compressor (12 inches (305 mm) away from compressor)
  - Liquid leaving condenser
  - Liquid at TXV #1
  - Liquid at TXV #2 (if applicable)
  - Suction at evaporator #1
**Refrigerant Pressures - psig (kPa)**
- Discharge at compressor
- Suction at compressor
- Liquid leaving condenser
- Liquid at TXV #1
- Liquid at TXV #2 (if applicable)
- Suction at evaporator #1
- Suction at evaporator #2 (if applicable)

**Air Pressures - w.g. (Pa)**
- Fan total or fan static pressure
- Evaporator coil pressure drop
- Air supply plenum
- Condenser coil pressure drop
- Car pressurization
- Cab pressurization

**Electrical Data**
- Evaporator blower motor volts - each phase
- Evaporator blower motor amps - each phase
- Evaporator blower motor watts - each phase
- Evaporator blower motor power factor
- Evaporator blower motor speed
- Compressor motor volts - each phase
- Compressor motor amps - each phase
- Compressor motor power factor
- Compressor motor watts
- Compressor speed
- Condenser fan motor volts - each phase
- Condenser fan motor amps - each phase
- Condenser fan motor power factor
- Condenser fan motor watts
- Condenser fan motor speed
- Heater watts

**Event Data**
- Compressor operation
- Solenoid Valve, SLV1 (Main Liquid Line)
- Solenoid Valve, SLV2 (if applicable)
- High Limit Switch
- Back-up protection activation device
17.3.5.4.5 Test Requirements

17.3.5.4.5.1 Test Specimen

Prior to car shipment to the climate room test facility, the ventilation and air conditioning system shall be given a complete production conformance test to verify the correct operation of all apparatus.

17.3.5.4.5.2 Air Balance

Air balance test shall be conducted to demonstrate the compliance with the specified fresh air volume and car pressurization requirements of Section 12.2.1, and to demonstrate the uniformity of the interior air distribution required by Section 12.5.4. The cab air supply shall be also measured. The total measured return and fresh air volume of each system shall be within ±10 percent of the total mixed air volume as measured by the equipment manufacturer during its Qualification Test. The outlet velocities at diffusers shall meet the requirements of Section 12.2.4. Any changes to the air distribution system, made after the test, will invalidate the test results, and the test will need to be repeated.

17.3.5.4.5.3 Car Body Heat Transfer

Car body heat transfer tests (UA-Factor) shall be conducted to verify conformance with Section 12.4.2. During the test, separate blowers from the system blowers may be used to equalize temperatures inside the car. Heat generated by these blowers shall be included in the calculations.

17.3.5.4.5.4 Scan Test

The climate room conditions and the car interior heat load shall be varied such that the temperature sensors operate the ventilation and air conditioning system through the full control range of cooling and ventilating.

All control points shall be verified on temperature rising and temperature falling including a demonstration of the pumpdown cycle. The results of this test shall conform with the results of the unit qualification test. A recording instrument shall register each event of automatic control. The test shall be conducted slowly to observe possible contactor chattering or short cycling, which shall be considered as being among the possible malfunctions. Any malfunction of the system components shall constitute a failure of the test.

17.3.5.4.6 Cooling Tests

The cooling tests of Sections 17.3.5.4.6.1, 17.3.5.4.6.2 and 17.3.5.4.6.3 below shall be conducted in sequence, without prolonged interruptions and/or temperature changes between these tests, except for the car interior temperature changes due to the application of heat loads. The sequence shall begin by "soaking" the car at 105°FDB and 80°FWB (40.5°CDB and 26.7°CWB) for at least 12 hours. For the first 6 hours, all car doors shall be open. The second 6-hour "soak" time shall include simulated solar load and all car doors shall be closed. Car instrumentation, per requirements of Sections 17.3.4.6.3 and 17.3.4.6.4, shall be complete and functional. With the same ambient conditions, the following cooling tests shall be performed:
17.3.5.4.6.1 Pull down Test with Solar Load

After the air conditioning equipment is energized, record the length of time required to reach the design dry bulb control temperature, measured at the return air sensor, and the average car temperature. The test shall be considered completed when the car interior temperatures become stabilized.

17.3.5.4.6.2 Steady State without Passengers

After the Pull down test and car temperature stabilization, all data required shall be recorded. Interior car temperatures shall meet the requirements of Section 12.5.4. If required, all necessary diffuser adjustments and air distribution corrections shall be made at this time, in which case the test sequence shall be repeated starting from the air balance and including the full "soak".

17.3.5.4.6.3 Steady State at Design Conditions

The specified heat loads of Section 12.4.2 shall be applied in this test. After system and temperature stabilization, all required data shall be recorded. Adjustment shall be made as necessary to meet the temperature variation requirements of Section 12.5.4. If adjustments are necessary, the test sequence shall be repeated starting from the air balance and including the full "soak".

17.3.5.4.6.4 Door Cycling

Starting with steady state at design conditions, a car door cycling test shall be run to verify conformance to the door cycling temperature variation and restabilization requirements of Section 12.5.4. The door cycling test shall be conducted for one hour. The doors on one side of the car shall remain closed.

17.3.5.4.6.5 Steady State, Design Conditions, AW3 Passenger Load

After system and temperature stabilization is obtained, record all data requirements during the system steady state of operation. The system shall maintain full, cool operation, the average interior temperature shall not be less than 20°F (-6.66°C) below exterior ambient temperature and the temperature variation requirements of Section 12.5.4 shall be met.

17.3.5.4.6.6 Maximum Operating Conditions

A steady state operation shall be attained at ambient conditions specified in Section 17.3.4.6.5.4 and AW3 passenger and full solar load. Air conditioning system shall operate for one hour without malfunction. Modulation is permitted.

17.3.5.4.6.7 Modulation Pressure Switch Test

This test shall be conducted at ambient conditions specified in Section 17.3.4.6.5.5 and internal load necessary to achieve the system modulation. The test results shall conform to the results of the similar unit qualification test.
17.3.5.4.6.8 High Pressure Cut-Off Switch Test

This test shall be conducted at ambient conditions specified in Section 17.3.4.6.5.6 and internal load necessary to achieve the high pressure cut-off. The test results shall conform to the results of the similar unit qualification test.

17.3.5.4.6.9 Low Temperature Operation Test

This test shall be conducted for a period of four hours at ambient conditions determined from the control chart to be 2°F (1°C) higher than the compressor switching point. Sufficient internal heat load shall be provided to maintain continuous compressor operation at its minimum capacity mode, while maintaining return air temperature no more than 2°F (1°C) above the compressor control shut-off temperature. Successful test criteria is the same as for the unit qualification test per Section 17.3.4.6.5.7.

17.3.5.4.6.10 Condensate Carry-Over

A condensate carry-over test shall be conducted at ambient conditions specified in Section 17.3.4.6.5.8 and internal load sufficient to stabilize the system operation in full cooling mode. The test shall be continued for four hours after stabilization. Immediately after the test completion the car ceiling panels and/or the air conditioning unit shall be opened and observed for the signs of the exterior condensation and/or evaporator condensate carry-over. Successful test criteria is the same as for the unit qualification test per Section 17.3.4.6.5.8.

17.3.5.4.7 Abnormal Heating Condition Tests

The following tests shall be performed under the conditions described below:

17.3.5.4.7.1 Abnormal Heating Condition, Restricted Air

This test shall be conducted at conditions specified in Section 17.3.4.6.5.12.

17.3.5.4.7.2 Abnormal Heating Condition, No Air

This test shall be conducted at conditions specified in Section 17.3.4.6.5.13.

17.3.5.4.7.3 Back-Up Protection

This test shall be conducted at conditions specified in Section 17.3.4.6.5.14.
17.3.5.4.8 Heating System Test

A test shall be performed on a cab car in a cold room maintained at 11°F (-11.67°C) to demonstrate that the heating system meets the criteria specified in Section 12.3. The car shall be soaked in this environment for not less than eight hours prior to the start of the test. The tests shall satisfy the following:

- All performance criteria listed in Section 12.3 shall be verified.
- The time required for initial raising the temperature of the interior of the car from cold room environment to the thermostat setting shall be tested and recorded. The mass capacitance of the car shall be determined during this test.
- The time required to raise the car temperature from stabilized interior layover conditions at minimum exterior ambient shall not exceed the requirements of Section 12.3.3.1.
- The temperature within the car shall be maintained within the limits specified in Section 12.5.4.
- The temperature throughout the car shall be uniform within the tolerances specified in Section 12.5.4.
- The temperature shall be maintained at the temperature specified in Section 12.5.6.2.1 during the “lay-up” cycle.

17.3.5.4.9 Heated Windshield Test

The heated windshield shall be tested to illustrate compliance with the requirements of Section 3.10.3. The overheat protection requirements of Section 6.4.5 shall also be verified.

17.3.5.5 Lighting

Light intensity readings shall be taken (without light from other sources) on the first car of each type to verify conformance with the requirements in Section 14.2.1.

17.3.5.6 Weight Balancing

Weight balancing tests shall be performed on one completed car of each type to verify compliance with the requirements of Section 2.2.5.4.

17.3.5.7 Coupled Car Clearance

Two five car units shall be coupled and checked for proper truck, drawbar, coupler, cable and hose clearance under the worst case geometric requirements for these elements at all locations designated by NYCT. The car ends shall be checked for proper intercar clearance. The couplers and drawbar shall be checked for proper vertical clearance.

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and horizontal swing and for clearance from the truck, under car components, anti-climber and ground (top of rail). All truck, trainline, and coupler cables and hoses shall be checked for clearance and the absence of stretching and chafing. The trucks shall be checked for proper vertical and horizontal swing and for clearance from under car components. The intercar barriers shall be checked for proper function at entry to and exit from curves and in reverse curves.

17.3.5.8 Parking Brake

A parking brake system test shall be performed on one Unit. Design compliance with Section 2.4.3.3 shall be demonstrated by measuring the force required to move the Unit with the parking brake applied. The test shall be performed with bedded-in brake shoes.

17.3.5.9 Noise and Vibration

After equipment installation, noise and vibration tests shall be performed on the first car of each type to confirm compliance with the static car condition requirements of Section 2.7.

Compliance with the Specification is to be based on measurements taken in a free-field environment such as outdoors, away from any reflecting surfaces other than the ground, ties, and ballast, on track with newly ground, welded rail. Reflected sound shall be such as to not influence the directly radiated sound from the equipment measured by more than 2 dB. All measurements shall be made with an ambient sound level in the vicinity of the test measurement locations of not less than 10 dB below the noise produced by the equipment being measured, when evaluated using the same scale or octave band.

For these tests, the following shall be recorded:

- Description of noise or vibration source being measured, including pertinent performance data;
- Description of the environment where the noise or vibration source is measured, including a sketch showing source and measurement positions;
- Operating conditions of noise or vibration source during measurements;
- Pertinent meteorological data;
- Locations and orientations of microphones with respect to noise source;
- Equipment used for making measurements;
- Description and measurements of ambient noises;
17.3.5.10 Horn

The horn, as mounted on a completed A Car, shall be tested for compliance to the requirements of Section 10.3.3.5.

17.3.5.11 Car Networks MOD 02

The Contractor shall test the complete car network system. A simulator shall be used in lieu of trainline signals on B cars. The test shall include, but not be limited to, the following:

- Test the ability to communicate with all nodes,
- Measure data rates and error rates,
- Proper transmission and reception of signals by nodes and their connected systems,
- Exercise all network commands, and
- Response to Faults.

17.3.6 Unit Qualification Tests

The following Unit tests shall be performed by the Contractor on NYCT's property:

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<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Ride Quality</td>
<td>First Unit</td>
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<tr>
<td>Noise and Vibration</td>
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<td>First Unit</td>
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<td>4- and 6-Car Units</td>
<td>First Two Units</td>
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<td>FMECA Validation</td>
<td>First Unit</td>
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<tr>
<td>Parking Brake</td>
<td>One Unit</td>
<td>17.3.6.14</td>
</tr>
</tbody>
</table>
17.3.6.1 Trainlines

The first two Units shall be tested to demonstrate that all trainline functions perform satisfactorily between cars within a Unit and when train operating Units are coupled together. These tests shall include running as well as static tests. Five Car Unit ends shall be coupled in any combinations. The other Car-end configurations within the Unit will be tested after the "30 day operations test".

17.3.6.2 Clearance

One of the first two units shall be operated through a representative section of the IRT at AW0, as selected by the NYCT, to ensure clearances with the existing wayside facilities.

17.3.6.3 Performance

Unit running tests shall be performed on systems related to propulsion and braking on the first complete Unit and on the first and second complete Units as a 10-car train. The tests shall verify the requirements of Section 2.4. This series of tests shall also be used to determine the equipment settings and calibrations to be used for the remainder of the Unit and car acceptance program.

All Unit acceptance testing and qualification testing shall be performed at the NYCT designated test site. The Contractor shall schedule all operational testing so as not to interfere with passenger service or system maintenance. The operating rules and procedures required in the Contract for passenger service operation shall be approved and placed in effect before any operational testing begins.

As a minimum, two runs in each direction shall be made for each test condition.

The relationship of motor torque vs. car load and brake cylinder pressure vs. car load developed for a continuous range of passenger loads from AW0 to AW3 as measured by air spring pressure and shall be referenced to evaluate the performance of all other units and/or cars, which may then be tested without load during Unit Pre-shipment Dynamic Tests and Unit Acceptance Tests. (Refer to Section 17.3.9 and 17.3.10).

A 10-car train (2-Units) shall be tested to verify compliant acceleration and braking performance of a 10-car configuration.

All recorded data shall be corrected for voltage and grade as part of the Contractor's test report. Test reports shall be forwarded to and become the property of NYCT. Records of all parameter settings for acceleration and deceleration shall be furnished for each car.

If any Unit, Units or car, under any load condition or train configuration, or any apparatus fails to satisfy the specified performance and design criteria, the Unit, Units or cars, with the necessary adjustments, shall be retested at the Contractor's expense. If modifications are necessary, they shall be verified by appropriate retest, as determined by NYCT, and implemented on a fleet wide basis at the Contractor's expense.
17.3.6.3.1 Instrumentation

For these tests each Unit shall have Contractor-supplied, multiple-channel thermal pen recorders and multiple channel magnetic tape recorders or approved equal which shall produce a permanent test record. The Contractor shall supply all recorders, sensors, pickups, equipment racks, test wiring termination panels, calibration equipment, wiring, and inverters to operate this instrumentation using the car battery low voltage power system supply. The equipment shall function over the battery low voltage range described in Section 2.3 and otherwise not be damaged by the conditions specified in Section 9.8.2.

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 will be permitted. The test wiring termination panels shall include test jacks and switching for each channel to permit calibration signals to be injected into each recorder channel without requiring wiring or connectors to be disconnected and shall be arranged so that calibration signals cannot be fed back into the monitored equipment. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the Specification and design data.

The Contractor shall provide necessary weights to simulate AW1, AW2 and AW3 passenger loads. These steel weights shall be configured for fork lift truck handling and loading through passenger side doors. Upon completion of Program testing, the weights shall become the property of NYCT.

Tests shall be performed on a complete train operating Unit. For each test, only the relevant channels from the following list shall be recorded or as otherwise specified by NYCT:

- Acceleration (positive and negative)
- Traction motor torque (each truck)
- Spin-slide system operation (each truck-gross and minor)
- Brake cylinder pressure (each truck)
- Braked wheel temperature on one axle
- Contact Rail voltage
- Line current for all car types
- Brake signal current for all trucks
- Speed
- Auxiliary current
17.3.6.3.2 Propulsion Performance Tests

This series of tests shall be run at passenger loads of AW0, AW2 and AW3. Compliance with the performance requirements in Section 2.4 shall be demonstrated. (Braking shall be monitored during the propulsion tests.)

17.3.6.3.3 Braking Performance Tests

This series of tests shall be run at AW0, AW2, and AW3. For the all-friction brake stop tests, brake elements shall be cooled to a maximum of 150°F (66°C) as measured by thermocouples before initiation of any test. Compliance with the performance requirements in Sections 2.4, shall be demonstrated.

The pneumatic emergency brake pipe system shall be tested to verify compliance with the emergency brake reaction time requirements of Section 10.3.1.1.

17.3.6.3.4 Thermal Capacity Tests

One complete Unit shall be instrumented and tested to verify compliance with the duty cycle requirements specified in Section 2.4.5.

17.3.6.3.5 Wheel Slip Control

All power and braking modes shall be tested to verify compliance with Section 2.4.4. Each axle of the wheel slip test train shall be monitored and recorded.
17.3.6.3.6 Auxiliary IVPS and AC Power Supply

The Contractor shall operate the auxiliary IVPS and ac power supply test instrumentation throughout all car performance testing to verify that the requirements of Sections 2 and 9 are met. Chart recordings which contain representative samples of the power supply operating characteristics, taken during the auxiliary IVPS and ac power supply conformance tests and the Unit performance tests, shall be copied and included in an auxiliary IVPS and ac power supply test report.

17.3.6.4 30-Day Operations

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The first two Units, operating as a 10-car train, shall be given a 30-day Operations Test before Acceptance. The cars shall be instrumented during the test to determine that all systems are functioning properly. The instrumentation shall be as specified in Section 17.3.6.3.1. The test shall be conducted in actual revenue service, with normal in-service passenger loads. Prior to being placed in service, the Unit shall be given an operations, safety and reliability test as approved by NYCT. These tests shall verify compliant operation of the doors, brakes and coupler controls as a minimum.

Final inspection and approval of the first two Units shall be given after the Units have been delivered, inspected and tested on the NYCT's property, and has, to the satisfaction of the NYCT, performed for an uninterrupted period of thirty (30) days.

17.3.6.5 Ride Quality

Ride quality tests shall be performed on one Unit. The tests shall prove compliance with the ride quality specifications of Section 2.7.8.

As a minimum, ride quality tests shall consist of operating the Unit at speeds of 10 mph (16 km/hr) 30 mph (48 km/hr) and 50 mph (80.5 km/hr) over track selected by NYCT, under three load conditions: AW0, AW2, and AW3. Instrumentation capable of measuring the magnitude of the vertical, longitudinal, and lateral shocks and vibrations experienced, shall be provided and monitored by the Contractor. Sensing units shall be located on the Unit car floors above the intersection of the car longitudinal centerlines and a truck transverse centerlines, at the center of the cars between trucks, and at three seat locations to be determined by NYCT. Provision shall be made for recording vertical, lateral, and longitudinal shocks and vibrations concurrently.

Acceptability of the ride quality will be determined by an analysis of the recorded root-mean-square accelerations.

In the event that the dynamic behavior of the Unit does not meet the Specification requirements, the Contractor shall submit for NYCT review, within 60 calendar days, an analysis of the problem and a plan of action for its correction. If authorized by NYCT, the corrective measures shall be installed on the test Unit within 90 days at the expense of the Contractor, the Unit shall be retested, and, if the measures are successful, they shall be applied to all Units. If not successful, the analysis and corrective action steps shall be repeated, and the Units retested until Specification compliance is attained.
17.3.6.6 Noise and Vibration

After equipment installation, noise and vibration tests shall be performed on the first Unit to confirm compliance with the static Unit condition requirements of Section 2.7.

Compliance with the Specification is to be based on measurements taken in a free-field environment such as outdoors, away from any reflecting surfaces other than the ground, ties, and ballast, on track with newly ground, welded rail. Reflected sound shall be such as to not influence the directly radiated sound from the equipment measured by more than 2 dB. All measurements shall be made with an ambient sound level in the vicinity of the test measurement locations of not less than 10 dB below the noise produced by the equipment being measured, when evaluated using the same scale or octave band.

For these tests, the following shall be recorded:

- Description of noise or vibration source being measured, including pertinent performance data;
- Description of the environment where the noise or vibration source is measured, including a sketch showing source and measurement positions;
- Operating conditions of noise or vibration source during measurements;
- Pertinent meteorological data;
- Locations and orientations of microphones with respect to noise source;
- Equipment used for making measurements;
- Description and measurements of ambient noises;
- Data obtained, including range of variation; and
- Instrument settings, corrections, and calibration records.

The results shall be evaluated and any corrective action required shall be approved by NYCT. After corrective action is taken, the applicable tests shall be rerun. If the corrective action is successful, it shall be applied to all cars. If not successful, these steps shall be repeated until Specification compliance is attained.

In addition, the Contractor shall conduct on NYCT's behalf, a test in compliance with the "New York City-Rapid Transit Noise Code, Chapter 736". Reference Appendix C of this Specification for a copy of the noise code.
The Unit networks test shall be performed to validate operation of the complete system. Tests shall be conducted on both one-Unit and two-Unit configurations. Tests shall include all elements tested in lower level network qualification tests. The Unit Network test shall be done with two Units in train-coupled configurations that will be normally used in Revenue service (passenger service). The other Unit configurations will be tested after the "30 day operations test".

17.3.6.8 Electromagnetic Compatibility

An electromagnetic compatibility test shall be performed on two Units by methods referenced in Section 2.6.3 for compliance with those requirements and for the compatibility with the NYCT traction power distribution, and communications systems.

During these tests, confirmation of appropriate emissions limits as previously developed shall be conducted by monitoring the traction power distribution, railway signal, and communication systems functions.

17.3.6.9 Battery Capacity

Unit batteries shall be discharged so that the remaining capacity corresponds to the worst-case design conditions. Then the batteries shall be tested for compliance with Section 9.9.2.

17.3.6.10 Intentionally Blank

17.3.6.11 Thermal Mapping

One Unit shall be tested to demonstrate that temperature condition assumptions used in design of car equipment are valid. The Unit shall be thoroughly instrumented to measure actual temperatures that temperature-sensitive components experience during the most severe set of conditions permissible within the requirements and design parameters of the Specification. Measured temperatures shall be compared to design assumptions to determine validity of those assumptions and whether design changes are necessary to ensure Specification compliance, including reliability requirements.

17.3.6.12 4- and 6-Car Units

4 and 6-Car Units shall each be given a functional test to verify that all systems operate correctly when placed in these Unit configurations. Acceleration and braking performance, having been adjusted per Section 2.4.1, shall be included within this verification. The 4 and 6 Car Units tests may be tested after the "30 day operations test".
17.3.6.13 FMECA Validation

One of the first Unit delivered shall be utilized to verify compliant performance with the System Safety Program requirements of Section 18.4.2. Specifically, Category I and II hazards, identified as required within Section 18.4.2.3, shall be validated to not create an unsafe condition.

17.3.6.14 Parking Brake

A parking brake system test shall be performed on one Unit at a location designated by NYCT.

17.3.7 System Conformance Tests

17.3.7.1 General

All equipment on the cars shall be given functional and acceptance tests at the system manufacturer's facility prior to shipment to the Contractor's assembly facility. The tests to be performed on each system shall be in accordance with this Specification and the approved Contractor-furnished test plan. The test reports of all Conformance tests shall be available upon request by NYCT for a period of 5 years after the test being performed, except for truck system conformance test, which shall be included in each Car History Book.

The following tests shall be performed:

<table>
<thead>
<tr>
<th>Test</th>
<th>Reference</th>
</tr>
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<tbody>
<tr>
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<td>17.3.7.3</td>
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<tr>
<td>HVAC Unit</td>
<td>17.3.7.4</td>
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<tr>
<td>Motors</td>
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<tr>
<td>Traction Gear Unit</td>
<td>17.3.7.6</td>
</tr>
<tr>
<td>Traction Power Control</td>
<td>17.3.7.7</td>
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<tr>
<td>Auxiliary AC Power Supply</td>
<td>17.3.7.8</td>
</tr>
<tr>
<td>Low Voltage Power Supply</td>
<td>17.3.7.9</td>
</tr>
<tr>
<td>Battery</td>
<td>17.3.7.10</td>
</tr>
<tr>
<td>Brake Equipment</td>
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</tr>
<tr>
<td>Communications Equipment</td>
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<td>Trucks</td>
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</tr>
<tr>
<td>Couplers</td>
<td>17.3.7.14</td>
</tr>
</tbody>
</table>

17.3.7.2 Electrical Apparatus

Each system that is separately assembled, housed, and wired into a packaged unit prior to installation in a car or Unit 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 NYCT.
17.3.7.3 Insulation Testing

The integrity of the electrical insulation shall be confirmed where specified below by performing insulation resistance tests and high potential tests on individual devices, systems and apparatus.

17.3.7.3.1 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 line switches and circuit breakers. Semiconductor devices 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.

On items with double insulation, such as grid resistors mounted by insulators to a frame insulated from car body, each set of insulation shall be individually tested; *i.e.*, resistors to frame and frame to car body.

The following insulation resistance limits shall apply when all circuits on the vehicle of a given voltage class are connected in parallel under all environmental conditions including high humidity:

<table>
<thead>
<tr>
<th>Nominal Circuit Voltage Volts dc or ac rms</th>
<th>Minimum Insulation Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 90 volts except battery assembly</td>
<td>2 megohms at 500 Vdc</td>
</tr>
<tr>
<td>90 to 300 volts</td>
<td>4 megohms at 1,000 Vdc</td>
</tr>
<tr>
<td>Above 300 volts</td>
<td>5 megohms at 1,000 Vdc</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.

17.3.7.3.2 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 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 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 together the various wires in a system to insure 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 grid resistors mounted by insulators to a frame insulated from car body, each set of insulation shall be individually tested; *(i.e.,)* resistors to frame and frame to car body.)
The test shall be conducted by applying the test voltage, as listed below, for a period of 1 minute, across the insulation being tested, the test is 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>Nominal Circuit Voltage Volts dc or ac rms</th>
<th>Test Voltage, ac rms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 300 volts</td>
<td>2 ( V + 1,000 ) volts</td>
</tr>
<tr>
<td>Equal to or above 300 volts</td>
<td>2.25 ( V + 2,000 ) volts</td>
</tr>
</tbody>
</table>

Standard apparatus may be production tested for 1 second at a test voltage 20 percent higher than the above listed 1 minute test voltage.

Alternative high potential test criteria such as IEC may be proposed for NYCT approval.

17.3.7.4 HVAC

Each ventilation and air conditioning unit shall be placed in a test cell and a heat load shall be applied to both the evaporator and condenser coils. The unit shall be operated at least 5 hours with a clean-up "Y"-strainer mesh and a filter-drier in-place. Upon test completion, a new standard-type filter shall be installed.

The unit shall be given a complete functional test to verify compressor unloading, control points of all pressure switches and all return and fresh air thermostats. Power consumption of all motors, evaporator and condenser fan motor speeds, system pressures and temperatures, and the applied loads to the evaporator and condenser shall be recorded.

Refrigerant and oil samples shall be taken from the first six units following the test run and analyzed by an independent laboratory, according to a plan approved by NYCT, to verify the adequacy of the system cleanliness and adequacy of evacuation/dehydration. Test results shall comply with the requirements of ARI Standard 700, except that the limit on oil in the refrigerant shall not apply. If the results from the first six units are acceptable, a sampling plan of one unit in six shall be employed thereafter. If the first six units are not acceptable, manufacturer shall improve its relevant manufacturing procedures, the affected units shall be purged, re-cleaned and re-sampled, and in addition, the second group of six units shall be sampled and the refrigerant and oil analysis cycle repeated.

The manufacturer shall conduct insulation resistance and high potential tests on each unit according to Section 17.3.7.3.

17.3.7.5 Motors

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Each traction motor, ac auxiliary motor, and dc motor shall be given a "routine" test by the manufacturer in accordance with IEC Publication 349, unless otherwise approved. For traction motors, the requirements of IEC Publication 349, Paragraph 5.1.3 shall apply as described in Section 17.3.3.7.1. For AC auxiliary motors, routine test equivalents to IEC 349 may be proposed. Motors balance shall be dynamically tested in accordance with NEMA MG 1-12.06.
17.3.7.6 Traction Gear Units

Each traction gear unit shall be given the manufacturers "routine" test, which shall include, at a minimum, the following:

- Gear tooth mesh shall be checked to verify that it is within the manufacturer's tolerances before the gear unit is operated.
- No-load operation at 60 mph (96.5 km/h) equivalent car speed for 10 minutes for each speed in each direction. Noise and vibration produced by each gear unit and gear sump oil temperature shall be continuously monitored. All gear units which do not meet the manufacturer's requirements for oil temperature, or the manufacturer's requirements for noise and those of Section 2.7 relative to these speed and load conditions shall be rejected. Noise shall be checked at 60 mph (96.5 km/h).

17.3.7.7 Tractive Power Control

With control power connected and traction power disconnected, all electromechanical devices in each traction power control system shall be tested for correct sequences of operation in both powering and braking modes by simulating the operation of the control lock and master controller and observing the functioning of the various pieces of apparatus involved.

17.3.7.8 Auxiliary AC Power Supply

Each auxiliary inverter shall be given a routine test by the manufacturer in accordance with IEC 411 and to verify compliance with all aspects of the following for the nominal power input conditions defined in Section 2.3.

- All output and control requirements
- Performance requirements
- Fault detection and annunciation requirements
- Insulation and isolation requirements. Insulation shall be tested as required in Section 17.3.7.3

Identical requirements shall apply to intermediate voltage power supply equipment, if used.
17.3.7.9 Low Voltage Power Supply

Low voltage power supply conformance tests shall include the following:

- All units shall be subjected to a high potential test in accordance with Section 17.3.7.3.2 or IEC Publication 77 recommendations.

- Output voltage shall be adjusted to be within +1, -0 percent of the specified nominal output voltage.

- Output current limit shall be adjusted to be within +10, -0 percent of the Contractor's stated nominal rated output current. In the event the power supply design for current limit function incorporates two or more break points, the current or voltage setting at the additional points shall be adjusted to be within +10, -0 percent of the Contractor's stated nominal value.

- Over voltage and under voltage shut off points shall be adjusted to be within +1, -0 percent of the specified values.
Each power supply shall be run for one half hour at nominal output voltage as adjusted above, rated output current, and nominal input voltage.

Proper functioning of safety interlocks shall be demonstrated.

All other features such as time delay relays, and layover shutdown, shall be exercised and adjusted, as required, to be within +10, -0 percent of the Contractor's stated values where appropriate.

17.3.7.10 Battery

Five percent of the batteries supplied, selected at random by NYCT, shall be given a capacity test at the point of manufacture. The test shall be at the 5 hour rate, at 20°C ambient temperature in accordance with Section 4.2.1 of IEC Publication 623.

17.3.7.11 Brake Equipment

All electrical and electronic assemblies shall be subjected to an insulation resistance and high potential test in accordance with the requirements of Section 17.3.7.3.

All valves shall be test-rack tested and certified for performance in accordance with manufacturer's specifications and test codes, as approved by NYCT.

All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with the manufacturer's specifications and test codes, as approved by NYCT.

All reservoirs shall be tested and certified in accordance with ASME Codes for Unfired Pressure Vessels.

17.3.7.12 Communications System

All electrical and electronic assemblies shall be subjected to an insulation resistance and a high potential test in accordance with the requirements of Section 17.3.7.3.

All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with the manufacturer's specifications and test codes, as approved by NYCT.

17.3.7.13 Trucks

Each truck shall have all production truck welds including those on the frame, bolster and any other primary structural members subjected to magnetic particle or dye penetrant inspection, except critical welds which shall also be inspected by radiography, or by section and etch, on 10 percent of the trucks chosen at random.
Magnetic particle inspection shall be in accordance with ASTM E 709. Dye penetrant inspection shall be in accordance with ASTM E 165. Cast trucks shall be 100 percent magnetic particle inspected. Radiographic inspection shall be continued at a rate of one truck frame for each ten trucks produced.

If defects are found during sampling inspection, the Contractor shall positively locate the beginning of such defects in previous truck frames and apply appropriate corrective action.

17.3.7.13.1 Bearing Lateral Clearance

A 10 percent sample of mounted journal bearings shall be measured to verify conformance to installed lateral clearance requirements.

17.3.7.13.2 Wheel Gauge

All wheel-axle assemblies shall be measured to verify conformance with gauge dimension requirements in Section 4.4.4.1.

17.3.7.13.3 Axle Run Out

All wheel-axle assemblies shall be measured to verify conformance to axle run out (concentricity) requirements in Section 4.4.4.1.

17.3.7.13.4 Tread Run Out

All treads on wheel-axle assemblies shall be measured to verify conformance to lateral and radial run out requirements in Section 4.4.4.1.

17.3.7.13.5 Tram and Axle Parallelism

All truck assemblies shall be measured to verify conformance to tram and axle parallelism requirements in Section 4.6 under AWO and AW3 loads.

17.3.7.14 Couplers

All couplers and link bars shall be given a routine test as approved by NYCT.

17.3.8 Unit Pre-Shipment Static Tests

Unless otherwise approved by NYCT, the tests listed in this section shall be performed by the Contractor on each Unit prior to shipment to NYCT. The Contractor's static tests shall include all tests and adjustments which can be made prior to shipment in order to keep the Unit Acceptance Tests, specified in Section 17.3.10, and any subsequent adjustments, to a minimum.
The following tests shall be performed:

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**17.3.8.1 Watertightness MOD 05 CO 208 CO 117**

For each car within a Unit, all areas of the car sides, ends, and roof, including doors and windows, shall be given a complete test for watertightness. The tests shall be made before installation of sound deadening material, thermal insulation, and interior finish. Water shall be sprayed from nozzles which are between 34 inches (865 mm) and 79 inches (2000 mm) from, and aimed directly at, the surface being tested. Not less than 2.9 gallons per minute (11.1 L/min) shall be delivered to each square foot of surface being tested, and the nozzle velocity of the water shall be not less than 80 feet per second (25 m/sec). All of the above-mentioned parameters have to be met, or as otherwise approved by the Authority.

All spray applications shall run for 10 minutes before the inspection for leaks begins, and shall run continuously during the inspection. Individual exterior equipment enclosures shall be watertightness tested as indicated in this Section.

The traction motor clamshell and external lead connections specified in Section 10.2.8.4 shall also be given a water test. The water flow rate and velocity shall be as specified for the car body water test.

**17.3.8.2 Weighing**

The Contractor shall weigh each car prior to shipment. The weight at each truck of the car shall be provided separately. A weighing device which provides a permanent record of the weight shall be used, and those weight tickets shall be submitted to NYCT. Copies shall be included in the Car History Book or the equivalent database. The weighing device shall be maintained within an accuracy of 0.2 percent. The Contractor shall submit written verification that the weighing device was calibrated within two weeks prior to the first weighing, and has been calibrated at least once each year over the life of the Contract.
17.3.8.3 Car and Unit Wiring

Car and Unit wiring acceptance testing shall be performed at the Contractor's facility on all cars and Units after the wiring and equipment installation is completed and shall consist of the tests described in Sections 17.3.8.3.1 and 17.3.8.3.2.

17.3.8.3.1 Wiring Continuity Checks

All circuits shall be tested to ensure continuity and correct polarity of equipment and devices. All frame grounds and terminal connections shall be checked for tightness.

17.3.8.3.2 Insulation Testing MOD 02

The insulation of all car circuits shall be subject to insulation resistance and high potential testing as specified in Section 17.3.7.3. Detachable car jumper cables shall receive independent insulation resistance and high potential tests.

The test voltage on a completed car shall be 0.85 times the value defined above for the individual device or system to be tested.

For the insulation resistance testing, the battery assembly shall be given a separate test for insulation from car body. Each terminal of the battery shall be measured to the metallic portion of the battery tray with a micrometer. The maximum measured current from each terminal shall be 20 mA.

17.3.8.4 Pneumatic System Leakage Test

The following pneumatic system leakage test shall be performed on each Unit. Testing shall:

- Place all cut-out cocks in their normal operating position.
- Allow the air suspension system to become fully charged and determine that the leveling valves are in "lap" position.
- Install a test gauge in the main reservoir.
- Adjust the compressor governor to its normal operating pressures.
- After the system is fully charged slowly bleed air from the main reservoir until the air compressor starts. Close the main reservoir bleed, and allow the compressor to recharge the system.
- After the compressor cuts out and after any drain valve action has terminated, record the main reservoir test gauge reading and start the clock.
- After 3 minutes (for temperature effect), again record the main reservoir test gauge reading.
- Wait 5 minutes more and record the main reservoir test gauge reading again.
Main reservoir pressure drop shall not exceed a total of 10 psig (70 kPa) for the full 8 minute period and a total of 5 psig (35 kPa) for the last five minutes of the period. (The compressor shall not be permitted to start during the timed test period.)

If the Unit fails to meet the above requirements, the leakage must be corrected and the Unit retested until the requirements are met.

17.3.8.5 Trainlines and Networks

The Contractor shall verify the accuracy of each Unit's hard wired and network trainline connections by the use of a test panel which shall be connected to the coupler's electric head and indicate, by the illumination of lights, or other appropriate means, that the trainline signals correspond to the Unit controls, and trainlined systems are operated.

A set of standard worst-case conditions shall be developed to allow uniform network tests. Simulation routines within the various connected systems may be used to provide the necessary traffic levels. The methodology and conditions for this test shall be developed as part of the Unit Networks Qualification Test. The test shall validate 100 percent functionality of the networks, with a pre-defined error rate.

17.3.8.6 System Functional Verification

After completion of each car and its assembly into a Unit, the Contractor shall demonstrate that each Unit subsystem is operational and that each A Car’s and Train Operator’s console can properly control a train. The tests shall be conducted by applying nominal contact line voltage described in Section 2.3.1 to the Unit and functionally testing all systems.

The test procedure shall include and use a check-off list that shall become a record that all systems have been actuated and have functioned as required.

After completion of each Unit test prior to shipment, the Contractor shall demonstrate that all discrepancies logged against the Unit during its construction and test period, by either the Contractor's own inspection forces or NYCT inspectors, have been suitably resolved to the satisfaction of the NYCT.

17.3.8.7 Doors, Operators, and Controls

The doors and their operating equipment shall be tested and adjusted on all cars to assure smooth functioning, attainment of the required speed of operation, and proper functioning of controls, signals and interlocks, as specified in Section 11.

All doors shall be operated a minimum of 100 consecutive, successful cycles. Initiation of the cycling shall be through the normal control circuitry. Proper forces for opening and closing shall be verified on every door before and after the above cycling.
The obstruction detection feature shall be checked for proper operation and adjusted, if necessary, as specified in Section 11.5, prior to the start of the cycling test. This feature shall operate properly, without the need for readjustment, at the end of the cycling tests.

17.3.8.8 Air Conditioning

The thermostatic operation of the air conditioning equipment in all cars shall be demonstrated by test. A procedure for this test, including instrumentation from devices and facility used, shall be submitted for approval. Instrumentation necessary to record the data indicated below shall be provided.

All functions, including the sequence of compressor unloading, all pressure control switches, functioning, expansion and solenoid valve operation, system modulation, and system pump-down shall be verified. The system refrigerant charge and the refrigerant condition (wet or dry) in both liquid sight glasses shall be recorded. The car air balance and pressurization shall be verified on the first 20 cars and on one of each car type in each sequential 40-car lot. The oil level in the compressor shall be recorded. Noise and vibration levels shall also be measured and recorded on each unit.

17.3.8.9 Headlights and Taillights

The headlights and taillights on each end car of a Unit shall be functionally checked, aimed and adjusted.

17.3.8.10 Friction Brake

The Contractor shall perform a complete functional test of the friction brake system prior to shipment of each Unit. Tests shall include verification of the feedback command and load-weigh signals and the appropriate response; brake cylinder pressure settings; control and indicator checks; brake system leakage test; and a functional test of the brake fault detection system.

17.3.8.11 Tractive Power Control

With traction power disconnected, all electromechanical components of each traction power control shall be tested for correct sequence of operation in both powering and braking modes by operating both the cab controls and (separately) the portable test unit, observing the functioning of the various pieces of apparatus involved. Any component that fails to function in the proper sequence shall be repaired and the test repeated until successful before proceeding to the next sequence of the propulsion test series.

17.3.8.12 Communication

The radio system shall be tested for power output, voltage standing wave ratio (VSWR), and for clarity of voice transmission and reception on all channels and modes. The PA system, cab intercom, and PEI (passenger emergency intercom) shall be tested for volume level and clarity of voice transmission and reception.
17.3.9 Unit Pre-shipment Dynamic Tests

CO 187

CO 237

The Contractor shall demonstrate, prior to Unit shipment to NYCT, that each Unit's tractive power, dynamic braking, and friction braking systems are compliant with the requirements of Section 2.4 up to the traction motor's base speed. The contractor, prior to testing, shall submit a unit dynamic test procedure for NYCT’s approval. The test, or portions thereof, may be conducted on NYCT test track if the contractor does not have the appropriate facilities.

For each test, the following parameters shall be recorded simultaneously on a multiple-channel linear thermal pen recording oscillograph, Gould 16 channel chart recorder Model No. ES2000 or approved equal. The Contractor shall supply all recorders, sensors, pickups, wiring, and inverters to operate this instrumentation using the unit's low voltage power system supply. Internal combustion engines driving a generator or use of the vehicle auxiliary inverter will not be permitted. The test equipment shall function over the low voltage power system voltage range specified in Section 2.3.3 and otherwise not be damaged by the conditions specified elsewhere in this Specification. Isolation amplifiers and voltage dividers shall be provided as part of the instrumentation package to isolate the instrumentation wiring and equipment from high voltages; no exposed terminals with potential differences greater than 50 volts will be permitted. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the Specification and design data. All charts obtained from the recordings shall be forwarded to, and become the property of NYCT.

The following data shall be recorded:

- Acceleration
- Car Speed
- Line Voltage
- Line Current for cars
- Traction Motor current on each truck
- Propulsion and braking trainline control signals
  (These may be multiplexed to a single analog channel.)
- Brake cylinder pressure for each truck
- Distance
- Time.

Any adjustments required as a result of Contractor tests, to obtain values corresponding to the specified performance, shall be made by the Contractor prior to shipment to NYCT for acceptance testing and shall be noted in the Car History Book, or the equivalent data base.
17.3.10 Unit Acceptance Tests

17.3.10.1 General

CO 187

CO 237

Acceptance tests shall be performed by the Contractor after each Unit has arrived on NYCT's property. The tests shall be satisfactorily completed by the Contractor as one of the conditions of Acceptance. All tests shall be performed on all Units.
After receipt of each Unit at the NYCT and before it is operated, it shall be jointly inspected by the NYCT and the Contractor. The Contractor shall make such reassembly, adjustment, or repair as required for proper operation before acceptance testing is begun. Contractor shall provide the NYCT with evidence that the inadequacy has been corrected prior to shipment of additional Units.

Successful completion of all of the Contractor's acceptance tests shall be required before formal Delivery to NYCT.

The following tests shall be performed:

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17.3.10.2 Intentionally
CO 237

17.3.10.3 Pneumatic System Leakage Test

The pneumatic system leakage test described in Section 17.3.8.4 shall be performed. If the Unit fails to meet this test, the leakage must be corrected and the Unit retested until the requirements are met.

17.3.10.4 Miscellaneous Body Tests and Adjustments

The following tests and adjustments shall be performed prior to Dynamic Tests within Section 17.3.10.6.

- Truck clearances, car dimensions, and car height shall be verified.
- Couplers shall be verified for proper alignment and level.
- Air springs shall be adjusted to within the specified air pressure design tolerance.

17.3.10.5 Functional Tests

A complete, orderly, and comprehensive test of each and every Unit's system shall be made to verify proper operation. The Portable Test Units (PTUs) shall be used for these tests to the maximum extent possible. All devices bypassed by the use of the PTUs shall also be tested. These tests shall be performed at a NYCT facility on each Unit prior to track operation on NYCT property.
COMPLIANCE PROGRAM

17.3.10.6 Dynamic Tests

CO 187

The Contractor shall demonstrate, that each Unit's tractive power, dynamic braking, and friction braking systems are compliant with the requirements of Section 2.4. The contractor, prior to testing, shall submit a Unit dynamic test procedure for the NYCT's approval.

For each test, the following parameters shall be recorded simultaneously on a multiple-channel linear thermal pen recording oscillograph, Gould 16 channel chart recorder Model No. ES2000 or approved equal. The Contractor shall supply all recorders, sensors, pickups, wiring, and inverters to operate this instrumentation using the unit's low voltage power system supply. Internal combustion engines driving a generator or use of the vehicle auxiliary inverter will not be permitted. The test equipment shall function over the low voltage power system voltage range specified in Section 2.3.3 and otherwise not be damaged by the conditions specified elsewhere in this Specification. Isolation amplifiers and voltage dividers shall be provided as part of the instrumentation package to isolate the instrumentation wiring and equipment from high voltages; no exposed terminals with potential differences greater than 50 volts will be permitted. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the Specification and design data. All charts obtained from the recordings shall be forwarded to, and become the property of NYCT.

The following data shall be recorded:

- Acceleration,
- Car Speed,
- Line Voltage,
- Line Current for cars,
- Traction Motor torque on each truck,
- Propulsion and braking trainline control signals,
  (These may be multiplexed to a single analog channel.)
- Brake cylinder pressure for each truck,
- Distance, and
- Time.

Any adjustments required as a result of Contractor tests, to obtain values corresponding to the specified performance, shall be made by the Contractor and re-tested prior to Acceptance.

17.3.10.7 "Burn-In" Tests

CO 187

Each Unit will be given a monitored operational "Burn-In" by the Contractor. The "Burn-In" will include 24 hours of simulated revenue service and will commence after all other tests for the Unit have been successfully completed. During the last eight hours of testing, there shall be no failures of equipment. A download of the MDS shall be made available to NYCT for review. If a failure occurs, this eight hour portion shall be repeated following correction and full documentations of failure.
17.3.10.7.1 Test Instrumentation

To perform "Dynamic Test", the Contractor shall provide the following instrumentation, subject to NYCT approval, as part of the Contract:

- Three sets of car test equipment, as specified in Section 17.3.10.6, complete with assembled cables, cabinets, and power supply equipment to permit it to be used to record and play back the parameters specified in that section. No engineering and assembly work shall be required, other than to set the equipment into a car and to plug or connect the test cables into the vehicle equipment and test equipment.

- Necessary wiring diagrams, schematics, and procedures to permit the test equipment to be installed, calibrated, operated, maintained, and repaired.

- Sufficient recording media to store all "Dynamic Test" records.

All test instrumentation and the test equipment manufacturer furnished manuals shall become the property of NYCT upon completion of Dynamic Tests. The instrumentation equipment shall be operational at the time of turn over.

17.3.11 R142 and R142A Unit Compatibility Tests

The following Unit compatibility tests shall be performed by the Contractor on NYCT's property:

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17.3.11.1 Trainlines

One R142A Unit and one R142 Unit shall be tested to demonstrate that all trainline functions perform satisfactorily when operating Units are coupled together. These tests shall include running as well as static tests. Unit ends shall be coupled in all combinations.

The Contractor shall demonstrate that each Unit subsystem is operational and that each A Car's and Train Operator's console can properly control a train. The tests shall be conducted by applying nominal contact line voltage described in Section 2.3.1 to the Unit and functionally testing all systems.

A functional test of the friction brake system shall be performed. Tests shall include verification of the feedback command and load-weigh signals and the appropriate response; brake cylinder pressure settings control and indicator checks.
With traction power disconnected, all electromechanical components of a traction power control of each unit shall be tested for correct sequence of operation in both powering and braking modes by operating both the cab controls and (separately) the portable test unit, observing the functioning of the various pieces of apparatus involved.

17.3.11.2 Inter-Car Clearance

An R142 and an R142A Unit coupled together as a 10-car train shall be operated through the worst case track geometry found on the IRT, as selected by the NYCT, to ensure the inter-car clearance.

17.3.11.3 Performance

Unit running tests shall be performed on systems related to propulsion and braking on one R142A Unit and one R142 Unit as a 10-car train. The tests shall verify the requirements of Section 2.4.

All compatibility testing shall be performed at the NYCT designated test site.

The relationship of motor torque vs. car load and brake cylinder pressure vs. car load developed for a continuous range of passenger loads from AW0 to AW3 as measured by air spring pressure and shall be referenced to evaluate the performance of all other units and/or cars, which may then be tested without load during Unit Pre-shipment Dynamic Tests and Unit Acceptance Tests. (Refer to Sections 17.3.9 and 17.3.10.)

A 10-car train (2 Units) shall be tested to verify compliant acceleration and braking performance of a 10-car configuration.

All recorded data shall be corrected for voltage and grade as part of the Contractor's test report. Test reports shall be forwarded to and become the property of NYCT. Records of all parameter settings for acceleration and deceleration shall be furnished for each car.

17.3.11.3.1 Instrumentation

For these tests each Unit shall have Contractor-supplied, multiple-channel thermal pen recorders and multiple channel magnetic tape recorders or approved equal which shall produce a permanent test record, as defined under Section 17.3.6.3.1.

17.3.11.3.2 Propulsion Performance Tests

This series of tests shall be run at passenger loads of AW0, AW2 and AW3. Compliance with the performance requirements in Section 2.4 shall be demonstrated. (Braking shall be monitored during the propulsion tests.)
17.3.11.3.3 Braking Performance Tests

This series of tests shall be run at AW0, AW2, and AW3. For the all-friction brake stop test, brake elements shall be cooled to a maximum of 150°F (66°C) as measured by thermocouples before initiation of any test. Compliance with the performance requirements in Section 2.4 shall be determined.

The pneumatic emergency brake pipe system shall be tested to verify compliance with the emergency brake reaction time requirements in Section 10.3.1.1.
## SECTION 18

### SYSTEM ASSURANCE

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SECTION 18

18.0 SYSTEM ASSURANCE

This Section establishes criteria for the development and implementation of a system assurance program to optimize the quality, reliability and maintainability characteristics and safety aspects of the NYCT’s system elements and of the completed vehicle. The vehicle shall be designed to provide a high degree of safety and reliability, and to minimize downtime during preventive and corrective maintenance activities. Designs shall assure that vehicles perform as required without excessive failures, delays, interrupted service, or hazards to passengers.

18.1 Quality Assurance Requirements

18.1.1 General Requirements

The Contractor shall plan and implement a Quality Assurance (QA) Program to assure delivery of a quality product to the NYCT under the terms of this contract. The elements of the program shall be imposed on the contractor’s entire organization and all manufacturers, subcontractors, and suppliers that perform Contract work. The QA Program shall assure that all aspects of the Contract are in conformance with the design, materials and workmanship requirements provided in this Specification and that those requirements shall be provided in a timely manner. The Program shall also require the Contractor to document inspection of the design and manufacturing operations.

The Contractor shall be solely responsible for all of the quality assurance functions required by this Contract. The Contractor shall assure Contract compliance by subcontractors and suppliers. Surveillance of subcontractors shall include sampling and review of products, records, procedures, processes, manufacturing operations and Quality Control methods.

The Contractor's quality assurance efforts shall be in compliance with the requirements of ISO 9000 or ANSI/ASQC Q9000-1, latest revision. The Contractor need not be registered under ISO 9000 or ANSI/ASQC Q9000-1 to obtain compliance.

18.1.2 Quality Assurance Program

18.1.2.1 Assessment of Quality Assurance Program

The NYCT shall have the right to visit facilities of the Contractor and subcontractors to assess their quality assurance programs. This assessment will determine if the quality assurance programs will assure product compliance with the Specification requirements. During assessment, the NYCT may inspect production facilities, examine operations in progress, and review documentation. If deficiencies are noted, the Contractor shall ensure that corrective action is accomplished and approved. Corrective measures and their documentation are a condition for the NYCT's acceptance of the Quality Assurance Program Plan.

After Notice To Proceed (NTP), the NYCT shall have free access to shops of the Contractor and subcontractors. The NYCT will perform quality assurance inspections during the Contractor's execution of the Contract to ensure that the Contractor is meeting all of its Quality Assurance Program requirements. The
inspections will be performed independent of and in addition to the Contractor's quality assurance function. These monitoring functions will confirm that all deliverables under the Contract, and NYCT-approved Contractor drawings and documentation conform to the Specification. The NYCT's quality assurance activities will in no way replace, negate, override, or lessen the Contractor's quality assurance and other obligations.

Quality assurance responsibilities required by this Specification include planning, establishing and maintaining a quality assurance program; performing all work required by the quality assurance program; and conducting regular QA program audits.

18.1.2.2 Quality Assurance Program Plan

Within 60 days after NTP, the Contractor shall submit a Quality Assurance Plan to the NYCT for approval. This plan shall regulate procedures, methods and processes to ensure compliance with all Contract requirements. As a condition of having the Plan approved, the Contractor shall incorporate written procedures defining its QA program. The Plan shall include as a minimum, product, Contract compliance and Corrective Action procedures. The Plan shall include software QA requirements referenced in Section 16.3.

The Quality Assurance Program Plan shall include an Inspection and Test Plan. The plan shall show major manufacturing and inspection milestones on a schedule, including planned dates for submittals. This plan will be used by the NYCT's quality assurance representative to identify the Contractor's inspection and test witness points. This Plan, and its attendant schedule, shall be updated as milestone dates or other significant items change.

The approved Quality Assurance Program Plan and supplemental manuals, procedures, and instructions shall be subject to periodic audits by the Contractor as determined by NYCT. Audits will assess implementation of the quality assurance program.
18.1.2.3 Quality Assurance Manual

The Contractor's quality assurance manual shall be submitted for approval. The Manual shall describe methods to plan, implement, and maintain its quality program. All engineering, procurement, manufacturing, inspection and test plans and procedures shall be developed using the methods and procedures found in the approved Quality Manual. The quality assurance manual shall begin with a policy statement, signed by the Contractor's chief executive. It shall clearly define the authority of the Quality Assurance Department and the responsibilities of every department for quality. An organization chart shall be included to show the reporting relationships of all management staff. The Manual shall clearly indicate that Quality Assurance personnel shall have sufficient authority and organizational freedom to insure that a nonconforming or discrepant product or service will not be delivered to the NYCT. The responsibility for the quality assurance function shall be so placed in the Contractor's own organization that meeting schedule and cost projections will not compromise the quality of products or services delivered under the terms of the Contract. The manual shall also contain or refer to a comprehensive collection of forms for documentation of quality control activities. Forms shall be designed to assure compliance of materials, processes, personnel, and products to the approved design drawings and applicable specifications. Quality assurance manuals of the Contractor and subcontractors shall be submitted to the NYCT for approval 24 weeks after NTP. However, the portion of the QA program pertaining
to engineering and design shall be submitted within four weeks after NTP. Deficiencies in these manuals shall be corrected within 30 days. Revisions shall be submitted to the NYCT for review. Contract work that is performed prior to the NYCT's approval of these manuals shall be at the Contractor's risk.

The Contractor's quality assurance manual shall provide procedures to control the activities listed in Sections 18.2.4 through 18.2.5.

18.1.2.4 Design Control

Written procedures shall be implemented to assure designs are clearly defined. Design reviews shall verify adequacy of the designs. Design inputs from technical specifications, regulatory requirements, industry codes, and military standards shall be identified and documented. Procedures shall be developed for translating these design inputs into design specifications and drawings. These design documents shall be the basis for purchase, manufacture, fabrication, test, inspection, and quality standards of the Contractor and subcontractors. Design changes shall be made using the same design and drafting procedures which controlled creation and presentation of the original design.

The Contractor shall establish and maintain objective evidence of compliance with all of the requirements of this Specifications and accepted design control procedures.

The Contractor shall implement a Configuration Management Plan that maintains and assures the latest drawing and software configuration. The Contractor shall ensure that requirements for the effectivity point of changes are met and that obsolete contract drawings and requirements are promptly removed from the system. Means of tracking the effectivity points shall be employed and made available to the NYCT.

18.1.2.5 Purchasing

The Contractor shall outline the methods to be used for selection and control of Subcontractors and suppliers. The Contractor shall be responsible for ensuring that all supplies and services procured conform to Contract requirements. The subcontractor quality function shall be reviewed and assessed by the Contractor at intervals consistent with product complexity and quality requirements.

Purchase specifications shall require all purchased materials, equipment, and services to comply with the Contractor's material, quality, workmanship, and performance criteria. Purchase specifications shall transmit quality requirements, specifications, and standards to subcontractors. Purchased materials shall be inspected by the Contractor upon receipt to verify conformance to design and test requirements. Purchase order requirements shall insure that the subcontractor will notify and obtain approval from the Contractor for design changes and use of certificates of compliance (where applicable), prior to implementation. The Contractor shall meet with subcontractors and suppliers as needed to clarify provisions of the purchase contracts. Evidence of compliance with the purchase specifications shall be available for the NYCT's review up to five years after the last Contract deliverable is furnished.

The NYCT reserves the right to inspect, at the source, any supplies furnished or services rendered under the Contract. The Contractor shall assure the NYCT's right to make contact with manufacturers, subcontractors,
or suppliers, to discuss scheduling, design, or quality issues. The NYCT shall coordinate with the Contractor regarding any action required due to discussions with the Contractor's subcontractors and suppliers. When the NYCT elects to inspect at a subcontractor's facility, such inspection shall not be used by the Contractor as evidence of effective quality control of the subcontractor.

18.1.2.6 Materials Control

Written procedures shall be implemented to assure purchased material conforms to requirements of the purchase specifications. These measures shall include receipt inspection, evaluation of production facilities, and review of material certifications, quality assurance manuals for suppliers of systems, and procedures. There shall also be procedures for the qualification and acceptance of material suppliers.

The Contractor shall submit written procedures for identification and control of product. The written procedures shall assure items are handled, stored, and shipped properly to prevent damage and loss. There shall be instructions for serialization and part identification, precautionary signs, protection against weathering and corrosion, drying agents, moisture barriers, and control of shelf life.

If the NYCT believes defective work has occurred, or defective materials have been used, the Contractor shall furnish the appliances and labor to investigate. Defective construction or materials which may be disclosed shall be corrected promptly; all costs shall be borne by the Contractor. If defects are not found, and it is determined that the investigation was materially responsible for delay of any Deliverables subject to liquidated damages, the Contract time for the affected Deliverable(s) shall be extended without liquidated damages for the same period the Contractor needed to investigate.

Parts and apparatus damaged during construction, testing, or shipment shall be made good at the expense of the Contractor. Repair procedures shall be subject to approval by the NYCT.

Written procedures shall be implemented to prevent use of items which do not conform to specifications. These controls shall provide instructions to identify and document noncompliance. The procedures shall instruct personnel to segregate noncompliant parts, require disposition by the appropriate department, and notify the affected organizations. Defective items shall be tagged, documented, and segregated in a holding area pending disposition by the Material Review Board (MRB).

The Contractor shall establish a Material Review Board involving representatives of the Contractor's quality control, manufacturing, purchasing, and engineering groups. The Board shall recommend whether deficient items shall be completed, scrapped, repaired, or used as-is. The Board shall promptly identify causes of defects, recommend corrective actions to prevent recurrence, and follow-up to verify satisfactory response. Prior approval by the NYCT shall only be required in the event a decision is made to direct nonconforming materials into the production flow. The Board shall issue reports at least on a monthly basis to summarize its activities. These reports shall be a complete listing of items received into the MRB hold area along with a description of part deficiencies and dispositions.

The Contractor shall submit a Material Review Board procedure for review and approval as part of the Quality Assurance Manual.
18.1.2.7 Manufacturing and Process Control

Written procedures shall be developed to control manufacturing and production processes shown on the approved manufacturing and inspection plans. These plans shall be approved by the NYCT before the start of any work. The manufacturing plan shall include a product work-flow block diagram. It shall show significant operations and related points for critical inspections, examinations, and tests. Control/Hold points for inspections, examinations, and tests shall be established to prevent out-of-sequence installation and ensure that no work will be hidden from inspection or test by succeeding assembly. Items installed out of order or found hidden by succeeding assembly shall be inspected and tested to provide the same assurance as the approved inspection and test plan.

Certain special manufacturing and production processes shall be performed by certified personnel using qualified procedures under specified environmental conditions. These processes shall include welding, heat treatment, non-destructive tests, and wheel pressing. Procedures shall be controlled to assure compliance with specification requirements. Applicable codes, standards, regulations, and acceptance criteria for special processes and tests shall be cited by procedures, drawings, and checklists.

Conditions which adversely affect product quality shall be identified, controlled, and eliminated. Evidence of corrective actions to prevent recurrence of such conditions shall be verified and documented.

Materials used in manufacturing operations shall be identified. Documents which trace items throughout receipt, storage, fabrication, repair, and shipment shall be filed. Markings shall be transferred to each part of an identified item when subdivided. Marking shall not be obliterated or hidden by surface treatments. Manufacturing history of items shall be documented on forms which accompany parts and assemblies as they are processed.

18.1.2.8 Inspection and Test

The Contractor shall establish formal inspection and test procedures. All inspection and tests shall be performed to demonstrate compliance with Specification requirements, confirm elimination of deficiencies, and provide information on vehicle technical characteristics.

Written procedures shall be implemented to assure all items will perform satisfactorily in service. Functional, operational, and acceptance testing shall be performed under controlled conditions, using appropriate test equipment. Test equipment shall be operated by persons who have received adequate indoctrination and training. Test procedures shall reference test objectives and list prerequisites to be met. Test instrumentation requirements shall also be listed for each test procedure. The Contractor's inspectors shall monitor tests and verify that specified conditions are satisfied.

18.1.2.9 Inspection, Measuring and Test Equipment

The Contractor shall ensure that inspection, measuring, and test equipment shall be identified, controlled, calibrated, and maintained in order to demonstrate the conformance of work to Specification requirements.
Written procedures shall be implemented to assure tools and inspection and test equipment are calibrated. Tooling and fixtures used as a medium of inspection shall be included in these procedures. Calibrations and adjustments shall be performed at prescribed intervals. Calibration standards shall be traceable to the National Institute of Standards and Technology or approved equal. Calibration status shall be labeled on the controlled item and recorded to assure adherence to calibration schedules. Calibration labels shall identify the date of current calibration, by whom calibrated, and when the next calibration is due.

18.1.2.10 Inspection and Test Status

The Contractor shall provide written procedures to identify the inspection and test status of work during production and installation. The procedures shall be capable of identifying the progressive inspection status of components or materials as to their acceptance, rejection, or non-inspection status. The procedures shall ensure that only work which has passed the required inspections and tests is accepted. Nonconforming items shall be identified by physical segregation and status indicators such as markings, serialization, stamps, tags and inspection records.

18.1.2.11 Nonconforming Material

The Contractor shall provide written procedures for control of nonconforming material, including procedures for its identification, segregation and disposition. The Material Review Board shall perform evaluation and determine disposition of nonconforming material. Disposition to use "as-is" or repair of nonconforming material shall require NYCT approval. All nonconforming material shall be positively identified to prevent unauthorized use, shipment or mixing with conforming material. Bonded holding areas shall be established by the Contractor to isolate nonconforming items.

The Contractor shall be required to present Corrective Action statements for all documented discrepant material or activity. Corrective action shall extend to all subcontractors and suppliers.

18.1.2.12 Engineering Change Control

Written procedures shall be implemented to ensure inspections and tests are based on latest approved designs. The change control system shall require controlled documents to be prepared, issued, and revised. This system shall assure that all materials, replacement parts lists, and operation and maintenance data reflect the latest configuration of parts and equipment. Engineering change procedures shall be included in the Configuration Management Plan.

18.1.2.13 Record Keeping

Written procedures shall be implemented to verify that quality assurance records demonstrate compliance with requirements of the purchase specifications. These procedures shall include a Quality Assurance records list that will define which records will be kept. The records list shall include results of examinations, inspections, tests, process controls, certification of processes and personnel, non-conformances (including disposition), calibrations, corrective action, audits and any other quality requirements defined by the contract. These records shall be controlled and available to the NYCT upon request.
Exceptions to the quality of workmanship taken by the NYCT on any vehicle, system, or component shall be posted conspicuously and in a convenient location for review. These notices shall be distributed to departments whose input is needed for resolution. A means to obtain and translate input into corrective action shall be established. Contractor's inspection personnel shall keep these notices current so rejection or approval status of each exception may be readily determined throughout manufacturing.

18.1.2.14 Qualification of Personnel

Contractor personnel performing work, inspections or tests shall be qualified for such activity by virtue of prior experience and training, and verified by testing where applicable. Records of personnel certification and qualifications shall be maintained and available for NYCT review.

18.1.2.15 Quality Assurance Procedures

The Contractor shall submit for approval, written procedures to assure effective implementation of the quality assurance activities. As a minimum the following procedures shall be included as part of the Contractor's Quality Assurance Manual:

- Design control, including technical documentation and engineering changes;
- Transmission of all quality assurance requirements to procurement sources;
- Surveillance of subcontractors and suppliers;
- Receiving, in-process, and final inspections;
- Production and process control;
- Operator certifications and qualifications;
- Functional testing;
- Discrepancy control;
- Measuring and test equipment calibration and certification;
- Drawing control;
- Quality assurance records;
- Shipping, handling, and storing;
- Selection of qualified procurement sources;
- Evaluation and assessment of subcontractor's quality assurance program;
- Monitoring of subcontractor quality assurance performance; and
- Evaluation of procured articles against purchase order requirements.

18.1.3 Quality Control Functions

18.1.3.1 General

Inspection and verification of compliance shall be assured by the Contractor at the facilities of the Carbuilder, or its subcontractors or other manufacturers. Further inspection at the Contractor's and NYCT's facilities to assess transportation damage to vehicles or equipment shall also be required.
SYSTEM ASSURANCE

All entities within the Contractor's organization shall enforce the quality assurance program. Schedule and cost decisions shall not compromise quality. If a conflict arises as a result of this provision, details shall be explained to the NYCT by the Contractor's quality assurance designee. Such matters shall be resolved to the satisfaction of the NYCT before shipment of affected items. The Contractor shall employ sufficient staff to perform effective Quality Control.

The Contractor's quality control program shall implement written procedures for enforcement of receiving, in-process, first article, final, and acceptance inspections. Enforcement shall assure that products are manufactured correctly, marked with appropriate identification, successfully tested, and packed to preclude damage during shipment. Preparation for shipment of each vehicle shall be confirmed by completed check lists for each shipment.

The NYCT may also make inspections of items, completed or in-progress, with, without, or in addition to the Contractor's inspection. This shall in no way delete, lessen or take the place of the Contractor's obligation to conduct thorough inspections.

The NYCT reserves the right to reject all materials and workmanship which do not fully conform to this Specification. Repetitious rejections at either the Contractor's or subcontractor’s facilities shall be cause to withdraw the NYCT's inspection. In such case, the work in question shall be stopped until a satisfactory corrective action agreement is reached between the NYCT and the Contractor.

18.1.3.2 Scheduling Inspections

The Contractor shall give ten calendar days' notice before each vendor shipment of major items to its plant; this, so the NYCT can be present during the pre-shipment inspection. The Contractor shall not schedule more than two vendor inspections on the same date without prior approval by the NYCT. After notice by the Contractor, the NYCT will advise within five calendar days whether or not an inspector will be present for the inspection. Work shall follow the Contractor's manufacturing and inspection plans and not be moved from sites without notice to the NYCT. Equipment shall be operational before shipment.

Inspection and testing will not be conducted by the NYCT on Saturdays, Sundays, or holidays observed by the NYCT. Specific tests or inspections may be permitted, as agreed. Failure by the Contractor to recognize this restriction will be reason to reject the equipment involved. Inspections will then be rescheduled at the NYCT's convenience for normal daytime shifts. The NYCT's representatives may be available for evening shift work, special tests, and special inspection on weekends and holidays, if notified 48 hours in advance.

18.1.3.3 Contractor Provisions for the NYCT's Inspection

The Contractor shall extend to the NYCT its full cooperation and provide facilities at its car construction plants of its Carbuilder, including any final assembly site. These facilities shall enable convenient inspection of materials, work, and equipment. The provisions shall provide for separated office space, desks, locker facilities, and file cabinets. Copies of all drawings, diagrams, schedules, changes, deviations, and data shall also be furnished. Data shall be enough to verify design, construction, assembly, installation, workmanship, clearance, tolerance, and functioning of the vehicles.
The NYCT's in-plant representatives shall be provided with a heated, cooled, and adequately lighted private office for a minimum of three people, with access to toilets. Telephones with an outside line and a telefax machine shall be available and dedicated to the NYCT's use within the private office. The Contractor shall supply four dedicated telephone lines for this use.

18.1.3.4 Levels of Inspection

The Contractor shall specify 100 percent, or sampling inspection, for discrete items of work. If sampling plans are proposed, the Contractor shall submit complete details of the plans to the NYCT. Sampling procedures which determine Acceptable Quality Levels (AQL) and Average Outgoing Quality Levels (AOQL) shall be performed under MIL-STD-105D ANSI/ASQC Z 1.9, or other approved plan.

18.1.3.5 Statistical Quality Control

Statistical quality control methods (SQC) may be used to accept parts and materials and to evaluate processes. Such methods shall be performed under MIL-STD-105E guidelines. Results shall be documented. A list of parts and material to be inspected by SQC shall be presented to the NYCT for approval.

18.1.3.6 Inspection Status

The Contractor shall maintain a system to identify acceptance, rejection, or non-inspection status of materials and components. Inspection status shall be identified by tags and stamps.

18.1.3.7 Receiving Inspection

Written procedures shall be implemented to assure items are inspected upon receipt to verify conformance to acceptance criteria of specifications and drawings. All inspections will be performed to Purchase Order requirements and/or specification drawings and requirements. Material certifications and test reports shall be retained.

18.1.3.8 First Article Inspections

A First Article Inspection (FAI) will be performed jointly, by the NYCT and the Contractor, on all major subassemblies and the fully assembled vehicle. Equipment shall be shipped from the point of manufacture only after an FAI has been offered and either passed, or waived by the NYCT. The Contractor shall provide a minimum of 15 working days' notice to the NYCT before any FAI. The Contractor shall not schedule more than two FAI's on the same date without prior approval by the NYCT. Except where the requirement has been waived by the NYCT, the Contractor shall perform pre-FAIs when it is needed to assure the subcontractor is prepared.

First Article Inspection will evaluate component and system maintainability where possible. FAI will only be performed on a component built using approved production processes and tooling, and shall establish the quality of workmanship for the balance of like components. The level shall be established jointly by the NYCT and the Contractor.
First Article Inspection will not be conducted until the design drawings of the article have been conditionally approved or approved. If conditionally approved drawings are used, the NYCT’s conditions for approval shall be satisfied at the FAI and represented by the inspection article.

First Article Inspected items shall be retained for the duration of the manufacturing phase and stored in a secure area at the Contractor's facilities. These items may be utilized for production of the last cars with prior NYCT approval.

As a minimum, First Article Inspections will also be performed on car body components, including:

- Side Frames,
- Roof,
- Ends,
- Floor,
- Complete car body structure,
- Interior equipment installation,
- Underfloor equipment installation, and
- Trucks.

The requirements below shall apply to each FAI:

- A complete set of approved or conditionally approved drawings and software documentation (with the NYCT's comments) for the item to be inspected shall be available;
- For purchased items, a copy of the Vendor's purchase order with commercial items excluded, shall be available;
- Completed inspection forms that control and document acceptance of in-process work shall be available;
- Completed test documents that reflect Unit has passed testing shall be available;
- The inspection work space shall provide the proper environment for inspection of piece part, subassembly or car final assembly;
- When appropriate, the inspection article shall be displayed on a stand or table in a well-lit work space with all necessary inspection tools, go/no-go gauges, plug gauges and handling aids;
- Correct tools and labor to take mechanical or electrical measurements shall be provided;
- Tools and labor for disassembly and removal of covers shall be provided; and
- Functional testing shall be performed.
18.1.3.9 Inspection of Work In-Process

The Contractor's Quality Assurance Department shall maintain and direct a force of inspectors to verify that work in its shops is performed in compliance with the approved design drawings. Discrepancies in the work shall be recorded, and departments responsible for the work shall be notified of the need for corrections. Repairs and corrections shall be inspected for conformance to drawings and NYCT-approved rework instructions, as needed. Reinspection acceptance status shall be indicated by the Contractor's inspectors by stamp or initials on the original of the discrepancy report. Responsible manufacturing supervision shall be notified of rework that is rejected.

18.1.3.10 Hold Point Inspection

The Contractor shall establish hold points in the manufacturing process to provide critical inspections. Hold points shall be utilized to inspect completed operations or installations. Hold points shall also be used to inspect items that are about to be covered by succeeding assembly operations. The Contractor shall use inspection forms to record the list of discrepancies noted. Nonconforming products shall not be released from a hold point area until all discrepancies have been corrected. The inspection forms shall be posted at or near the point of inspection for each vehicle and included with the Car History Book when all discrepancies have been eliminated. The Contractor shall submit a list of hold point inspections to the NYCT for review and approval.

18.1.3.11 Final Inspections

The Contractor shall schedule one day for the NYCT's inspection of each car before each shipment. After all work is completed, the Contractor shall perform final inspection to written procedures prior to the NYCT's inspection. Workmanship items covered by prior inspection reports shall be corrected before final inspection begins.

The Contractor shall provide a qualified supervisor to accompany the NYCT during final inspection to assure that proper corrective action is taken. The Contractor shall provide labor and appropriate tools to remove or open and reapply covers and doors. During final inspection, all systems shall be operational with use of approved types of special equipment or power supplies.

18.1.3.12 Shipping Inspection

The Contractor shall prepare written procedures to ensure completion of manufacture prior to shipment and that all shipments shall be adequately prepared to preclude damage during shipment. These procedures shall include vehicle shipping preparation instructions and inspection procedures for vehicles scheduled for shipment to the acceptance site.
18.1.3.13 Acceptance Testing

The Contractor shall test car functions and performance at the manufacturing site to assure compliance with all technical requirements of this Contract. Functional tests shall be performed to approved procedures. The results shall be documented and included in the Car History Book. Corrective measures shall be made and tests shall be repeated until successful. Final vehicle inspection shall not be permitted until functional testing is completed and accepted.

18.1.3.14 Retrofit Inspection

The Contractor shall provide written procedures to inspect retrofits or changes made to vehicles at the Contractor's acceptance site and on the NYCT's property. When a retrofit or change is made by the Contractor, it shall be to the entire fleet in kind, or on an effectivity point basis. Quality Control shall verify and document completion status of changes.

18.1.4 Quality Assurance Audits

18.1.4.1 General

The NYCT will audit the Contractor's quality assurance activities to determine compliance with the approved Quality Assurance Program Plan. The audit will be conducted to the schedule in Section 18.1.4.2. During the initial audit of the Contractor's quality assurance functions, the NYCT shall reserve the right to audit the quality assurance programs of subcontractors. Audits shall be performed to approved checklists by personnel other than those who performed the work.

The NYCT will notify the Contractor of noncompliance found during audits. The Contractor shall correct noncompliance promptly and request approval by the NYCT. Noncompliance with any part of the approved Quality Assurance Program Plan shall be cause for rejection of Contract work. If the Contractor is responsible, work on the Contract shall be rejected. If a subcontractor is responsible, work by that subcontractor shall be rejected.

After corrective action of the noncompliance has been verified, the Contractor will be notified; Contract work may be resumed. Schedule delays caused by non-compliance with the approved Quality Assurance Program Plan shall not justify an extension of time under the Contract.

Audits shall report on the degree of compliance with approved quality assurance procedures listed in Section 18.1.2.15.

18.1.4.2 Audits of The Contractor

The NYCT will audit the Contractor's quality assurance program at the following times:

- Before production of the first car shell. This audit shall include the Contractor and subcontractors.
After completion of the first shell before installation of equipment.

One month before the NYCT's acceptance of the first car.

Any time the NYCT determines an audit to be appropriate.

18.1.4.3 Contractor Audits of Manufacturers

The Contractor shall audit subcontractors according to the following schedule:

- As a condition of the subcontract or purchase order before the start of work, and
- Within one month before the Contractor's acceptance of the first article inspection, or of supplied items and services.

Audits of the Carbuilder, manufacturers, subcontractors, and suppliers may be witnessed by the NYCT.

18.1.4.4 Audit Reports

Audit reports shall be submitted as follows:

- Within two weeks following audits, the NYCT will furnish the Contractor with a report of each audit. The audit report will describe scope of the audit and procedures followed. The report will identify deficiencies, corrective actions, and date when corrective action for each deficiency is required;
- The Contractor shall prepare a similar report for submittal to the NYCT for each audit of manufacturers, subcontractors, and suppliers; and
- The Contractor shall submit a formal written response to the NYCT within ten working days following the receipt of each audit report. The response shall request approval for the proposed methods and timetables to achieve compliance with the audit report.

18.2 Reliability

Each component, assembly, subsystem, and system element shall be designed to perform its function under the specified design operating conditions without failure for the durations specified. The Contractor shall furnish equipment that meets the Mean Distance Between Failure (MDBF) [Note: NYCT definition for MDBF and train delay.] requirements, considering all failure modes for components, assemblies, subsystems, and system elements. The combination of which shall result in realization of the following:

- Car Level MDBF = 100,000 miles (160,900 km)
Mean Distance Between Failure (MDBF): The MDBF of an item is the ratio of total operating distance accumulated by the total population of identical items to the total number of relevant critical failures which result in a train delay as defined in Section 1.8.1 of the Specification, as calculated by using NYCT's present tracking and calculation methods.

The Contractor shall also furnish equipment that meets the MDBCF requirements specified in Section 18.2.1 of the Specification.

Mean Distance Between Component Failure (MDBCF): The MDBCF of an item is the ratio of the total operating distance, $d$, accumulated by the total population of identical items to the total number of relevant failures, $F$, occurring within the population of identical items during the time $t$. It is expressed by the following equation:

$$\text{MDBCF} = \frac{d}{F}$$

Mean Time Between Component Failures (MTBCF): The MTBCF of an item is the ratio of the total operating time, $t$, accumulated by the total population of identical items to the total number of relevant failures, $F$, occurring within the population of identical items during time $t$. It is expressed by the following equation:

$$\text{MTBCF} = \frac{t}{F}$$

Relevant Failure: A relevant failure of an item is an independent failure which results in a temporary or permanent loss of function of that item caused by either of the following:

- A fault in the item while operating within its design and environmental specification limits.
- Improper operation, maintenance or testing of the item as a result of Contractor-supplied documentation.

At any time up to and including the completion of the warranty period, for any relevant failure, the Contractor shall review the failure and provide a failure analysis report.

In addition to compliance with the reliability requirements provided below, in the event NYCT discloses a fleet defect as set forth within Article 910 of the Contract Terms and Conditions, the Contractor shall comply with all the requirements of such Article 910.

18.2.1 Reliability Requirements

The following reliability requirements are established for the systems and components of the vehicle, assuming routine maintenance is performed by the NYCT as recommended by the Contractor.
For the above, a chargeable failure shall be defined as any failure that requires repair or replacement of any subsystem or vehicle component. Chargeable failures will also include intermittent failures, unverified failures and software failures. Chargeable failures will exclude consumable items, except those which are not achieving their design. Other failures to be excluded include:

- A failure occurrence in equipment of another subsystem, due to the primary failure,
- A failure of the Contractor or NYCT 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 Section 2.5.2, or
- Due to an accident.

The term "unusual aspect or severity" shall be understood to mean a condition that does not occur on the NYCT “rail lines” more often than once in 10 years. The time, place or type of service in which the car was being operated at the time of a failure shall not be of any consequence. The data collection shall be made throughout the warranty period. MDBCF shall be based on a period of twelve (12) months following initial burn-in, but no less than three (3) months following any design change, for the affected system.

### 18.2.2 Reliability and Failure Analyses

The Contractor shall submit a reliability prediction which demonstrates that the specified MDBF and MDBCF requirements shall be achievable. The reliability prediction shall use the MIL-HDBK-217F part stress method for the "ground mobile" environment. For piece parts not contained in MIL-HDBK-217, certified field failure data shall be used to establish predicted failure rates.

The Contractor shall perform and submit a Failure Modes and Effects Analysis (FMEA) to identify weaknesses in safety critical 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.
FMEA and reliability prediction shall be updated throughout vehicle design development. A schedule of milestones which includes submittal of both the reliability prediction and FMEA shall be identified in the Reliability Program Plan.

18.2.3 Reliability Program

The Contractor's reliability program plan shall be submitted within 60 days after NTP. The plan shall address, to NYCT's satisfaction, applicable elements of MIL-STD-785 B; including, but not limited to: Monitoring/Control of Subcontractors and Suppliers; Program Review; Failure Reporting, Analysis, and Corrective Action System (FRACAS); Failure Review Board; Reliability Modeling; Reliability Allocations; Reliability Predictions; Part Derating; Thermal Reliability; and Reliability Development/Growth Testing. In addition, the Program plan shall address:

- Reliability program objectives;
- Reliability program schedule, which identifies specific tasks, with start and completion dates, and explains how these tasks are coordinated and integrated with major program milestones for design, manufacturing, and testing;
- Methodology whereby the Contractor shall predict compliance with the reliability requirements specified in Section 18.2.1;
- Organization of personnel responsible for managing the reliability program;
- Controls for activities of subcontractors and equipment suppliers, to assure their compliance with reliability program methods and objectives; and
- Demonstration testing plans for verification of compliance with reliability requirements specified in Section 18.2.1 when calculations and analyses are inconclusive, or when past performance records are incomplete or unavailable.

Reliability progress reporting, which details implementation of the approved reliability program, shall be submitted to the NYCT on a monthly basis.

18.2.4 Reliability Demonstration Plan

The Contractor shall submit a reliability demonstration plan no later than 90 days before delivery of the first Unit. The plan shall address the following to illustrate compliance with the specified MDBF and MDBCF requirements:

- Demonstration schedule (excluding Unit delivery and burn-in time);
- Reliability demonstration procedures and forms for recording and submitting data;
Success-failure criteria for measuring MDBF and MDCF values for individual equipment items and subsystems under demonstration;

Failure analysis of reported failures to identify the cause and need for corrective action. The Contractor shall establish a Failure Review Board to meet with the NYCT, as required, to determine the need and depth of failure analyses;

Change control procedures for implementing design changes during the demonstration program; and

Format and location of test records, test logs, and data records.

The Contractor shall furnish onsite, for the entire demonstration, a qualified reliability engineer to oversee associated activities. The Contractor proposed reliability engineer shall be subject to NYCT approval.

If, after the end of the demonstration, the NYCT is unable to substantiate that the equipment has met the reliability requirements, the Contractor shall redesign, as needed, to achieve acceptable reliability. Acceptable MDBF data shall be obtained by another demonstration, and the Contractor shall bear all costs associated with the redesign effort, including vehicle modifications and associated costs.

18.2.5 Reliability Demonstration Procedures

The Contractor shall provide a minimum of the following requirements in its reliability demonstration procedures:

- All equipment failures reported during reliability testing shall be classified as relevant or non-relevant failures by the Failure Review Board. Failures shall include all failures, whether occurring in revenue service or not.

- The plan shall describe the details of the burn-in period for each vehicle. All equipment failures during the burn-in shall be reported and recorded, but not counted in establishing MDBF values.

- A proposed plan for corrective action shall be developed and forwarded to the NYCT for approval. The plan shall include proposed restart procedures, proposed changes, and appropriate supporting data. The proposed plan shall clearly identify a specific method for verifying the effectiveness of change(s). Credit may not be taken for time from previous failed tests, and the specified performance and other required characteristics of the equipment shall not be changed to achieve reliability requirements unless approved by the NYCT.

- Preventive maintenance procedures specified for the equipment during normal operation shall be performed by the NYCT during the reliability demonstration.
A record shall be maintained which contains all the information necessary to calculate MTBF, MTBCF, MDBF and MDBCF values for the vehicle and major systems, and to verify successful demonstration of the reliability requirements, per Section 18.2 and 18.2.1. The failure record shall be provided to NYCT in hard copy and electronically.

The Contractor shall provide a detailed discussion of the reliability demonstration procedures in the reliability demonstration plan.

18.3 Maintainability

18.3.1 General

The vehicle shall incorporate designs which reduces maintenance, substantially improving service intervals and component replacement beyond those described within NYCT’s document entitled "SMS Generic Car Workscope And Time Intervals", reference Appendix C. The designs shall also minimize MTTR (Mean Time To Repair, including all access time) and costs throughout the design life. The objectives of the maintainability program, including corrective and preventive maintenance, shall provide for:

- Enhancement of vehicle availability,
- Minimization of maintenance costs, and
- Minimization of vehicle downtime.

The quantitative maintainability requirement for the NYCT’s vehicle shall result in a MTTR of no greater than 1.8 hours. This shall be the weighted average of the MTTR of the key system elements as listed below.

<table>
<thead>
<tr>
<th>System Element</th>
<th>MTTR (hours)</th>
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</thead>
<tbody>
<tr>
<td>Traction Equipment &amp; Controls</td>
<td>1.75</td>
</tr>
<tr>
<td>Friction Braking</td>
<td>2.03</td>
</tr>
<tr>
<td>Communications</td>
<td>1.04</td>
</tr>
<tr>
<td>Side Doors &amp; Controls</td>
<td>0.84</td>
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<tr>
<td>Lighting</td>
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<td>Auxiliary Electrical Apparatus</td>
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<td>HVAC</td>
<td>2.12</td>
</tr>
<tr>
<td>Couplers &amp; Draft Gear</td>
<td>1.50</td>
</tr>
<tr>
<td>Trucks &amp; Suspension</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Compliance with requirements shall be illustrated during the Maintainability Demonstration required within Section 18.3.3.
18.3.2 Maintenance Plan

The Contractor's maintainability program shall include a detailed plan outlining all schedules and activities for vehicle corrective and preventive maintenance. This plan, along with the proposed maintenance manuals and associated drawings, shall be included in the Master Program Schedule (refer to Section 19.1.4 and 19.1.6). The plan shall outline each maintenance task, time schedules, recommended tools, personnel, and skill levels required. These recommendations shall be based upon those of the Contractor and of the equipment suppliers. The weighted average of the component MTTR shall illustrate compliance with the overall MTTR requirements. This plan shall be coordinated with the maintenance manuals and agree with them.

18.3.3 Maintainability Demonstration

Each equipment FAI shall include evaluations of maintainability. At the car level, a formal demonstration shall be performed based on MIL-STD-471 and a minimum sample size of one Unit. As part of the training program for maintenance personnel, selected servicing, preventive maintenance, troubleshooting, change-out of components, corrective maintenance, and use of special tools shall be demonstrated where special emphasis, instruction, or proficiency is needed. Demonstration shall use production Units on NYCT property. Actions necessary to enable train movement under disabling conditions shall also be demonstrated. The procedures used in the Demonstration shall be the same as those within the manuals delivered per Section 20. The Contractor shall submit a Maintainability Demonstration Procedure no later than 90 days before delivery of the first Unit.

18.3.4 Preventive Maintenance

Preventive maintenance shall comprise the tasks that are performed to defer or prevent an anticipated failure occurrence and worn conditions. The total of preventive maintenance tasks, as defined in the maintenance manual, shall have less activities and greater intervals than the NYCT SMS. (See Appendix C.)

18.4 Regulatory Requirements

18.4.1 General

The NYCT’s vehicle shall be designed and constructed to be safe to passengers, persons near the vehicle, and employees, both under normal operating conditions and in the event of equipment failure. The Contractor shall insure that all systems' safety aspects are considered for each individual system and for systems as integrated to complete the vehicle design.

Conflicts between performance and safety requirements will be addressed on a case-by-case basis. The guidelines for resolution of conflicts will be as follows:

- Applications, which in accordance with the requirements of this section are determined to have a significant impact on passenger safety, will conform to applicable safety requirements. Requirements for other material characteristics or properties will conform to that of materials
typically used for the application that are available at the time of award of contract. Typical examples of this application are materials used in the interior of the car body.

- Applications which do not meet the criteria described in the previous paragraph will require conformance to all operational, performance, service, and maintenance requirements.

18.4.1.1 Industry Codes and Standards

All equipment shall comply with applicable codes, standards, and regulations cited in Section 18.4.1.2 and elsewhere in this Specification. Where conflicts exist between standards, the more restrictive, as determined by the NYCT, shall apply.

18.4.1.2 Governmental Rules and Regulations

All equipment shall comply with applicable local, state, and federal rules and regulations. These include, but are not limited to, the following:


- Code of Federal Regulations, Title 49, Parts 27 and 37: "Transportation for Individuals with Disabilities." (U.S. Dept. of Transportation).


Deviations from, and substitutions of, specified standards shall be made only if previously approved by the NYCT. Contractor shall submit a detailed comparison of the alternative criteria, the rationale for the alternative, and whether the proposed code or standard meets or exceeds the existing standard.

18.4.2 System Safety Program

Contractor shall develop, implement, and maintain a comprehensive System Safety Program (SSP) conforming to the guidelines and requirements of MIL-STD-882, Section 4 and all Tasks within Sections 100 and 200 of that document. The NYCT will use the implementation guidelines of Appendices A and B of MIL-STD-882 as the basis for determining acceptability of the Contractor's SSP.

The SSP shall identify all hazards related to the vehicle and impose design requirements and management controls which prevent mishaps by eliminating hazards or reducing risk to levels acceptable to the NYCT. The SSP shall be developed in the earliest phases of the Contract and shall be continuously maintained throughout as design and construction evolves.

Safety requirements, defined in this Section 18.4 and elsewhere in this Specification, shall be incorporated into the SSP and the Contractor's designs.
18.4.2.1 Applicability of MIL-STD-882

Specific portions of MIL-STD-882 are referenced herein. These references shall not be construed as limiting the applicability of any portions of MIL-STD-882, referenced or not. Requirements may be waived or amended only where approved by the NYCT.

Formats for reports, listings, analyses, and other required submittals shall be jointly determined between the NYCT and the Contractor.

The term MA appearing within MIL-STD-882 shall be interpreted as meaning the NYCT. All responsibilities imposed upon the MA by MIL-STD-882 shall be considered as completely satisfied by the contents of this Specification. The Contractor is solely responsible for development of the SSP.

The term GFE/GFP appearing within MIL-STD-882 shall be interpreted to mean the NYCT-furnished equipment (DFE). The Contractor shall assume that no hazard analysis data for this equipment will be available and shall proceed with Paragraph 213.2.2 of Task 213.

18.4.2.2 General Design Requirements

Hazards shall be resolved according to the precedence rules listed in Paragraph 4.4 in MIL-STD-882, with the restriction that hazards with Category I and II severity (as defined in MIL-STD-882) shall be resolved only by methods 4.3a or 4.3b of Paragraph 4.3, and as mandated by this Section 18.4.

The general safety design requirements of Paragraph 4.3 in MIL-STD-882, and the guidelines listed below, shall be incorporated into the design of all vehicle systems affecting safety:

- Only components with high reliability and which have been proven in conditions similar to the projected service shall be utilized.
- All devices not guaranteed fail-safe shall be assumed capable of failing in permissive modes.
- All electronic circuits and software shall be assumed capable of failing in permissive modes.
- 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.
- All vital circuits not wholly within the system apparatus enclosure shall be double-wire, and double-break, with the exception of connections to non-vital circuits, which may be single-wire, and single-break.
- Any component or wire becoming grounded shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that will permit a flow of current equal to, or in excess of, 75 percent of the release value of any safety device in the circuit.
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.

Commands that result in permissive conditions shall be propagated by no less than two 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.

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

Circuit breakers and fuses 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.

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

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

Mechanical systems which apply force to achieve safe states shall not depend upon the application of fluid pressure or electrical energy, unless specifically approved.

All locks, catches, and similar devices affecting safety shall be either self-engaging without application of power, or, if engaged by application of power, shall remain fully and safely engaged in the absence of power.

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

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

18.4.2.3 Failure-Induced Hazards

Vehicle 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.
Vehicle systems whose failure could result in hazards of Category I or II severity shall conform to both of the following design principals, and shall be validated per Unit Qualification Test as specified within Section 17.3.6.13:

- The failure of a single device shall not result in a permissive condition, and
- An undetected failure of any device shall not permit a subsequent device failure to result in a permissive condition.

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 more-safe or less-safe condition, respectively, such as: stop vs. proceed, a lower speed vs. a higher speed, deceleration vs. acceleration, brakes applied vs. brakes released, actuation of alarm vs. no actuation of alarm.

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

- The utilization of fail-safe devices, that is, devices with known, guaranteed-by-the-manufacturer failure modes, such as signal-grade relays, and
- Independent channels with independent checking of each. All channels shall indicate a permissive state in order that the controlled system achieve a permissive state. Failure in any channel shall not affect any other channel, or force the system into a permissive state. Lack of correspondence between channels shall be alarmed and shall force a restrictive state on the system. Checking equipment invariably requires devices conforming to this 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 in fact a dangerous condition may exist, shall not be considered safe.

18.4.2.4 Friction Brake System

Regardless of the methods selected to insure the safety of other systems, the friction brake system shall be a system conforming to the second safety design principle and conformance method defined in Section 18.4.2.3.

The friction brake system shall consist of two completely independent systems, with one system for each truck. Each system is permitted to have independent permissive failure modes. Refer to Section 10 for friction brake control details.
18.4.2.5 Fire and Life Safety

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

Design shall provide for equipment to be located outside of the passenger compartment, whenever practical, in order to isolate potential ignition sources from combustible materials. Vehicle end-caps and the floor shall be designed to prevent propagation of an underfloor fire to the vehicle interior. 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.

18.4.2.6 Safety Under Normal Operating Conditions

The vehicle shall present a safe, hazard-free environment to passengers and the operating and maintenance personnel.

Passengers shall not be exposed to tripping hazards, sharp points and 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, windscreens, controls, and other objects with which the passengers must interface.

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

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 compartmentalization, interlocks, and similar measures. All equipment shall be free from sharp points and edges. All equipment enclosures containing hazardous materials, lethal or injurious voltages, or other risks shall be clearly labeled on both the outside and inside of the equipment enclosures.

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.

18.4.2.7 Human Error and Other External Influences

The Contractor may wish to use MIL-STD-882 and MIL-STD-782 as guides. All systems shall minimize unsafe conditions resulting from human error. No sequence of operations, or the simultaneous activation of any controls, shall result in unsafe conditions. Where conflicting commands, such as simultaneous power and brake, are requested, the more restrictive 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.

18.4.2.8 Hazard Identification

Contractor shall identify all failure-induced and normal operating (non-failure condition) hazards falling into severity Categories I, II, and III. Hazards shall be compiled into lists and submitted for approval to the NYCT.

As required by MIL-STD-882, hazard lists shall be organized into a Preliminary Hazard List (PHL), Subsystem Hazard List (SSHL), and System Hazard List (SHL) as described in Tasks 201, 203, and 204, respectively.

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:

- Emergency brake fails to apply when requested,
- Service brakes fail to apply when requested,
- Propulsion fails to cease when requested,
- No-motion detection system indicates no-motion when train is moving,
- Door opens spontaneously when not commanded,
- Door opens on wrong side of car,
- Door closes on person's limb and indicates door closed and locked to the control system,
- Door interlocks erroneously indicate door is closed and locked,
- Excessive currents or overheated equipment cause fire hazard,
- Indication of uncoupled when not uncoupled, and
- Train moves in wrong direction.

18.4.2.9 Hazard Analyses

Contractor shall perform hazard analyses on all hazards identified in the hazard lists developed in Section 18.4.2.8. Per-hour failure rates shall be established for each Category of hazard severity. Analyses shall demonstrate that the vehicle conforms to the requirements of this Specification and that all identified hazards are either eliminated, or reduced to levels of risk acceptable to the NYCT.
All hazard analyses shall be adjusted or amended as the vehicle design and construction progresses.

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. Failure rate for Category I and II hazards must be less than $10^{-7}$ per hour of operation. Failure rate for Category III hazard must be less than $10^{-5}$ per hour of operation.

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 analysis. All methods shall be submitted for review and approval to the NYCT.

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 NYCT where appropriate.

Analyses shall examine the vehicle in both single unit configurations of four or five cars multiple unit configurations consisting of all possible combinations of four and five car units and shall include circuit faults within the coupler electrical circuits.

Analyses shall identify all maintenance errors that could result in unsafe conditions, such as incorrect adjustment of sensors, and incorrect adjustments of the door obstruction sensing system to cite two, but not all, examples. Analyses shall also include design errors that could produce unsafe conditions, such as improper breaker type or rating and temperature or environmental dependence on proper operation for use in checking designs.
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19.7 Equipment Serialization Program .......................................................................................... T19-22
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19.9 *Intentionally Blank*............................................................................................................. T19-24 MOD 02
SECTION 19

19.0 CONTRACT MANAGEMENT

19.1 Management

19.1.1 General

This Section specifies the requirements for contract management. The management shall be sufficiently comprehensive to enable the NYCT to ascertain, with a high degree of confidence, that the Contractor will meet the requirements of this Specification, and to enable the NYCT to monitor the contractual effort.

19.1.2 Program Manager

The Contractor shall assign an individual, approved by NYCT, to serve as Program Manager for this Program. This individual shall have prior experience in management of rail passenger vehicle procurements and be familiar with design, subcontractor equipment procurement, construction, test, and inspection of rolling stock. This individual shall be granted full authority to render decisions on behalf of the Contractor pertaining to technical and commercial decisions on the Program. The Program Manager shall serve as the Contractor’s representative in all meetings with the NYCT and/or their duly appointed representatives. No substitution of the Program Manager will be permitted without NYCT’s prior approval.

19.1.3 Program Management Responsibilities

The Program Manager shall represent the Contractor during progress meetings, design review meetings, contract change negotiations, and open item meetings with the NYCT and, with the Program Manager's supporting staff, be capable of addressing all issues on the agenda for each scheduled meeting. The Program Manager shall arrange to have supporting staff members available for participation in these meetings, as required.

19.1.4 Management Program

19.1.4.1 General

The Contractor shall establish an organization to properly manage this procurement program. The organization shall be highly responsive to the needs of the NYCT as required in this Specification.

19.1.4.2 Management Plan MOD 02

The Contractor shall develop and submit to the NYCT for approval a Management Plan. The Management Plan shall be submitted within 30 days after Notice To Proceed (NTP) to the Contractor and updated monthly. The Management Plan shall show all design reviews and audits required by this Section and elsewhere in this Specification, and shall include, but shall not necessarily be limited to:

- An organization chart including a definition of the responsibilities and qualifications of all personnel therein.
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- The internal methods, communications, and correspondence control to be used to monitor, oversee, and manage the Program Schedule, technical performance, program changes, subcontracts, purchase orders, material procurement, in-service support, warranty, systems assurance analysis, tests, and demonstrations.

- A Master Program Schedule in Critical Path Method (CPM) format showing key milestones and events as detailed in Article 109 of the Terms and Conditions.

- A list of drawings to be submitted during the design review phase of the program and a schedule for the submittal of these drawings.

- An updated and expanded Contract Data Requirements List (CDRL) based on the information in each Section of this Specification within 60 days after Contractor NTP. The CDRL shall contain the consolidated listing of all required data including specific format, quantity, frequency, and paragraph reference of submittal as required by the Technical Requirements. Submittals include, but are not limited to, schedules, plans, procedures, reports, certificates, samples, certifications, test results, and as-built drawings. The CDRL list shall be in accordance with the following column headings:
  - Item No: Numeric identifier
  - Title: CDRL item
  - Reference Section: Location of requirement within the Contract Documents
  - Description: Brief description of required due dates and frequency
  - Quantity: Number of documents, units, or copies required

19.1.4.3 Submittal Review Prioritization Plan

To expedite the design review and approval process, NYCT intends to develop a comprehensive plan for prioritizing the review of submittals in cooperation with the Contractor. For this reason, the Contractor shall schedule a series of meetings with NYCT within two weeks of submittal of the Management Plan to develop the Submittal Review Prioritization Plan (“Review Plan”). This plan will be based on the Drawing Schedule and CDRL submitted in the Management Plan, and will include drawings at levels of indenture below that of those in the Drawing Schedule. The Submittal Review Prioritization Plan, once agreed to, shall become part of the Management Plan. Subsequent updates to the Review Plan shall be ongoing as required to meet the needs of the Program.

The Prioritization plan will group submittals into categories based on their criticality to various phases of the program. Suggested submittal groupings are as follows:

- Advance submittals which must be reviewed and approved (informally, at least) early in the program to allow further design work to proceed. These should be key conceptual design submittals that define basic vehicle and system configurations and demonstrate Specification compliance at the vehicle and system level.
Submittals which must be reviewed and approved prior to the start of procurement activities

Submittals which must be reviewed and approved prior to the start of manufacturing

Submittals which must be reviewed and approved prior to first article inspection

Submittals which must be reviewed and approved prior to the start of vehicle testing

Submittals which must be reviewed and approved prior to delivery of the first unit

Submittals for which review and approval may be deferred to some point after delivery of the first unit

As-built submittals

Submittals for information only (i.e., formal review and approval is not required)

Note that it may, in some cases, be determined that drawings scheduled for completion at an early stage in the program do not require review until a later stage, depending on the agreed-upon criticality of those drawings to the overall design. Note also that NYCT approval of the Submittal Prioritization Review Plan and the agreed-upon deferral of review and approval for a given submittal does not in any way relieve the Contractor from compliance with the Specification, or from the responsibility to produce a satisfactory design. Items not reviewed are not exempt from the requirements of the contract. Any items which are proposed as alternatives to the contract requirements must be submitted to NYCT for review and approval prior to the start of procurement, whether identified as such in the original Review Plan or not.

The Review Plan shall also include a description of review program logistics, particularly those aspects of the program which supplement the traditional submittal and review process in order to accelerate design review and approval. These may include provisions for co-residence of cognizant Contractor and Authority personnel to expedite turnaround of submittals, non-binding up-front reviews that are contingent on ultimate receipt of supporting drawings, in-process design reviews convened as needed, and any other methods for expediting review that are deemed appropriate by the Contractor and NYCT.

19.1.5 Monthly Progress Reports

After initial approval of the Master Program Schedule and monthly thereafter, the Contractor shall submit to the NYCT a copy of the updated Master Program Schedule containing data as of the end of each month. The purpose of the monthly progress reports is the joint review and agreement on job progress. Job progress shall specifically include:

- Actual completion dates for activities completed during the report period,
- Actual start dates for activities started during the report period,
Estimated remaining durations for activities in progress,

Estimated start dates for activities scheduled to start during the six weeks following the report period,

Changes in the durations of activities and minor logic changes,

Work-arounds needed to make up for schedule slippage, as necessary, and

Activities not previously included in the master program schedule.

The Contractor shall also provide a narrative which shall state the work actually completed and reflect the progress in terms of days ahead of or behind the specified dates for each of the work items, as well as percent completed.

19.1.6 Master Program Schedule Updating

The Contractor shall update the Master Program Schedule in the following manner:

Initial schedule shall remain the same for each update.

Actual progress shall be shown using different colored lines or lines of a different pattern from those used when preparing the initial schedule. Actual progress shall be shown directly under the activity with the percentage complete indicated as of the date prepared.

Date of the updates shall be provided.

Actual start/finish dates shall be shown for activities in progress.

19.1.7 Progress Review Meetings

Progress Review Meetings (PRMs) will be initially held every week. As the Unit design is completed, NYCT may elect to decrease the frequency of these meetings. Depending on the subject matter to be covered in the Progress Review Meetings, the NYCT may opt to conduct certain meetings at the car construction facilities or facilities of the Contractor's subcontractors. The NYCT will make this known to the Contractor at least five days prior to the meetings.

The Contractor shall prepare and distribute an agenda to all participants expected to attend the meetings three days prior to the scheduled meeting date.

The appropriate Contractor personnel, based upon anticipated agenda, shall attend.
As a minimum, the following topics shall be discussed:

- Introduce new attendees and areas of responsibility.
- Review minutes of previous meetings, amend minutes if necessary, and accept minutes.
- Review of the updated Master Program Schedule.
- Analyze work accomplished since previous meetings, including: design status, fabrication problems, product delivery problems, schedule slippages, problems arising from proposed changes, and other circumstances which might affect progress of the work.
- Discuss sequence of critical work and schedule of manufacturing using the Contract Schedule and Monthly Progress Reports.
- Discuss engineering, manufacturing, and quality control.
- Discuss changed conditions and time extensions.
- Discuss corrective measures to maintain Progress Schedule when necessary.
- Discuss work to be done in the next six weeks.

Each of the inquiries, reports, and requests for solution of problems presented during such meetings shall be answered, when possible, during the meeting; those not answered during the meeting shall be solved and the resolution documented and delivered in person or mailed to the NYCT’s designee, within three working days of the close of the meeting, or longer time frame if mutually acceptable.

19.1.8 Contractor Representatives

The Contractor, and its subsuppliers, shall provide qualified technical and administrative support on the NYCT’s property commencing with the arrival of the first pre-production vehicle and concluding with the completion of the warranty program. The Contractor Representatives shall be fully qualified for the on-site tasks. Included among the personnel shall be a full range of engineering skills, until such time as all cars are accepted. All necessary specialized support shall be available, on short notice, to assist the on-site personnel in the investigation and resolution of car and equipment malfunctions.

Contractor Representatives must be identified by the Contractor and display appropriate identification while on NYCT property. Contractor's on-site personnel must undergo NYCT's safety training prior to access to NYCT facilities.
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19.1.9 Industrial Designer

The Contractor shall provide industrial design services during the design and manufacturing phases of the Contract. It shall be the responsibility of this Industrial Designer to finalize NYCT's industrial designs in such a manner that the function, value and appearance of its systems are optimized for the mutual benefit of the NYCT and its passengers. The Industrial Designer shall lead the design effort of the vehicle's interior, exterior, and equipment layout. The Contractor shall provide a minimum of four (4) interior and three (3) exterior finalized color detail renderings for the NYCT's review during the development of the car design. The renderings shall be the basis for the NYCT's selection of the design that will be carried through to production. The Industrial Designer shall place emphasis on safety, human factors (ergonomics), aesthetics, manufacturability, maintainability, and cost, when developing the final design of the car.

The industrial design services shall include, but not be limited to:

- Vehicle exterior aesthetics,
- Vehicle interior aesthetics,
- Vehicle configuration with respect to NYCT system clearance restrictions,
- Cab equipment arrangement and Operator's cab console,
- Vehicle equipment arrangement and maintenance access,
- Between car barriers,
- Materials selection and application, and
- Human factors engineering (ergonomics).

The Industrial Designer shall be identified and presented to NYCT for approval. Prior experience as an industrial designer for a rail vehicle procurement program is required. The NYCT reserves the right to reject prospective Industrial Designers presented by the Contractor for approval.

19.2 Design Approvals, Contractor's Drawings, Documentation and Data Requirements

19.2.1 Review Procedures for Drawings, Documents and Data

The Contractor shall submit drawings in accordance with the Review Plan (refer to Section 19.1.4.3) within the Contractor's Management Plan. As described in Section 19.1.4.3, this Plan is based on the Contractor’s Drawing Submittal List and Schedule. The Contractor shall submit five copies, and one electronic copy, of all documents, data, assembly and installation drawings required to convey concept, design, dimensions, maintenance, operation, and overall assembly aspects and interfaces for review. Subassembly drawings shall also be submitted for information to facilitate the review of assembly and installation drawings. Drawings shall be accompanied by material specifications, process specifications, flammability and smoke emissions data, and test data required to permit review of the drawings. The NYCT reserves the right to request additional drawings, documents, or data, or any combination of documents, drawings, or data to support the review process. When submitting drawings of structural parts or assemblies for the car body structure, equipment supports, and trucks, the Contractor shall also submit, for review and approval, stress analyses for these parts or assemblies in summary form. Other contract deliverables including material samples, test plans, test procedures, and analyses as required by this Specification shall be submitted in the quantities specified.
Review of Contractor submittals shall be secured before manufacturing any parts, as indicated in the Review Plan.

Except as provided below, or as defined in the Review Plan, the NYCT will return submittals approved, or with comments noted, within 30 calendar days after receipt by the NYCT. The NYCT will disposition the submittal, within 90 calendar days after receipt by the NYCT, all manuals and catalogs identified in Section 20.1, Training and Manuals. The NYCT will respond to the Contractor at an address within the United States designated by the Contractor. To prevent grouping of drawings into large packages submitted to the NYCT, the NYCT will not be obligated to review more than 100 drawings and technical documents, within a 30-day period. In the event that more than 100 drawings are submitted for review in a 30-day period, the NYCT will make every effort to review them within the 30 days, except, if specifically identified elsewhere in the Specification. If this is not possible, the NYCT will review them in accordance with priorities as mutually agreed to between the Contractor and the NYCT.

As submitted by the Contractor, the drawings, documents and data shall be accompanied by a letter of transmittal listing drawing and document titles, numbers, and revisions. If more than one drawing or document is submitted at a time, the drawings and documents shall be listed in the transmittal in numerical sequence.

No extension of Contract time will be allowed for revision of Contractor's drawings or documents which have been either "disapproved" or "conditionally approved". Such drawings and documents shall be resubmitted and will be reviewed and returned to the Contractor within the same time intervals as would be allotted to the drawings and documents when initially submitted. Drawings shall be submitted in an orderly and logical sequence to enable the NYCT to readily determine and review the interface relationships between all major structural elements and their subassemblies and also between the structural elements and the attached apparatus, equipment, wiring, piping and hardware.

The Contractor shall maintain a record of Contractor and Subcontractor drawing and document status. This shall include drawing and document numbers, revision letter, drawing title, date submitted, transmittal document, disposition, and the document number identifying the disposition. This status shall be updated not less than monthly and submitted to the NYCT as part of the Monthly Progress Report (reference Section 19.1.5).

19.2.2 Requirements for Drawings, Documents and Data MOD 04

All drawings shall be produced electronically utilizing computer-aided design software. All dimensions shall be expressed in the English system; all wording shall be in the English language. All terminology used shall be conventional to the U.S. transit and railroad industries. Drawings shall be made to the third-angle projection system.

All drawings submitted by the Contractor shall be in the format as required by NYCT Specification 8004-GENL-87, entitled "Engineering Record Drawings", within Appendix C.

A revision block shall be provided for all documents, drawings, and data. The revision block shall identify the revision letter, date of revision, the initials of the engineer authorizing the revision, a description of the
change and a summary of the change, the location of the change on the drawing and the reason for making the change. The full description of the change and the reason for making the change shall be shown on a change sheet or similar document accompanying the drawing and appropriately referenced in the revision block. Subsequent to document, drawing, and data approval by the NYCT, engineering change requests (ECR) must be submitted to the NYCT for approval before incorporation of any document, drawing, and data revisions. Upon receipt of ECR approval, the document, drawing, and data shall be revised and the document, drawing, and data, with the accompanying approved ECR, shall be submitted for approval. No additional revisions to an approved documents, drawings, and data shall be made without an approved ECR.

All structural drawings shall be of sufficient scale and size to clearly delineate the shape and size of all assemblies, members and components. The drawings shall be completely dimensioned. Build up of materials shall be shown and identified (thicknesses dimensioned). Full and complete information regarding location, type, size, and extent of all welds shall be clearly shown on the drawings. All joints and connections shall be detailed, with all dimensions, showing the size of the fasteners, and complete AWS, or equivalent, weld symbols (including size and process). The list of materials shall include the material's specification with grade, temper, thickness, and nominal size.

All structural drawings shall be zoned to make it easier to locate details. The zones shall be approximately 3 inches by 3 inches in size. The vertical divisions shall be designated by letter and the horizontal divisions designated by number. Whenever a cut, section or detail is referenced on a drawing, its location, by sheet and zone, where it can be found shall be given. Wherever the cut, section, or detail is shown, the location by sheet number and zone from whence it came shall be given.

All drawings supplied by the Contractor shall be delineated in a manner that permits the wiring, piping, and mechanical interface relationships between components furnished by the Carbuilder and its Subcontractors to be clearly identifiable.

Whenever reference is made on a drawing to a material or process by the Contractor's own specification number, the drawing shall also give the commercial equivalent. If there is no commercial equivalent, the Contractor shall provide copies of its specification.

Totally integrated vehicle schematics relating to all electrical and pneumatic systems shall include component identification, component values, waveforms, voltages, currents, resistance values, wire identification, connector identification, and connector pin numbers. All components on PC boards shall be individually shown in the schematics. Schematics shall be comprehensive in nature and thoroughly detailed to permit use by the NYCT shop electricians and air brake specialists to troubleshoot and repair vehicle systems.

Schematic location (page number, for example) of the energization portion of each device (such as the coil in a relay) shall be noted adjacent to the operating portions (such as relay interlocks) of the device.
A set of device tables shall be located in a single section at the rear of the schematic book. This table shall be arranged in logical fashion by system device type. This table shall include data for all system and subsystem components including but not limited to:

- Electrical control and power components (groups, panels, PC cards, contactors, relays, circuit breakers, capacitors, inductors, resistors, specialized modules, rectifiers, thyristors, diodes, fuses, and other components, as appropriate)
- Electrical machinery (rotating equipment, reactors, transformers, pumps, fans, compressors, switchgear, and other machinery)
- Pneumatic control and power devices (valves, chokes, strainers, reducers, and other components)
- Pneumatic machinery (compressors, air cylinders, air motors, air latches, and other machinery)

As a minimum, device listings shall include the following:

- Location in schematic and schematic designation,
- Type, model, and part number,
- Location on vehicle,
- Function,
- Schematic symbol,
- Appropriate ratings data, and
- Interface information, as appropriate.

The integrated schematic drawings shall be formatted by subsystem, using identical device symbols and wire and pipe designators for each subsystem. All interfaces, from page to page, and subsystem to subsystem, shall be clearly delineated. The integrated schematic and narrative shall be designed, drafted, assembled, and published by the Contractor, or by a single subcontractor placed under contract for that express purpose. It will not be acceptable to assemble a collection of subcontractor drawings, independently produced, into a single, vehicle integrated schematic. To ensure clarity, the Contractor shall select lettering and detail size to be legible for a schematic page reduced to a size of 5 inches x 7 inches; however, the schematic shall be submitted in an 8-1/2 inch x 11-inch page format.

Wiring diagrams shall be integrated connection diagrams and a wire list in book form based on the integrated schematic. The diagrams shall show all wiring, raceways, conduits, and connections.

The wire list shall include each individual wire segment in the vehicle, listed separately, whether the wire is used for the transfer of power or information.
As a minimum, the following information shall be provided for each wire segment:

- Wire code (schematic designation),
- Origin (FROM device/terminal),
- Destination (TO device/terminal),
- Wire size,
- Voltage rating,
- Length,
- Appropriate specifications,
- Jacket color, and
- Harness designation.

Instructional drawings shall be prepared in accordance with the requirements of Air Transport Association of America (ATA) Specification No. 100 "Specification for Manufacturer's Technical Data" and shall be prepared so that reduction can be made to 8-1/2 inch by 11-inch dimensions.

The following ANSI standard for the preparation of drawings shall apply: Y1.1, Abbreviations for Use on Drawings; Y32.2, Graphics Symbols for Electrical and Electronic Diagrams; and Y32.14, Graphic Symbols for Logic Diagrams. The requirements for ATA and ANSI standard graphic symbols and abbreviations may be waived by the NYCT provided a system of standard abbreviations and symbols for all drawings submitted is used and the Contractor provides the NYCT with five copies of a bound booklet in a format which contains a legend cross-referencing all abbreviations and graphic symbols used on drawings to those required by the ATA and ANSI standards.

19.2.3 Drawings Requiring Approval

Drawings to be furnished by the Contractor for approval by the NYCT shall include but not be limited to those listed below. The NYCT reserves the right to request additional drawings as required to clarify and amplify the intent of drawings furnished.

- General:
  - Exterior elevations of both sides of vehicle
  - Exterior elevations of both ends of vehicle
  - Floor plan
  - Reflected ceiling plan
  - Roof plan
  - Interior, longitudinal sections of both sides of vehicle
  - Interior elevations of both ends of vehicle
  - Plan layout, cab equipment
  - Layout of cab console
  - Interior elevations of cab layout
  - Reflected plan, undercar equipment layout
  - Reflected plan, conduit and cable layouts
  - Reflected plan, piping layout
Side elevation, undercar equipment layout
 Relation of ends of vehicles on curves, and showing vertical and horizontal drawbar swings both static and dynamic
 Car body and wayside clearance drawings

Sections:
 Transverse sections to show all variations in cross section such as through doors and windows, roof, etc.
 Transverse section to show extreme movements of vehicle (including yaw) permitted by vehicle suspension and running gear.
 Transverse and longitudinal sections to show physical relationship of major undercar components.
 Transverse sections to show vertical and lateral undercar equipment clearances to rail and roadbed.

Framing and Miscellaneous Drawings:
 Underframe and bolster - plan, elevations, and sections
 Anti-climbers - plan, elevations, and sections
 Side frame(s) - plan, elevations, and sections
 Roof frame - plan, elevations, and sections
 End frame - plan, elevations, and sections
 Coupler and drawbar attachment to underframe - plan, elevations, and sections

Trucks:
 Truck assembly - plan and elevations and equipment application
 Truck frame - details
 Bolster - details
 Suspension - details
 Wheels - details
 Axle - details
 Journal bearings - details
 Gear units - assembly
 Axle assembly - complete
 Brake equipment - details
 Traction motors - details
 Speed sensors - details
 Ground brushes - details

Air Conditioning Unit:
 Plan, elevations
 Installation details
Electrical and piping schematics
Assembly details

Doors, Windscreens:
Plan, elevations, sections
Hardware and attaching details

Coupler and Draw Bar:
Plan, elevations
Pneumatic, mechanical, and electrical details (Coupler Only)

Ducting (HVAC, Traction, ECU):
Plans, elevations, sections
Joining details

Propulsion Equipment:
Inverters - details
Controls - details

Equipment Boxes, Compartments and Lockers:
Plan, elevation, sections
Hardware details

Master Controller:
Plan, location
Details

Lighting Fixtures:
Location
Details

Seating:
Plan, elevations, sections
Attaching details and stanchions
Wheelchair area plan, elevation, and sections

Auxiliary Electric Equipment:
Auxiliary power supply - details
Low voltage power supply - details
Battery - details
Circuit breaker panels - details
Knife switch - details
High speed circuit breaker - details
19.2.4 Documents Requiring Approval

Design test documents to be furnished by the Contractor for approval by the NYCT shall include, but not be limited to, those listed below. The NYCT reserves the right to request additional documents, as required, to clarify and amplify the intent of the vehicle design.

- Weight analysis
- FMEA analysis
19.2.5 Review of Contractor Documents, Drawings and Data

All drawings, technical data, test procedures, test schedules, test results, test reports, progress schedules and reports, drawing lists, samples, and other data submitted by the Contractor and requiring review by the NYCT will be handled in accordance with the above provisions.

Approval does not relieve the Contractor of the obligation to meet all of the requirements of the Contract. Approval of a document, drawing, and data which contain deviations from, or violation of, the Specification does not constitute authority for that deviation or violation. Such deviations must be specifically requested and granted.

19.2.6 Subcontractor Certification

The Contractor shall obtain from each of its subcontractors and suppliers of any tier, a written certification that the method being used for installation and connection of its equipment by the Contractor is satisfactory to such subcontractor. The certification shall be readily available to the NYCT.

19.3 Design Review Requirements

19.3.1 Design Review Meetings

A series of design review meetings as scheduled in the approved Management Plan will be held in which the Contractor conducts a presentation in accordance with a previously approved agenda. In its presentation, the Contractor shall address design approaches, concepts, and design details. During these design review meetings, action items will be identified, with each action item assigned to an individual for disposition by a pre-determined response date. A design review action item log will be maintained by the NYCT.

Design review meetings will typically be of one to three days' duration and should address more than one system or subsystem where possible. Ten working days prior to a design review meeting, the Contractor shall submit 5 copies of the agenda and a data package covering information to be addressed in the meeting. Design Review meetings shall be held at locations as mutually agreed and shall include sites of the Carbuilder and any...
of its subcontractors or suppliers. Design review meeting minutes shall be prepared by the Contractor and submitted to the NYCT for review and approval.

Attendance at design review meetings will include representatives of the Contractor and appropriate subcontractors and suppliers, and the NYCT or its representative.

19.3.1.1 Specification Review

Within two weeks after NTP, the Contractor's Program Manager, the Contractor's technical specialists, major subcontractors and suppliers, and the NYCT shall perform a detailed review of these Specifications. During this meeting the Contractor will be asked to provide an explanation of the approach planned in response to each Specification requirement. The NYCT will answer any questions which the Contractor may have regarding Specification requirements.

19.3.1.2 Preliminary Design Review

Upon reaching agreement with regard to the design concepts, the Contractor shall prepare conceptual design drawings for review by the NYCT. Drawings shall be submitted for review and comment. Two weeks subsequent to receipt of conceptual design drawings, a Preliminary Design Review Meeting (PDR), as scheduled in the approved Management Plan, shall be held at the NYCT or its representatives' office in the United States.

19.3.1.3 In-Process Design Review

As the design progresses, a review of the design progress and the work performed in making the transition from conceptual design to final design will be conducted by the NYCT. IPDR meetings will take place monthly. The In-Process Design Review (IPDR) is to serve a two-fold purpose:

- Determine the progress of the work.
- Serve as a forum to discuss design problems and alternative solutions, and to answer questions raised by the Contractor and its Subcontractors.

19.3.1.4 Critical Design Review

The Critical Design Review (CDR) will take place when the design is essentially complete. The CDR is to provide the opportunity to review, revise, and agree on the details of the final design prior to release of the designs for manufacture.

19.3.1.5 First Article Inspections

First Article Inspections, as detailed in Section 18.1.3.8 and as defined within Section 1.8.1 - Definitions, shall be performed as part of the design review process.
19.4 Additional Drawings, Documents and Data to Be Furnished by Contractor

Within 120 days after Contractor NTP, the Contractor shall submit a schedule for submittal of the following drawings, documentation, and data to the NYCT for its review, in accordance with the Master Program Schedule:

- Dynamic outline of the vehicle showing clearance diagrams which reflect all undercar, side, or roof mounted equipment under conditions which consider the maximum truck lateral, vertical, and roll suspension limits and maximum wheel wear.
- Single line control schematic and functional block diagrams for each subsystem, showing all values, operations, and control components.
- General control circuit interface data such as type of signal, range, circuit loading and impedance, type of transducer or pickup, and mechanical requirements.
- Graphs and curves showing response and functional characteristics of major subsystems and components.
- Documentation of analyses conducted by the Contractor, as specifically called for in these Specifications.
- Propulsion System Technical Data shall be submitted as follows:
  - Capability curves of tractive effort versus command signal and speed for both acceleration and dynamic braking mode;
  - Single line diagram of power circuits and functional diagrams of the control loop including input and output signals;
  - Number and connection of power semiconductors used in propulsion circuits together with current and voltage rating of each;
  - Propulsion system estimated energy consumption;
  - Propulsion motor characteristics based on performance criteria, specified wheel size, and offered gear ratio, showing motor voltage, speed and efficiency versus motor current for both propulsion and braking modes;
  - Typical cross section of traction motor;
  - Typical cross section of gear drive units;
  - Detail of coupling and mounting interface between gearbox and traction motor; and
Anticipated resilient characteristics, including natural frequency of gear and motor unit suspension.

Friction Brake System Technical Data shall be submitted as follows:

- Capability curve of tractive effort versus command signal and speed;
- Functional diagram showing control loop and values of all input and output signals;
- Curves of operating pressures versus torque for full operating speed range;
- Tabulation of all electrical loads, giving both maximum instantaneous and average demand;
- Documentation of safety analyses required in Sections 19.2 and 18.4;
- System flow diagram if applicable, showing functional arrangement of all valves, reservoirs, adjustment points and operating units;
- Typical cross section and details of a tread brake unit including mounting details; and
- Description of friction material proposed together with experience data from comparable applications.

Truck Technical Data shall be submitted as follows:

- Drawings showing the truck assembly in plan, side and front view. The drawings shall identify all welds and indicate relation of welded seams to the neutral axes of the weldment. General arrangement, load paths, provision for equalization, and interfaces shall be clearly shown. A quality control procedure shall be submitted outlining the proposed methods of assuring the structural integrity of truck frame members, with particular attention to critical sections, inspection and repair of defects.

- A list of car body motion limits in relation to the truck shall be provided as follows:
  - Vertical (up and down),
  - Lateral,
  - Longitudinal, and
  - Roll angle.
Suspension data shall be provided as follows:

- Type of primary and main suspension;
- Manufacturer of air spring;
- Damping constant of each shock absorber;
- Spring constant of body suspension (expressed as a curve, if not linear), vertical, lateral (at working height) with ends of springs maintained parallel;
- Relationship of air spring pressure to vertical force at constant height and also at various heights;
- No load and maximum load air spring pressures;
- Total air spring volume; including auxiliary reservoir volume;
- Air spring damping orifice size and damping rates, vertical and roll for trucks;
- Air supply requirements;
- Vertical spring constants or load-deflection curves of all resilient truck components other than the body suspension system; and
- Roll stabilizer arrangement and parameters.

Material specifications and static and dynamic design stress levels of truck frame components, axles and springs shall be included.

Preliminary detail drawings and material specifications shall be provided for:

- Axles,
- Wheels,
- Hydraulic shock absorbers,
- Elastomeric journal bearing support, and
- Upstop assembly.

Auxiliary Electrical System Technical Data shall be submitted as follows:

- Operating characteristics of auxiliary system power supply components;
- Low-voltage power supply/battery charger operating characteristics;
- Battery discharge curves and charging requirements; and
- Tabulation of all low voltage dc loads, giving:
  - Maximum and average current,
  - Circuit breaker ratings, and
  - Continuous or intermittent load.

Flammability and Smoke Emission Data for all combustible materials in accordance with Section 15.25.
The Contractor shall implement a comprehensive program to control car weight and weight distribution. Prior to the first design review, the Contractor shall submit:

- A proposed weight data record format;
- Initial weight and balance estimates; and
- A proposed procedure for ensuring control of car and truck weight and balance, and car component-weight location.

The records for the first car of each type and for the first routine production car of each type shall contain as a minimum:

- Sum of estimated car body and car-mounted equipment weights;
- Location of equipped car body center of gravity (CG) with indicated location of car shell CG, and the CG's of individual major equipment relative to longitudinal and transverse geometric centerlines of the finished car body;
- Magnitude and location of the center of the car body load applied to each truck centerplate relative to longitudinal and transverse geometric centerlines of the finished car body;
- Weight and CG of each truck as equipped for service;
- Weight supported by the rail under each wheel for the truck alone and for the combined car and truck;
- Sum of all wheel loads;
- Contract empty car weight;
- List of actual car weights by car number;
- Cumulative average car weight; and
- Graphic comparison of cumulative average car weight with individual car weight by car number.

These data shall be updated and revised at frequent intervals throughout the car design and manufacturing phases as more precise estimates and actual weight data become available, and shall be submitted to the NYCT.

The submission shall include the most recent weights for the Unit less trucks, each truck and the complete Unit. It shall also include a list of weights for every system on the Unit, and indication of percentage of the estimated...
CONTRACT MANAGEMENT

weight that the system contributes to the total estimated weight. As equipment scale weights become
available, they shall replace the estimated weights in these reports. The Contractor shall require the full
cooperation of its subcontractors in this effort, and shall require weighing of sample components at the
earliest possible dates. A NYCT approved form shall be provided by the Contractor for submitting this
information.

19.5 As-Built Drawings to Be Furnished by Contractor

19.5.1 Time and Scope of Submittals

As-built drawings shall comply with NYCT Specification 8004-GENL-87, Engineering Record Drawings,
within Appendix C, except as indicated below. Within 90 days following the Acceptance of the first Unit At
six (6) months before the expiration of the warranty period of the first two (2) Operating Units, the Contractor
shall supply As-built Drawings for the following items:

- All Contractor’s and suppliers’ drawings, details, bills of material, and catalog cuts that are
  required by the NYCT for future installation, maintenance and repair purposes;
- All electrical schematics, electronic circuits, and wiring diagrams;
- All interface control drawings down to all LRUs;
- All assemblies, subassemblies, and arrangements of the vehicle;
- All items which are special purpose or fabricated by the Contractor, such as tooling; and
- All materials furnished by the Contractor and by its suppliers, down to and including the
  module and circuit board level. In every case, outline drawings shall not be considered
  acceptable.

All information required above shall also be supplied in a single electronic format usable by the NYCT. The
preferred format is AutoCad, latest version.

19.5.2 Transparency Quality Standards

The transparencies shall be produced on clear polyester film. The printing shall be on the back face and a
matte surface shall be provided on the front or both faces of the reproducibles. Printing shall be black and of
"wash-off" consistency. Reproductions shall be the same size as the original drawings.

19.5.3 Revision to be Included

The transparencies shall include all revisions made during construction and be in as-built configuration.
19.5.4 Title Block and Other Data

In the processing of the reproducibles of the Contractor's Drawings, the Contractor's title block shall be obliterated or as a minimum reduced to 1/4 scale and located on the lower left hand corner of the drawing, the drawing number and the drawing title shall be incorporated in the NYCT’s title block for identification purposes. The Bill of Material shall be left on the reproducible. The title block change applies only to the Contractor's drawings and does not apply to Subcontractor drawings of proprietary equipment such as motors, control components or brake components.

19.5.5 Material Identification Lists

Reproducible Material Identification Lists including a Contractor Number, a supplier number, and provision for the NYCT's Stores Number shall also be furnished by the Contractor and his suppliers. This data shall provide the NYCT with all the information required for procurement of materials used in the construction of all parts of the vehicle. These lists shall take the form of reproducible Bills of Materials suitable for loose leaf binding and shall be cross-referenced to the related drawings and the Bill of Materials.

19.5.6 List of Transparencies

The Contractor shall provide the NYCT with a complete list of transparencies to be supplied by itself, each of its subcontractors and suppliers.

19.6 Changes

Changes to the documents, drawings, or data shall be controlled by the processing of engineering change requests (ECR's). An engineering change to any part, assembly, or equipment item of the vehicle shall be designated as a Class I change when form, fit, function, or interchangeability is affected. All Class I ECR's must address the following:

- Delivered manuals,
- Delivered product (retrofit),
- Electromagnetic interference characteristics,
- Reliability or maintainability,
- Safety,
- Schedules of deliveries,
- Spares provisioning,
- Source or repairable items (source control drawing), or
- Weight or balance.

All other changes shall be designated as Class II changes.

All Class I ECR's together with documentation and cost information, shall be submitted to the NYCT for review prior to implementation. Time for review and schedule relief shall be considered by the NYCT in its review. Class II ECR's shall be submitted to the NYCT for information, approval of Class II ECR's will only
be required if the changes deviate from the Technical Specification requirements. The Contractor shall maintain an Engineering Change Status Report which shall list all approved changes, all Class II changes, their status and completion dates. The status shall be included with the monthly progress report. Implementation of an ECR shall require incorporation in all vehicles unless approved by the NYCT as an effective point change.

19.7 Equipment Serialization Program MOD 02

The Contractor shall furnish a comprehensive serialization program to provide necessary traceability and configuration control of all appropriate equipment down to the LRUs. All major parts and equipment are to have nameplates which identify the manufacturer, part nomenclature, part number and serial number. Part numbers and serial numbers shall be permanently stamped or engraved on the nameplate. Part numbers shall not exceed 13 digits. Serial numbers shall not exceed 15 digits including NYCT prefix. Duplicate serial numbers shall not be utilized within a type or model series. Reference Section 20.2 for bar coding requirements.

The serial number shall be bar coded. The NYCT will assign designated prefixed codes for identification of both Contractor and subcontractor serial numbers. With the approval of the NYCT a separate identification plate, permanently affixed to each serial numbered component shall be applied below the prescribed nameplate for the bar coded data. The surface of this plate shall be made receptive to the application of adhesive-based printed material. Adhesives shall not be used to secure nameplates to parts or equipment, except where approved by NYCT. The location of the nameplate and bar coding data shall have easy access for readability and scanning without disassembly of equipment or removal of the component from the vehicle.

The Contractor shall assign discrete serial numbers in sequence for the model series of the following parts and equipment:

- Air compressors,
- Air conditioning apparatus,
- * Axles,
- Batteries,
- Converters,
- Couplers,
- Destination signs,
- Door operators and controls,
- Gear units,
- * Journal bearings,
- Auxiliary Power Supply,
- Motors in any of the above,
- Principal units of communications equipment (not including speakers),
- Principal units of traction and braking apparatus,
- Air conditioning compressors,
- Traction motors,
- Truck castings and weldments (see Section 3.17.11, 2nd bullet),
The Contractor shall furnish to the NYCT a list of the items to be serial numbered. The NYCT will review this list for completeness, and if satisfactory, will approve this list within 30 days following receipt of such information. If additional items require serialization the NYCT will submit this information to the Contractor. The list shall be modified as required and resubmitted for approval for the duration of the contract.

Throughout the contracts, the R142 and R142A Contractors shall furnish manufacturer's data in electronic format to the NYCT and as approved by NYCT.

19.8 Car History Books

The Contractor shall provide the NYCT with a Car History Book for each vehicle at the time of delivery. Each Car History Book shall contain the following car-specific information:

- Certified weight, including scale tickets;
- Description of modifications and completion dates of incorporation;
- List of defects noted during manufacture and testing and the disposition of each;
- List of serial-numbered apparatus and their serial numbers;
- Provisions for recording inspection, servicing and major overhaul events;
- Shipping documents;
- Summary detail of each test and formal inspection performed on the complete vehicle or any part thereof;
- Wheels, journal bearings, and gear mounting records (including pressing charts); and
- A record of any abnormalities that occurred during the manufacture of the car or its subsystems, including their authorized repair procedures and quality control approval of work performed.

The R142A Contractor shall also furnish the NYCT, for inclusion in the Vehicle History Book, documentation recording changes made during the warranty period. The Car History Book shall also be submitted in an NYCT-approved electronic media.
## SECTION 20
### IN-SERVICE SUPPORT

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IN-SERVICE SUPPORT

Contract No. 34142A NYCT Division A

SECTION 20

20.0 IN-SERVICE SUPPORT

20.1 Training and Manuals

20.1.1 Deliverable Documentation and Training Materials

The Contractor shall furnish manuals for use by Train Operators and maintenance personnel in accordance with the requirements of this Specification. The software used for preparation of the manuals and catalogs shall be the latest version of FrameMaker+SGML, AutoCAD, or Microsoft Word. The software package to be used for each particular manual, procedure, drawing, or catalog is identified below. The software used to create manuals, catalogs and training aids shall be provided on the workstations, with site licenses and original documentation (see Section 20.4.3 for Workstation Requirements). The Contractor shall provide 8 copies of the final manuals and catalogs identified below, on CD-ROM, in addition to hard copies. Manuals and other deliverable user education support items to be supplied as part of this Contract are as follows:

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Software to be Used</th>
<th>Quantity of Hard Copies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train Operator's Manual (pocket size, plasticized)</td>
<td>Microsoft Word</td>
<td>2,500</td>
</tr>
<tr>
<td>Road Car Inspector's Troubleshooting Manual (pocket size, plasticized)</td>
<td>Microsoft Word</td>
<td>2,500</td>
</tr>
<tr>
<td>Work Manual/Inspection Procedures (10 copies plasticized)</td>
<td>FrameMaker+SGML</td>
<td>50</td>
</tr>
<tr>
<td>Overhaul Manuals</td>
<td>FrameMaker+SGML</td>
<td>20</td>
</tr>
<tr>
<td>Illustrated Parts Catalogs (additional magnetic copy of BOM on IBM tape)</td>
<td>FrameMaker+SGML</td>
<td>20</td>
</tr>
<tr>
<td>Maintenance and Engineering Instruction Manuals</td>
<td>Microsoft Word</td>
<td>50</td>
</tr>
<tr>
<td>Instructor Guides</td>
<td>Microsoft Word</td>
<td>10</td>
</tr>
<tr>
<td>Training Participant Guides</td>
<td>Microsoft Word</td>
<td>50</td>
</tr>
<tr>
<td>Training Aids (slides, overheads, mock-ups, videos, custom software)</td>
<td>N/A</td>
<td>2 sets</td>
</tr>
<tr>
<td>Special Presentation Equipment/ Workstations (with software)</td>
<td>N/A</td>
<td>2 sets</td>
</tr>
<tr>
<td>Special Test Equipment Manuals</td>
<td>Microsoft Word</td>
<td>10</td>
</tr>
<tr>
<td>As-Built Drawings (CD-ROM) for use on workstations (see Section 20.4.3.3)</td>
<td>AutoCAD</td>
<td>8 sets</td>
</tr>
</tbody>
</table>

Within 90 days after Notice to Proceed (NTP) to the Contractor, the Contractor shall submit to the NYCT, for approval, top level Tables of Contents, showing the sections and chapters, and sample formats or Style Guides for each type of deliverable above.

Within 240 days after Notice to Proceed (NTP) to the Contractor, the Contractor shall submit to the NYCT, for approval, Tables of Contents and sample pages for each type of deliverable above, from each subcontractor.

Delivery of 10 sets of final drafts of the Work Manual/Inspection Procedures, Overhaul Manuals and Illustrated Parts Catalogs; and 100 sets of final drafts of the Train Operator's Manual and Road Car Inspector's
Troubleshooting Manual shall occur with delivery of the first Unit. The final edition of all manuals, incorporating all changes deemed necessary, will be completed and delivered 4 months after receipt of comments and changes requested by the NYCT. Update requirements are as specified within Section 20.1.2. Final manuals shall incorporate all changes through the warranty period.

20.1.1.1 Train Operator’s Manual

The Train Operator's Manual shall contain all information needed for the optimum safe operation of the vehicle. It shall include general vehicle familiarization material, such as:

- Location, function and operation of controls, gauges, indicators and switches;
- Discussion of the trucks, couplers, lights, environmental control, air springs, leveling valves, and other features of the vehicle which the Train Operator may not be in a position to control or adjust but of which the Train Operator should have some basic knowledge;
- Emergency procedures;
- Trouble symptoms and diagnosis methods; and
- Train Operator corrective action, if any.

The manual shall be logically organized with systems and elements considered in descending order of importance. Care shall be taken that all statements are clear, positive, and accurate, with no possibility of incorrect implications or inferences.

This manual shall be similar to the corresponding R-68 manual.

20.1.1.2 Road Car Inspector’s Troubleshooting Manual

The Road Car Inspector’s Troubleshooting Manual shall contain all information needed to troubleshoot and repair vehicles when they experience failures during service. The purpose of the manual is to provide information required to return the vehicle to service or to remove it from service and relocate it to a maintenance shop to obtain further maintenance. The content and organization shall be similar to the Train Operator’s Manual, with troubleshooting and corrective action extending beyond what Train Operators are expected to perform, but falling within the Road Car Inspectors’ duties.

Sections of the Train Operator’s manual may be duplicated and expanded where appropriate.

This manual shall be similar to the corresponding R-68 manual.

20.1.1.3 Work Manual/Inspection Procedures

The Work Manual/Inspection Procedures shall enable the maintenance staff to have access to all information needed for shop maintenance, including preventive maintenance inspections, on-vehicle running maintenance and adjustment not performed by the Road Car Inspectors, and on-line trouble diagnosis of each system troubleshooting guides, equipment specifications and schematics for the vehicle and each of its systems. These procedures shall be the same as those contained in the Maintenance Plan (Section 18.3.2).
The Work Manual/Inspection Procedures shall contain instructions for using portable test units (PTUs) for maintenance, adjustment, test, and troubleshooting functions. It shall also include, in a separate section, all information needed for periodic inspection and servicing requirements, including lubrication, inspection and adjustment of all apparatus.


20.1.1.4 Overhaul Manuals

The Overhaul Manuals shall contain a detailed analysis of each component of the vehicle so that the maintenance staff can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace, and overhaul it. The Overhaul Manuals shall include instructions for using portable test units (PTUs), bench testers, and shop test stands for maintenance, adjustment, test, and troubleshooting functions as they apply to overhaul. These manuals shall be consistent with the Maintenance Plan (Section 18.3.2).


20.1.1.5 Illustrated Parts Catalogs

The Illustrated Parts Catalogs shall enumerate and describe every component with its related parts for the vehicles, PTUs, bench test equipment and special tools, including the supplier's number, the commercial equivalents, and the NYCT’s stock number, if any is provided by the NYCT.

Drawings showing cutaway and exploded views of subassemblies and components shall be used to permit identification of all parts. Parts common to different components for example, bolts and nuts shall bear the same Contractor's number in all components with a reference to the other components in which they are found. Each part or other component shall be identified as being part of the next higher assembly.

The Illustrated Parts Catalogs shall comply with NYCT Specification 1000-MMD-89, Multivolume Illustrated Parts Catalog. It shall include, as part of each section, a numerical index of the parts in that section.

In addition to properly indexed hard copy, parts BOM information is required for input into the existing NYCT master computer system, on IBM standard tape, no label, 6250 bpi, EBCDIC or ASCII, 150 characters per line.

20.1.1.6 Maintenance and Engineering Instruction Manual

The Maintenance and Engineering Instruction Manual shall contain sufficient material to aid the Contractor in performing the training requirements of Section 20.1.3.

It shall include a general overview of the entire car, showing general information on all of the subsystems, including performance characteristics, dimensions, weights, and capacity. The illustrations shall show interior
and exterior layouts, roof, ceiling and floor and underfloor layouts, indicating the location of all systems and subsystems of the car. Layout illustration views shall be in perspective, with suitable cutaways to clarify equipment locations. The use of two dimensional drawings shall be minimized. The manuals shall also provide a general description of all test and inspection equipment and special tools.

20.1.1.7 Instructor Guides

Instructor Guides shall include all information which will allow a trained NYCT instructor to present the course again at a later time. They shall include as a minimum, schedules for each course, outlines for the training modules, lesson plans, durations of each module, target audience and pre-requisites for each course, objectives, sequential lists of training materials, including instructions on how to present any working models or advanced technology training aids, copies of training aids for presentation (and hard copies for annotation), skills inventories (with answers), references to support materials, and any additional information deemed necessary for accurate reconstruction of the course.

20.1.1.8 Training Participant Guides

Training Participant Guides shall be in addition to any manuals provided to participants. The Guides shall include notebook sized copies of any training aids used by the instructor, including transparencies, annotated schematics, selected screen shots from technology-based training and key clips from video footage. The participant guides shall also include an up to date schedule of training modules to be presented in the applicable course and a list of referenced materials, including manuals provided for the training.

20.1.1.9 Training Aids

Training Aids shall include any slides, overheads, poster, annotated enlargements of schematics, mock-ups, videos, working models, cutaway diagrams, cutaway views or sectioned sample hardware, custom simulators, computer-based training modules, interactive video or other appropriate technology-based training available to make the material easier to present and understand.

Transparencies for use with an overhead projector shall illustrate subassemblies showing component locations, component cutaways, schematics, and wiring diagrams. Transparencies depicting hydraulic, pneumatic, and air conditioning systems shall include direction of flow for the particular medium. Any diagrams shall be displayed with sufficient scale and clarity to permit all to see clearly.

Where an actual set of equipment is planned for use as a training aid, an additional set, specifically for the purpose of training, shall be added to the number required for delivery. Contract spares will not be used for training.

Working mock-up(s) or simulators or computer-based emulators are required for at least the major systems/components, as follows:

- Traction Control (Propulsion and electric brakes)
- Side Doors and Door Controls
Braking System
Converter/Inverter
HVAC
Communication

Working mock-up(s) or simulators or computer-based emulators must be capable of demonstrating how the system or subsystem behaves and fails when operating in the intended environment. This includes the required capability to interface with other systems where appropriate and to insert faults for troubleshooting and repair training. If a complete vehicle or portion thereof is supplied for this purpose, it shall be capable of being driven from one shop to another for mobile training.

A fully operational simulator shall be supplied for Train Operator training (see Section 20.1.1.13).

To insure the safety of maintenance personnel, operating personnel, and passengers, the Contractor shall supply 5 copies of a video tape(s) which cover the procedure for preparation of a train for service, operation of a train under normal operation, and emergency procedures for moving trains under fault conditions. Any videotapes provided shall conform to NYCT 8013-GENL-90, Requirements for Video Training Tapes, within Appendix C.

20.1.1.10 Special Presentation Equipment/Workstations

Special Presentation Equipment/Workstations shall include any special presentation equipment, such as overhead presentation panels and CD-ROM equipped portable laptop computers and fully equipped workstations capable of updating and modifying manuals, catalogs, drawings and computer-based or computer-generated training aids provided under this contract. The presentation equipment and workstations shall have pre-installed any commercially available or custom-designed software used to generate and/or present the deliverable manuals and training aids. Software shall be the version used to create the deliverables rather than an earlier or later version and full developer versions, where applicable, rather than "run-time" versions.

Documentation for this equipment shall include original manufacturer documentation and any special instructions needed to supplement that documentation to allow the NYCT to update and modify the deliverable documents and training aids during the life of the vehicles.

20.1.1.11 Special Tools and Test Equipment Manuals

Operations and Maintenance Manuals for each special device identified in Sections 20.2 and 20.4 shall be presented in the same format as required for all other manuals. The manuals shall include setup and calibration procedures for each test device, as well as maintenance, troubleshooting and repair information and schematics for servicing and repairing the device.

Information on how to use the special tools or test equipment for troubleshooting or repairing the vehicles shall be found in the appropriate manuals where the equipment is needed.
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20.1.1.12 Interactive Electronic Technical Manuals

The R142 Contractor shall provide interactive electronic CD-ROM versions of the following technical manuals:

- Work Manual/Inspection Procedures
- Overhaul Manual
- Illustrated Parts Catalog

The Work Manual and Overhaul Manual shall incorporate applicable sections of the Illustrated Parts Catalog as part of the manual.

The electronic technical manuals shall structurally integrate and correlate text, pictures and sounds related to functional descriptions, repair and overhaul procedures, illustrations, photographs, videos, sound files, parts catalog data, and support information for equipment and components into a single browsable format. Off-the-shelf software, such as Assymetrix Multimedia Tool Book, Borland’s Delphi or Microsoft’s Visual Basic and Borland’s dBase V or Visual dBase or Microsoft’s Access shall be used for development. Manuals based on SGML or HTML in combination with a Web Browser may also be considered after a demonstration of suitability.

The user of each of the manuals should be able to read and scroll through the text and illustrations on the screen just as in a paper manual. The user should be able to "click" on highlighted text to obtain definitions for technical terms, detailed procedures, and relevant illustrations such as drawings, photographs, sound files or videos for equipment, components, and repair or overhaul processes, etc. mentioned in the text. The user should be able to search the text and exploded views based on key words, text strings, part numbers, etc.

When an illustration is mentioned in the text, the user should be able to "click" on that text item and have the illustration appear on the screen. If a component or part is mentioned, the user should be able to "click" on the text and obtain an exploded view of where that item is located with the item highlighted. The user should then be able to "zoom-in" on the illustration to obtain a magnified view and "click" on a particular part to obtain detailed information about the part such as commodity number, size, quantity used, manufacturer, etc.

The user should be able to browse the Interactive Illustrated Parts List and search by system, subsystem, figure number, index number, description (both by keyword and by text string), OEM Part Number, Contractor Part Number, NYCT Commodity Number, Reference Drawing Number and User Code. The user should also be able to jump to locations where the same part is used on other systems or subsystems of the vehicle.

As with the other Interactive Electronic Technical Manuals, the user should be able to "zoom-in" to or "zoom-out" of an illustration, "click" on parts or components to get more detailed information, etc.
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The R142A Contractor is not required to provide Interactive Electronic Manuals.

20.1.1.13 Operator Training Simulator

The R142 Contractor shall provide a fully operational cab simulator for operator training. It shall be a full function simulator for use in training and retraining operators in all operating functions for the fleet.

The simulator and associated deliverables shall conform to NYCT Specification 8018-GENL-97.

The R142 Contractor shall recognize that the R142 Operator Training Simulator will be used by the Authority for the R142A Operating Units. However, the R142 Contractor shall not be liable to make any modifications, changes or adjustments to such Operator Training Simulator in the event that, without fault of the R142 Contractor, it does not function for the R142A Operating Units, as long as it does with the R142 Operating Unit.

The R142A Contractor is not required to provide the simulator.

20.1.2 Format and Organization

The organization of the manuals shall treat the vehicle as an integrated system and not as a grouping of disassociated parts. The manuals shall highlight the precautions to be taken by operating and service personnel to assure their safety while operating vehicles and performing maintenance and servicing operations.

Manuals furnished under this Contract shall be complete, modern, thoroughly organized, and authentic with no extraneous or irrelevant information. The material in the maintenance manuals and parts catalogs shall be similarly organized and indexed, with a standard numbering system. The numbering of the sections shall be consistent from one type of manual to another to allow easy cross-referencing among different manuals. Each section of the maintenance manual shall be subdivided, to the extent required by the subject matter, into the same chapters, to facilitate looking up specific topics or tasks. Coverage of the chapters shall include the following topics:

- General subsystems description and operation, including how the system fits into the car and interfaces with other systems and subsystems;
- Block diagrams;
- Signal flow diagrams;
- Functional schematics;
- Functional wiring and/or piping diagrams;
- Troubleshooting techniques;
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- Microprocessor software;
- Lubrication and cleaning, including frequency, methods and trade identifications of recommended materials, component location and description;
- Inspection and maintenance standards including wear limits, settings, and tolerances;
- Installation and removal; and
- Test and evaluation procedures.

The format of all data contained in the maintenance and parts manuals shall be consistent from section to section.

Following the issue of each publication, the Contractor shall provide revised pages covering any changes, whether required by change of design or procedures or due to error, and these revisions shall be kept current during the term of this Contract up to and including the completion of the operation, maintenance and warranty requirements of the Contract. Manual and catalog revisions shall be supplied to the NYCT before or coincidental with the arrival of the altered parts or components.

A new status sheet listing the effective dates of each page shall be included for each manual at the time updates are forwarded to the NYCT. Each updated page shall be annotated with a vertical bar in the margin to indicate where material has been added, deleted or revised.

All publications shall be in loose leaf form, and use 70 pound offset paper. Plasticized paper shall be used for Train Operator and Road Car Inspector manuals and for 10 copies of the Work Manual/Inspection Procedures.

Pocket sized manuals for the Train Operators and Road Car Inspectors shall be reproduced on pages as approved by the NYCT. All other manuals shall be standard sized and shall be produced on 8-½” x 11” standard sized pages. Cross references and a Table of Contents shall be provided in each volume.

All covers shall be approximately 1/16 inch (2 mm) thick, resistant to oil, moisture, and wear, to a high degree commensurate with their intended uses. Final sets of manuals shall be serialized with numbers to be supplied by the NYCT. The numbers shall be permanently marked on the spine of the cover. Loose-leaf metal binder rings with locks shall be used to prevent undesired opening and to provide positive engagement when closed. Diagrams and illustrations shall not be loose or in pockets. All printed material shall be clearly reproducible by dry copying machines. This precludes the use of halftone illustrations and photographs. Line drawings, including exploded isometrics and three dimensional outline drawings are required.
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20.1.3  Training

20.1.3.1  General

The Contractor shall provide an educational program for the specified numbers of the NYCT’s designated instructors, Supervisors and Operating, Maintenance and Engineering personnel of a quality and depth sufficient to permit such personnel to safely and satisfactorily operate, service, and maintain the vehicles and all carborne equipment, and to train others in the operation and maintenance of the vehicles. The training shall be based on the NYCT’s "Train the Trainer" philosophy, to allow future training programs to benefit fully from the training materials provided.

The training shall be conducted in two phases, the first phase shall commence prior to the first production Unit being available for revenue service. The second phase shall commence by the end of the warranty period in order to provide adequate training of the NYCT’s designated personnel to allow them to become familiar with the equipment. Training shall include classroom and hands-on instruction through the use of actual equipment, mock-ups, models, manuals, diagrams, and parts catalogs. The Contractor shall assume no knowledge of the features of the cars on the part of the designated personnel, and shall design the training program to bring the level of student knowledge to one fully adequate for the objective. The Contractor may assume that all personnel possess the basic qualifications of their positions. The Contractor's approach to this effort shall be based on the assumption that the Contractor's own interests, immediate and ultimate, are best served by a satisfactory program. All courses of instruction shall be presented in the English language.

Prior to the initiation of classroom instruction, all instructors to be utilized by the Contractor shall attend a one-day orientation at the NYCT to become familiar with the NYCT’s safety regulations and facilities, and to be advised of student qualifications and expectations.

Manuals and other training materials to be used by the Contractor during training shall be delivered to the NYCT 60 days before training is conducted. The manuals shall be accurate, complete, of professional quality, and shall have been approved by NYCT. Drawings shall be the most recent version reviewed by NYCT.

The program shall be conducted at the NYCT’s facilities in New York City, and include classroom and hands-on instruction. The Contractor shall provide an adequate supply of high quality, professionally prepared material on paper, and such other training aids as may be necessary to impart the essential knowledge to the people involved and leave them with authoritative and up-to-date reference material. The program shall include steps to determine the proficiency of the students.

The training shall provide in-depth instruction covering all subjects and systems and their location, removal, replacement, and interfaces with other systems and parts of the car.

The total length of instruction for the entire training program shall not be less than 1000 classroom hours.

The Contractor shall, within 90 days after Notice to Proceed (NTP) submit an Educational Program Outline and a schedule for the NYCT’s approval, that identifies milestones for submitting the course outlines, lesson plans, instructor and student guides, audiovisual and other training aids, simulators, written and practical skills evaluations, and conducting classes. The training outline shall identify each module of instruction and the general topics to be taught and indicate the order in which modules will be presented.
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Training materials, including manuals and training aids, shall be as described in Section 20.1.1.

As training materials are being developed, the Contractor shall work closely with the NYCT’s staff, to ensure the NYCT’s Standards with respect to the course organization, content, and overall quality of written documents are being met.

All training materials, such as training aids and lesson plans, shall become the property of the NYCT at the completion of the training program. The Contractor shall be responsible for the condition of these materials for the duration of the training program, and shall replace all damaged materials unless the damage results from NYCT negligence. Lesson plans shall be updated as required during the course of instruction.

20.1.3.2 Instructor Qualifications

All of the instructors provided by the Contractor shall be fully capable of transmitting in-depth technical information that can be understood by participants. A detailed resume for each instructor shall be provided to the NYCT for approval, 60 days prior to commencement of scheduled course instruction.

The NYCT will recognize the instructor as qualified when the individual:

- Can communicate, in English, in a manner that allows the participants to understand;
- Has been trained in adult teaching principles and methods and has had experience in conducting technical training courses;
- Has an in-depth knowledge of the system under discussion, how it interfaces with other systems or subsystems, the procedures for isolating faults and troubleshooting, and is able to communicate that information to students in an effective manner; and
- Is able to design practical and written tests to determine the extent to which students understand and can apply the information that has been taught.

20.1.3.3 Training Schedules and Class Size

Class size will be from 5 to 10 people, depending on the nature of the course being taught. The number and types of individuals to be trained by the Contractor are as follows:

- Operating Personnel, including Supervisors, Instructors, and Central Control Dispatchers 40 persons
- Mechanical Technicians, Road Car Inspectors, Supervisors, and Instructors ..... 20 persons
- Electrical/Electronic Technicians, Supervisors, and Instructors ......................... 20 persons

The Contractor shall supervise all classes. Classes will generally run from Monday through Friday, 8 hours per day, beginning and ending at times consistent with the NYCT’s regular daytime operations.

The Contractor shall ensure that the necessary training equipment is available for use. The NYCT will furnish suitable classroom furniture (desks, chairs, and tables).
All courses shall include a combination of classroom and hands-on instruction. For most practical subjects, the expected portion of class time to be spent on hands-on activities is from 30 percent to 50 percent. Written and practical skills inventories shall be designed and given at suitable points in each course to determine the extent to which students have learned and can apply the information. Classroom instruction for maintenance courses shall include not only the details and functioning of parts under discussion, but the essentials of their routine care, including lubrication schedules, materials, contractor's recommendations for test frequency, tolerance limits, and methods for testing, including instruments required, when applicable. When methods of access, removal, dismantling, or application are not self-evident, the instruction shall cover these matters.

20.1.3.4 Train Operator and Road Car Inspector Training

Topics to be covered in the operations training program shall include, but not be limited to the following: vehicle specifications, controls and indicators; vehicle systems (i.e., propulsion, friction brake, electrical, truck and coupler assemblies, door control, environmental, lighting and communications); vehicle operations (i.e., actual operation of the vehicle in maintenance yards and on the main tracks); troubleshooting procedures; and recovery operations, as detailed in the corresponding manuals.

Train Operators shall be trained in a fully operational cab simulator; (see Section 20.1.1.13 for Simulator Requirements).

The Contractor's instructor shall be accompanied at all times by the NYCT’s qualified instructor or supervisor to ensure that all the NYCT’s rules and procedures are respected.

20.1.3.5 Maintenance Training

The NYCT’s employees shall be exposed to the depth of detail that is necessary for the performance of all preventive (scheduled) and corrective (unscheduled) maintenance operations for all aspects for the cars. Students shall be afforded the opportunity to perform the more complex maintenance functions on the vehicle and in the shop, in addition to troubleshooting systems with faults artificially introduced in the equipment while using the appropriate subsystem test devices.

The program shall emphasize the details of performing heavy maintenance repair and rebuilding of selected components. Examples include replacement of compressor seals and traction motor bearings.

Courses shall be divided into two classifications: electrical and electronic, and mechanical. To allow student participation during the demonstration and performance of maintenance functions, each course shall be separated into these two classifications.

20.1.3.6 Engineering and Supervisory Training

A summary course shall be provided, familiarizing generalists with the new equipment. The course shall cover, in executive summary fashion, all subjects covered in all other training courses.
The Contractor shall also include, as a part of its overall training program, a parts catalog seminar (or course of instruction) covering vehicle and vehicle component familiarization for material planners and operations
support personnel. This course of instruction shall be comprised of two classes with each class given to not more than 15 people per class. These classes shall be held during daylight hours at a location to be designated by the NYCT. The course given to each class shall be 40 hours in duration and shall include both classroom and field vehicle and component familiarization. An outline of this course of instruction shall be included in the Educational Program Outline.

20.1.3.8 Field Instruction and Warranty Field Instruction

In addition to the formal training described in Sections 20.1.3.1 through 20.1.3.7, regularly scheduled field instruction shall be provided by the Contractor during the warranty period for selected NYCT personnel. This instruction shall be hands-on apprenticeship style instruction, with the intent of producing Journeyman level mastery of the troubleshooting and repair tasks encountered. This activity shall be in addition to normal Contractor warranty efforts.

Field instruction involving use of the cars, including both maintenance and operation, shall be presented by instructors having thorough experience in maintenance, service or operation as the case may require. They shall be capable of communicating their knowledge to others and shall have their subjects properly organized prior to commencement of the class. Instruction in operation shall follow a logical progression involving the details of the cars, the manipulation of all controls, and actual operation. Actual operation shall be conducted under the NYCT’s operating rules and shall be performed by the NYCT’s qualified employees under the direction of the Contractor's representative. Operating instruction shall include trouble indications, their proper reporting, and corrective measures available to the Train Operator.

If desired, the Contractor may request to provide some of the field instruction in its own and its subcontractors' facilities. If the Contractor elects to provide this type of instruction as part of the formal instruction identified in Section 20.1.3.3, it must identify the number of hours and dates of the proposed training 60 days prior to the date the training is to occur. Upon request of NYCT, the Contractor shall make these shops available for a limited number of the NYCT’s supervisory and technical personnel to familiarize themselves with assembly methods.

20.2 Part and Device Identification System (Bar Coding) MOD 02

A system shall be furnished which identifies all replaceable components on the cars, all portable test equipment, gauges, special tools and spare parts. The system shall utilize bar code on labels permanently attached to the device, part and packaging to be identified. (Reference Section 19.7) The bar code identification system shall be approved by NYCT and employ a symbology that meets the bar code language requirements of the Automotive Industry Action Group (AIAG) Common Code 39.

The Contractor shall provide and apply all labels. Paper labels shall not be used.

The R142 Contractor-furnished bar code identification system shall include ten (10) scanners (readers), eight bar code printers (stationary type), 16 portable printers (hand held), four bar code engraving machines, associated software, and blank labels.
Additional requirements are contained in Appendix C, Bar Code Scanner System.

For serialized components, bar code labels shall uniquely identify the serial number (See Section 19.7).

For non-serialized components, bar code labels shall uniquely identify the manufacturer and part number.

The Contractor shall be responsible to enter Contract R34142A bar codes and associated data into the system, and maintain the data base throughout the warranty period.

20.3 Parts and Tools

20.3.1 Recommended Spare Parts

20.3.1.1 Recommended Consumable Parts

For the purposes of this Section, consumable parts shall be defined as those parts that are routinely replaced as part of the planned maintenance of the car, and that once replaced are not expected to be used again. Consumable parts shall include such items as filters and brake shoes.

The Contractor shall furnish a list of recommended consumable parts necessary to maintain the cars on an annual basis, consistent with the Contractor’s recommended maintenance practices. The list of recommended consumable parts shall be predicated on Contractor and Subcontractor experience with the equipment in service on other properties and on the maintenance requirements of NYCT. This list shall be updated as the Contractor's design progresses and shall be finalized as part of the Critical Design Review. Consumption rate data and data on lead time for procurement shall be made available to NYCT in support of these consumable parts recommendations.

20.3.1.2 Recommended Replacement Parts

For the purposes of this Section, replacement parts shall be defined as those parts that are not routinely replaced as part of the planned maintenance of the car, but that are reasonably expected to require replacement from time to time due to random failure. In general, replacement parts shall be used after the completion of the warranty period to address those needs that during the warranty period are met under the terms of the warranty.

The Contractor shall furnish a list of recommended replacement parts necessary to maintain the cars for 20 years, consistent with the Contractor’s recommended maintenance practices. The list of recommended replacement parts shall be predicated on Contractor and Subcontractor experience with the equipment in service on other properties and on the maintenance requirements of NYCT. This list shall be updated as the
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Contractor's design progresses and shall be finalized as part of the Critical Design Review. Consumption rate data and data on lead time for procurement shall be made available to NYCT in support of these replacement parts recommendations.

20.3.1.3 Recommended Repair Parts

For the purposes of this Section, repair parts shall be defined as those parts that are not routinely replaced as part of the planned maintenance of the car, but that are reasonably expected to require replacement from time to time due to external causes such as vandalism, abuse, or accident.

The Contractor shall furnish a list of recommended repair parts necessary to maintain the cars for 20 years. The list of recommended replacement parts shall be predicated on Contractor and Subcontractor experience with the equipment in service on other properties and on the service environment and maintenance requirements of NYCT. This list shall be updated as the Contractor's design progresses and shall be finalized as part of the Critical Design Review. Data on lead time for procurement of repair parts shall be made available to NYCT in support of these repair parts recommendations.

20.3.1.4 Recommended Overhaul Parts

For the purposes of this Section, overhaul parts shall be defined as those parts that are expected to be replaced at planned intervals, typically as part of NYCT’s SMS (Scheduled Maintenance System), and that once replaced are expected to be remanufactured, overhauled, or reconditioned for further use. Overhaul parts shall include such parts as air brake components and HVAC units.

The Contractor shall furnish a list of recommended overhaul parts to support an continuous, ongoing overhaul program for each such component, consistent with the Contractor’s recommended maintenance practices. The list of recommended overhaul parts shall be predicated on Contractor and Subcontractor experience with the equipment in service on other properties and on the maintenance requirements of NYCT. This list shall be updated as the Contractor's design progresses and shall be finalized as part of the Critical Design Review. In the case of components that normally receive only a mid-life overhaul, the Contractor shall consider the likelihood of future technological obsolescence in making its recommendations. Consumption rate data and data on lead time for procurement shall be made available to NYCT in support of these overhaul part recommendations.

20.3.2 Gauges and Special Tools

Three sets of any special tools required shall be supplied by the Contractor. Special tools include but are not limited to any jigs, fixtures, equipment, hand tools, power tools, or other tools and equipment necessary to maintain, repair, assemble, and disassemble the vehicle or subsystems, that are not commonly available from commercial tool suppliers.

All gauges or special tools, other than the PTUs and bench testers, that are required to maintain the vehicle shall be supplied along with complete manuals explaining the use of the gauge or tool and its care and
maintenance. Manufacturing drawings showing all dimensions and materials and part lists must also be supplied.

20.4 Test and Inspection Equipment

The Contractor shall provide all test and inspection equipment necessary for maintaining, troubleshooting, testing, repairing, calibrating and inspecting all carborne equipment. This shall include equipment for the support of back shop repair activities, and for on-board inspection and test of equipment.

20.4.1 Portable Test Equipment (PTE)

20.4.1.1 General

PTE shall be supplied for all on-board systems, to aid the maintenance staff in maintaining, troubleshooting, and repairing the car equipment.

Complete parts lists and schematic diagrams of the PTE and instructions concerning how to use them for their intended purpose shall be included in the appropriate manuals described in Section 20.1.1.

For each system there shall be system specific software to be utilized by a common PTE laptop. A total of 30 laptop PC PTEs shall be furnished. Cabling shall be standardized to perform testing for all carborne systems.

If there are PTEs which are not laptop PC based, twenty (20) of each type shall be furnished. All test functions required in any section of this document shall be performed by laptop PTE or other PTU. Software shall be subject to the requirements of Section 16.

The R142 Contractor shall furnish a bar code reader attachment with each R142 PTE for future use by NYCT. The R142A Contractor is not required to provide a bar code reader attachment for the PTE.

The carborne equipment design shall make use of multi-pin connectors to establish all the connections required for utilization of the PTEs. Power required for operation of the PTEs shall be supplied by the carborne low voltage power supply and the carborne auxiliary power supply, as is appropriate for the function. There shall be no high-voltage connections (600 Vdc) allowed between the vehicle and any PTE. 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 PTEs.

The PTEs shall include all cables, industrial grade connectors and associated equipment to interface with the test points.

20.4.1.2 Functional Requirements

The function of the PTEs 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 or subsystem 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, or gages. It will be acceptable to require a visual check for system response such as closure of a contactor, provided that the responding item of equipment does not require removal of other equipment or use of hand tools to permit observation of response, and does not require the maintenance technician to move more than 15 feet (4.6 m) to make the required observation. When used according to the instructions supplied by the Contractor, each PTE shall enable the maintenance technician to fully check and calibrate the system or subsystem under test and to locate and replace any removable component which has fully or partially failed. Response indicators and input-signal generators shall be built into the PTEs to the maximum extent possible, and shall have accuracy commensurate with the alignment tolerances specified.

20.4.1.3 Physical Requirements

The test equipment shall perform under the environmental conditions imposed by the activities of the vehicle inspection and repair shop. The test equipment shall be portable and suitable for industrial service for use on the shop floor, pit locations, and use in the yard. The test equipment shall be self protected in the event of an overload or short circuit condition.

The laptop PC PTEs shall, as a minimum, be based on the Intel 100 MHZ Pentium and shall include RAM and hard storage capable of storing all system and subsystem test software and fault log downloads from an entire workshift. (Reference Section 16.4.1 for spare storage requirements.) Twenty (20) additional access cables will also be provided so that the PTE’s can be connected directly to the remote as well as local PTE connectors on the train.

For PTE which do not consist of laptop PCs, response and output indicators and input signal generators shall be of an industrial grade. Each PTE shall be housed in an aluminum or fiberglass suitcase-type enclosure with a removable cover suitable for use in a shop environment and as manufactured by Zero Manufacturing Co., Skydyne, or approved equal. All meters supplied as part of the PTEs shall be of a variety capable of withstanding industrial service.

The weight for any PTE shall not exceed 30 lbs. (13.6 kg) without the prior approval of the NYCT. If a supplier of equipment has developed an acceptable PTE for use with similar equipment on a previous contract, and the supplier plans to utilize the same design for this contract, and the weight of the unit is not more than 20 percent above the specified weight limitation, the Contractor may seek the NYCT’s approval to utilize the existing PTE design.

20.4.1.4 Interface Connections

Connection of the PTE to the equipment shall be through two means. First, a test plug conveniently located on the vehicle so that the maintenance technician is able to observe the functioning of the specific system under test. Second, on the A Cars, a plug shall be located in the left side of the cab interior; on B Cars, a test plug shall be in the passenger area, located behind a secured panel.

Connectors used in the interface between the PTE and the system under test shall have recessed pins to prevent bending and breakage during frequent use. All connections shall be hand operated, robust, weathertight, quick disconnect, multi-pin connectors meeting the requirements of Section 15. ARO type quick disconnects or equal shall be used for all pressure test fittings.
20.4.1.5 Cables and Hoses

External hook-up multi-conductor cables shall be furnished to connect the vehicle systems with the PTE. A minimum number of cable connections shall be used to connect the test equipment to the systems under test. Cables shall be flexible, abrasion resistant, and oil resistant.

The connecting cables and hoses shall be stored within the PTE case.

The Contractor shall not require connection of external apparatus to the PTEs without the prior written approval of the NYCT. In such cases, terminals shall be provided to allow connection of the required apparatus to the PTEs. However, such apparatus shall be considered part of the PTEs and shall be supplied with it on a one-to-one basis.

20.4.2 Bench Test Equipment

Three (3) sets of bench test equipment except for HVAC system two (2) sets shall be supplied by the Contractor to support back shop repair and maintenance activities. The bench test equipment shall be designed for the purpose of testing, troubleshooting, and calibrating all electrical, electronic, mechanical, electro-mechanical, and pneumatic components of every vehicle subsystem. The bench test equipment shall consist of general purpose functional test systems for testing microprocessor and electronic printed circuit boards, electronic devices, modules, and assemblies; and specialized bench testers for testing high power, pneumatic and hydraulic equipment. The specialized bench test equipment for the friction brake system shall include an air brake valve test rack which shall allow for testing of all friction brake system valves. The bench test equipment for the HVAC system shall be divided into two separates units: one dedicated to the HVAC electronics and a second unit applied to the HVAC mechanical elements.

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. This includes, but is not limited to: each and every type of electronic circuit board, including mother boards and back plane wiring; relays; sensors; contactors; breakers; filters; transducer; friction brake system components and valves; pressure switches, including those from the HVAC system; antennae; and modules used in any car system. The bench test equipment shall include a full complement of support devices to enable testing to be performed on the line replacement unit without the need to remove additional equipment from the car to support use of the bench test equipment. If a PTE is necessary for using the bench test equipment, one shall be provided for each bench test equipment setup in addition to the quantities provided under Section 20.4.1.1. Additionally, if more than one subsystem requires the use of a PTE when using the bench test equipment, a PTE shall be provided for each subsystem requiring its use to enable more than one technician to use the bench test equipment simultaneously.

The bench test equipment shall also be used for calibrating all of the control equipment used in carborne systems, and testing complete assemblies of these same equipment when removed from the vehicle. It shall produce all of the operating commands and other input signals necessary to completely exercise all bench-repairable components; and to measure or indicate all of the signals, responses and outputs produced by a component by means of indicators such as LEDs, meters, oscilloscopes, or gauges. Dummy loads shall be applied to all outputs to simulate connected loads as installed on the car.
The R142 Contractor shall furnish a bar code reader attachment with each R142 bench tester for future use by NYCT. The R142A Contractor is not required to provide a bar code reader attachment for the bench testers.

Each piece of bench test equipment shall be supplied with an instructional manual that describes how to use the tester. Detailed step-by-step procedures shall be provided along with expected results. The bench test equipment, when used in accordance with instructions supplied by the Contractor, shall test and calibrate the vehicle equipment to a level equal in quality to that performed by the original supplier.

Complete details for troubleshooting and repairing the bench test equipment shall be provided. Complete parts lists and schematic diagrams of the bench test equipment shall be provided to enable its repair. The bench test equipment shall conform to the materials and workmanship, and documentation requirements of this Specification.

Bench test equipment shall be designed to operate on 120 volt, single phase or 208 volt three phase, 60 Hz, AC, and with shop air where pressures to 110 psi (758.5 kPa) are available. Other necessary operating voltages and pressures shall be produced by the bench test equipment. The bench test equipment shall include provisions for varying the input power, including electric, pneumatic and hydraulic, as may be appropriate for the unit under test over the full voltage and/or pressure range. The bench test equipment shall be suitably buffered to protect against failure of the bench test equipment when testing and troubleshooting defective units.

Bench test equipment shall include generic, commercially-available test equipment such as oscilloscopes, function generators, frequency counters, Digital Multi-Meters on a portable cart. Three (3) such set-ups shall be provided.

20.4.3 Workstation Equipment

Workstation capable of supporting software and hardware, shall be provided. The workstations shall be delivered prior to first Unit delivery, except the software workstations specified in Section 20.4.3.1.

As a minimum, the computer performance of all workstations shall exceed on the Intel 133 MHZ Pentium, with 32 M of RAM, 1.6 GB hard drive, with an internal CD-ROM writer (CD-RW) drive. A 101 key keyboard and a 2 button mouse shall be provided. A 1.44 MB floppy disk drive shall be included. The monitor shall be a 17", 0.28" pitch, SVGA color with a resolution of 1024 x 768 at a 75 Hz refresh rate. Additionally, a laser printer shall be included for making hard copies.

The R142 Contractor shall furnish a bar code reader attachment with each R142 workstation to allow codes of parts to be scanned. The R142A Contractor is not required to provide a bar code reader attachment for the workstations.

Appropriate tapes, cables, and accessory software shall be provided for all ancillary equipment.
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20.4.3.1 Software Workstation

Two (2) sets of computer-controlled workstation equipment shall be supplied by the Contractor to support the software maintenance of vehicles. The software workstation equipment shall enable the NYCT's personnel to modify all software source code, recompile it, and erase and program PROM semiconductor devices as detailed in Section 16.6.

20.4.3.2 Data Workstation

Two (2) sets of computer-controlled data workstation equipment shall be supplied by the Contractor to support the maintenance of vehicles as detailed in Section 8.3.2. The data workstation equipment shall enable NYCT's personnel to view downloads and analyze all such data downloaded from the vehicles. The Contractor shall provide a self-contained workstation which includes all of the software and hardware necessary to accomplish this.

20.4.3.3 Technical Documentation Library Equipment

Eight (8) sets of computer-controlled data workstation equipment shall be supplied by the Contractor to support the maintenance of Technical Support Services Engineering Libraries at Coney Island, Livingston Plaza and 207th Street and the Maintenance Standards and Procedures Documentation Center at Coney Island. Delivery of all eight (8) sets shall coincide with the delivery of CD-ROMS of the final manuals and catalogs. The document workstation equipment shall enable the NYCT's personnel to view manuals and drawings on DVD-ROM, including the Work Manual, Overhaul Manual and Illustrated Parts List, make revisions and add new information to both paper and electronic documents.

The minimum workstation requirements as stated in section 20.4.3 shall have the following modifications.

- The single hard drive shall be replaced with two (2) 18 GB, 7200 rpm Hard Drives. The single CD-R/RW optical drive replaced with one (1) DVD Dual layer +R writer, 8x+-/-R, 4x+-/-RW, CD-R, CD-RW combo drive and one (1) 40x CD/12x DVD-ROM drive (with all necessary cables, premastering/mastering software provided). The combo drive shall be capable of multi-session recording, on-the-fly recording, incremental packet writing and disc-at-once/track-at-once recording.

- 50 recordable DVD +R or – R blank discs are to be supplied with each unit.

- The provided laser printer shall be capable of 12 pages per minute, 600 dots per inch resolution.

All capabilities, speeds, and resolutions mentioned here are minimum requirements.

20.4.4 Environmental Chamber

An environmental chamber shall be provided for each set of bench test equipment provided. The environmental chamber shall enable components being tested to be exposed to low and high temperatures that would be experienced during normal operation in NYCT's service area. Additionally, the environmental chamber shall be capable of simulating the ambient temperatures to which equipment would be exposed as installed in the car and enable automated temperature cycling.
20.4.5 Inspection Equipment

Three (3) sets of inspection equipment shall be provided to support calibration of equipment that must be adjusted on the vehicle.

20.4.6 System Level Dynamic Tester (SLDT)

There shall be a System Level Dynamic Tester (SLDT) supplied for performing engineering tests and dynamic track testing. There shall be 10 SLDTs provided for the fleet.

The purpose of the SLDTs shall be to monitor vehicle systems while a train is being operated on the line at speeds up to 62 mph (100 kph). The SLDT shall be capable of performing the most frequently desired maintenance tests, reducing the need for strip chart recorders, oscilloscopes and other bulky test equipment. The SLDT shall be capable of monitoring a minimum of 150 analog and digital test points with sampling rates individually selectable to monitor signals at appropriate intervals so that equipment status may be isolated to a Line Replacement Unit (LRU). The Contractor shall submit a recommended list of test points for the NYCT’s review and approval.

The SLDT shall simulate a strip chart recorder and an oscilloscope, including monitoring selected signals in real time and playback of recorded data. Where data is collected through the MDL, the real time data may be transferred to the SLDT using batch-type communication methods. Data shall be recorded on or transferrable to a 3.5” disk. The SLDT shall contain indicator graphics to signal the status of binary electrical signals. Four, three-inch panel meter graphics, of appropriate ranges, shall monitor the non-binary test points as manually selected by menu or by four graphic switches.

Each SLDT shall be subject to the same manual and training requirements as all other equipment, including how to use the tester along with expected results and how to troubleshoot and repair the tester. Complete parts lists and schematic diagrams of the SLDT shall be provided.

The SLDT shall utilize the same laptop PC as the PTE, with harnesses or additional modules attached. In addition to the PCs provided for the PTEs, the Contractor shall provide one PC for each SLDT provided.

20.4.7 Intentionally Blank

20.4.8 Truck Frame Treatment Furnace

The R142 Contractor shall supply a zone control furnace for stress relieving and temper heat treatment of all the R142 and R142A truck frames. The NYCT will utilize this furnace when necessary, following truck rework and retrofits.
The furnace shall have the following features:

- **Maximum Furnace Temperature:** 1250°F
- **Power:** AC electric, 440/480 volts
- **Type:** Car bottom (bottom of furnace on wheels with tracks, moves out to accept load).
- **Size:** A minimum of three (3) separate zones, ten feet wide, twelve feet long, six feet high (10 ft. wide x 12 ft. long x 6 ft. high).
- **Temperature Control:** A minimum of three (3) separate zones, individually controlled to ±12°F, with programmed heating and cooling rates.
- **Temperature Recorder:** Time-temperature chart recorder with 24-hour time recording capability. Record on paper and with output to PC computer.
- **Fixtures:** Fixture(s) designed to hold and support truck frames to minimize distortion during stress relief or tempering.
- **Temperature Measurement:** Calibrated pyrometer for checking furnace temperature.

The R142 Contractor shall provide all interface details, installation instructions, and operating instructions for the equipment. The Contractor shall provide the necessary materials to effect the installation, assuming that the power source is within close proximity to the equipment. The furnace shall be delivered and installed at the NYCT's 207th Street Overhaul Facility. The R142 Contractor shall supervise the actual installation and verify post installation functionality.

The R142A Contractor shall provide truck drawings and any other information required to provide the fixtures for the truck frame treatment furnace.
20.4.8.1 Additional Requirements Related to Truck Frame Treatment Furnace

Warranty:

- All work, parts and materials furnished by the Contractor shall be fully warranted for a minimum period of two (2) years. In addition, the warranty shall cover fully all overhead costs associated providing services under the warranty, and labor associated with troubleshooting and the actual repair of the equipment. The warranty period shall start after all acceptance testing have been successfully completed.

The vendor shall provide the following Technical Manuals:

- System Manual that includes a system functional description, schematics for all mechanical, electrical, hydraulic and pneumatic systems, instructions for generating or revising automatic test sequences, block diagrams, wiring diagrams and parts lists.

- Service Manual that includes troubleshooting, maintenance and repair procedures, exploded view diagrams of system and components, part lists, and special tool lists.

- Operator Manual that includes a functional description of all features, work set-ups, step-by-step procedures of all operations and tests.

The vendor shall provide the following training to designated NYCT employees:

- The training shall be conducted for a minimum of four days. Two days of training shall be provided during the hours of 8:00 am to 4:00 pm and two days of training shall be provided during the hours of 4:00 pm to 7:00 pm. The training shall consist of classroom review of all documentation provided by the vendor and actual hands-on equipment demonstrations.

- Video tape that explains in detail the equipment's operating, features and maintenance.

Equipment Acceptance shall consist of the following:

- The equipment shall successfully pass all factory tests prior to delivery. These tests shall be made at the vendor's expense in presence of the Project Manager who reserves the right to determine which tests are necessary and which tests were successful.

- After installation and final inspection, the vendor shall demonstrate that the equipment is operating properly and can perform all of its intended functions under actual test conditions.

- After the vendor's demonstration that the equipment is operating properly and can perform the intended functions, a thirty-day trial period shall start and during this period the equipment shall operate trouble-free before it will be accepted.

Vendor qualification:

- The vendor or contractor shall have a minimum of five (5) years' successful field experience.
The Project Manager has the right to determine which vendor is qualified to perform the work.

Availability of Replacement and Spare Parts:

- The vendor shall guarantee replacement and spare parts are available for a period of at least five years.

Identification Tags:

- The manufacturer or Contractor shall permanently affix with a minimum of four rivets or bolts an ownership tag to equipment purchased by NYCT. The tag shall be made from stainless steel approximately 3 inches high x 4 inches wide. The manufacturer or Contractor shall stamp the following:
  - Property of NYCT
  - Manufacturer name, address and phone number
  - Model number and serial number
  - Date of manufacture and date of delivery
APPENDIX A

FIXED FACILITIES DESCRIPTION

DIVISION A (IRT); PLUS, FLUSHING LINE

A.1. General: This Appendix to the Technical Specification describes the fixed facilities and environmental conditions of the New York City Transit System's Division A; plus the Flushing Line (IRT). Fixed facilities descriptions furnished in this Appendix are to be considered by the Contractor as ancillary information to the Technical Specification for use in developing the technical definition of the cars meeting the requirements therein. Values given here are nominal and are subject to variation due to tolerance plus wear. Inclusion of this description of fixed facilities in the Specification does not relieve the Contractor of the responsibility to have its engineers and suppliers visit, view, inspect and become thoroughly familiar with the operating transit system, including structures, maintenance and storage facilities.

A.2. Fixed Facilities:

Platform dimensions are approximately as follows:

Platform height above base of rail: 4 feet ±0.5 ft.
(1.219 m ±0.15 m)

Platform length (minimum): 512 feet
(156.06 m)

Distance from edge of finished platform to centerline of track 4 feet 8 1/4 inches +0.5 ft. -0.1 ft.
in tangent track (for curved platforms, this dimension varies): (1.429 m + 0.15 m -0.03 m)

A.2.1. Contact Rail (Third Rail) and Protection Board Location:

(i) Contact rail type:
Steel of - 150 pounds/yard (74.40 kg/m) with resistivity of about 6.85 times that of copper.

(ii) Height of contact rail above top of running rail: 4.0 inches +3/4 inch, -1.0 inch
(102 mm + 19 mm, -25 mm)

(iii) Height of lower edge of protection board above:
Contact rail: 3 ½ inches ±1.0 inch
(89 mm ±25 mm) minimum

Top of running rail: 7 ½ inches minimum
(191 mm) minimum

(iv) Contact rail and approach ramps:
1.5 inch (38.1 mm) rise in 10 feet (3.048 m) giving slope of 0.72 degrees, high speed;
1.5 inch (38.1 mm) rise in 51 inches (1.295 mm) giving slope of 1.68 degrees, low speed, for track with speeds up to 50 mph; and
For contact rail side approaches, see NYCT Drawing No. T-2083, "150 lb. Contact Rail, End Approach and Assembly", located in "MW-1 Track Standards and Reference Manual within Appendix C of the Specification.

(v) Distance between centerline of contact rail and gauge line of the nearest running rail: 26 inches ±2 7/8 inches (660 mm ±73 mm)

(vi) Maximum contact rail gap: 145 ft. (44.2 m)

(vii) Minimum contact rail gap: 40 ft. (12.19 m)

A.2.2. Track:

(i) Rail type - 100 A R A, type B rail, and 115 RE rail, some 39-foot (11.887 m) bolted, some CWR, 1:40 cant.

(ii) Curve Radius Limits:
Tangent to 7500 ft.: 4 ft. 8 1/4 in. gauge (1.429 m) gauge
7500 ft. to 500 ft.: 4 ft. 8 ½ in. gauge (1.435 m) gauge
500 ft. to 200 ft.: 4 ft. 8 3/4 in. gauge (1.441 m) gauge
200 ft. to 100 ft.: 4 ft. 9 in. gauge (1.448 m) gauge

(iii) Horizontal Curves and Superelevation:
Minimum lateral radius at centerline of tracks: 100 feet ±10 feet (30.48 m ±3.05 m)
Maximum superelevation: 6 ½ inches ±1 inch (165 mm ±25 mm)
Minimum tangent length between reverse curves: 0 feet (0 m)
Minimum indices of reverse curves: 120 feet (36.58 m)
Radius of smallest turnout (No. 3.5 switch): 112.17 feet
(iv) Vertical Curves and Grades:
Vertical curves, rate of change of grade: 3 percent ±1 percent
(For a radius of approximately 2000 ft. with the curves corresponding to a length of vertical curve of not less than 200 feet).

Vertical Curves:
Mainline: 5 ½ percent per 100 feet (30.48 m)
Yard: 5 ½ percent per 100 feet (30.48 m)
Other: 5 ½ percent per 100 feet (30.48 m)

Grades:
Maximum Sustained Grade: 5 ½ percent

(v) Flangeways:
Curve radii less than 1,000 ft. and turnout side of #5 frogs: 2.0 inches + 3/4 inches, -1/2 inch (5.1 cm + 1.9 cm, -1.3 cm)
Curve radii less than 200 ft. and turnout side of #4 or less frogs: 2 1/4 inches ±3/4 inches (5.7 cm ±1.9 cm)
Special work, straight side (for all frog numbers) and turnout side of frogs #6 to #20: 1 3/4 inches + 5/8 inch, -½ inch (4.4 cm + 1.6 cm, -1.3 cm)

(vi) Wheel Load Limitations:
Maximum average wheel load - 13,800 pounds (6260 kg) on any two wheels on a side of a truck with no wheel exceeding 14,000 pounds (6350 kg).

(vii) Rail Wear:
Vertical wear, maximum: 3/4 inch (19 mm)
Horizontal wear, maximum: 13/16 inch (21 mm)

(viii) Crossovers:
Frog characteristics and gauges - varies 4 feet 9 inches to 4 feet 8 ½ inches (1.448 m to 1.435 m)
Flangeway:  (#20) minimum 1 3/4 inches (44.5 mm)
           (#3 ½) maximum 2 1/4 inches (57.2 mm).

(ix) Track spacing - minimum distance between centerline of tracks 11 feet (3.35 m)

(x) Track Maintenance Tolerances:
    Track Gauge: + 1½ inches, -3/4 inch from 4 feet 8 ½ inches (3.81 cm, -1.9 cm from 1.435 m)
    Alignment deviation of the mid-ordinate of 31 ft. chords: ±3.0 inches (±7.62 cm)
    Deviation from uniform profile (surface) of the track in 31 ft. chords: ±1½ inches (±3.81 cm)
    Deviation from established cross level at any point: ±3 ½ inches (±8.89 cm)
    Variation in cross level in spirals, 31 ft.: ±2 ½ inches (±6.35 cm)
    Deviation from desired elevation at any point in spirals: ±2 inches (±5.08 cm)
    Differences in cross level between any two points less than 31 feet apart (other than spirals): ±3 ½ inches (±8.89 cm)

A.3. Exterior Ambient Conditions:

Exterior ambient conditions for design purposes shall be as follows:
Summer-Surface
105°F (40.56°C) dry bulb temperature;
75°F (24°C) wet bulb temperature;
41° latitude, maximum solar heat rate;
8 mph (13 km/h) wind velocity.
Summer-Tunnel
120°F (48.89°C) dry bulb temperature, 80°F (27°C) wet bulb temperature; and
Winter-surface
0°F (-17.78°C) dry bulb temperature;
41° latitude, minimum solar heat rate; and
11 mph (17.7 km/h) wind velocity.
Winter-Tunnel
11°F (-11.67°C) dry bulb temperature.
Except as otherwise specified, minimum temperature for material selection purposes shall be -20°F (-29°C) and for material operation purpose shall be 0°F (-18°C).

**A.4. Duty Cycle:** Each duty cycle to be used to determine the adequacy of the propulsion and brake systems shall be based on whichever of the IRT routes and types of service causes the most severe duty of each specified type. The Superintendent will make available to the Contractor, route and train schedule information needed to calculate specified duties and the Contractor shall compute train performance for sufficient cases, to determine the most severe of each specified type for approval. Except as the specification states otherwise, each duty shall be based on AW3 loading of all cars in the train.

Dwell Times-Except as the specification indicates otherwise - station dwell times shall be 40 seconds and terminal layover times prior to start of next run shall be 10 minutes.

Propulsion System- Except as the specification indicates otherwise, each duty cycle shall include continuous operation for eight hours.

Friction Brake System-The friction brake system thermal design shall be based on continuous operation with dynamic brakes inoperative.

Performance Level-Except where the specifications indicates otherwise, the performance used for each duty cycle shall be the maximum service level defined as follows:

Maximum power shall be used except when coasting or an intermediate level of propulsion or braking is required to maintain a restricted speed or when braking is required for speed reduction or station stopping. Braking for speed reduction and station stopping shall be at the full service rate which requires maximum electrical braking effort (no friction braking) and shall not begin any sooner than necessary to make the required speed reduction or stop.
APPENDIX B

STANDARDS

The following is a list of standards referenced in this Specification. The list may not be all inclusive. The latest revision in effect for each standard at the time of NTP shall be used in conjunction with the Specification.

49 CFR Part 38
49 CFR Parts 27 and 37
49 CFR Parts 200 - 399
49 CFR 609
AAR C-II
AAR Communications Division
AAR Manual of Standards, Section F S-538, "Wiring Practice and Rolling Stock Standard"
AAR Manual Standards and Recommended Practices
AAR RP-037
AAR Scale Handbook
AAR Specification M-101
AAR Specification M-107
AAR Specification M-201
AAR Specification M-618
AAR Specification M-917
AAR Specification M-927
AAR Specification No. 2518
AAR Standard S-014
AAR Standard S-034, Specifications for the Construction of New Passenger Equipment Cars
AAR Standard S-042
AAR Standard S-501
AAR Standard S-502 (No.589)
AAR Standard S-503
AAR Standard S-540
AAR Wheel and Axle Manual
AFI Code
AGMA Standard 250.03
AIAG Common Code 39
AISI 201L
AISI 301LN
Aluminum Association No. 443
Aluminum Association of America’s “Engineering Data for Aluminum Structures”
Aluminum Association of America's "Specification for Aluminum Structures"
Aluminum Company of America's "Alumilite 204"
AMCA Bulletin 300
AMCA Fan Application Manual
AMCA Publication 201
AMCA Publication 203
American National Standard B18.1.2
ANSI A1.4
ANSI/ASHRAE Standard 37
ANSI/ASTM E 142
ANSI/ASTM E 94
ANSI B1.1 Standards
ANSI B1.13M (ISO-metric Standards)
ANSI B16.22
ANSI B16.88
ANSI B18.2.1
ANSI B31.1
ANSI C-80.5
ANSI C37.13
ANSI C37.14
ANSI C37.16
ANSI/ASQC Z1.9
ANSI/IEEE Standard 1016
ANSI/IEEE Standard 730
ANSI S1.4
ANSI S1.11
ANSI Standard B-2.1
ANSI Standard C-80.1
ANSI Standard C-80.5
ANSI Standard UL-6
ANSI Y1.1
ANSI Y32.14
ANSI Y 32.2
ANSI Z 26.1
ARI Standard 700
ARI Standard 710
ASCII Code
ASHRAE HVAC System and Equipment Manual
ASHRAE Standard 37
ASHRAE Standard 41.1
ASHRAE Standard 51-75
ASM Metals Handbook
ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels
ASME FAP-1-1990
ASME Section IX
ASME Section VIII, Part UHA
ASME Strength Allowables in Tables UHA-23 and UW-12
ASTM A 6
ASTM A 21
ASTM A 36
ASTM A 53
ASTM A 148
ASTM A 176
ASTM A 229
ASTM A 262
ASTM A 325
ASTM A 480
ASTM A 488
ASTM A 490
ASTM A 502
ASTM A 551
ASTM A 563 M
ASTM A 568
ASTM A 576
ASTM A 588
ASTM A 606
ASTM A 666
ASTM A 729
ASTM A 736
ASTM A 763
ASTM A 710
ASTM B 26
ASTM B 30
ASTM B 32
ASTM B 33
ASTM B 85
ASTM B 108
ASTM B 174
ASTM B 298
ASTM B 633
ASTM B 247
ASTM C 542
ASTM D 174
ASTM D 178
ASTM D 256
ASTM D 412
ASTM D 470
ASTM D 523
ASTM D 573
ASTM D 618
ASTM D 638
ASTM D 648
ASTM D 649
ASTM D 673
ASTM D 695
ASTM D 785
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ASTM D 790
ASTM D 792
ASTM D 952
ASTM D 1003
ASTM D 1055
ASTM D 1149
ASTM D 1499
ASTM D 1894
ASTM D 2047
ASTM D 2092
ASTM D 2200
ASTM D 2671
ASTM D 2724
ASTM D 3029
ASTM D 3159
ASTM D 3182
ASTM D 3183
ASTM D 3190
ASTM D 3574
ASTM D 3675
ASTM E 94
ASTM E 109
ASTM E 119
ASTM E 138
ASTM E 142
ASTM E 162
ASTM E 165
ASTM E 446
ASTM E 648
ASTM E 662
ASTM E 709
ASTM F 579
ASTM F 606
ASTM F 738 M
ASTM F 836 M
ASTM G 23
ATA Specification No. 100
ATA Specification No. 102
AWS B2.2-85
AWS D1.1
AWS D1.2
AWS D1.3
AWS Welding Handbook, Volume 2
Boeing Specification Support Standard BSS-7239
Car Materials Selection - January 1989"
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Chapter 2 of NFPA Publication No. 70, Article 240
EIA RS-132
EIA RS-204
EIA RS-220
EIA SE-101
EIA SE-103
EIA SE-105
FAA Specification No. AC 43.13-13.1A, Chapter 11, Section 449
Fastener Standards, Industrial Fasteners Institute
FAR 25.853
FCC Rules & Regulations
FED-STD-191A Textile Test Method 5830
Federal Motor Vehicle Safety Standard 108
Federal Motor Vehicle Safety Standard 209
Federal Motor Vehicle Safety Standard 210
Federal Register, Volume 54, No. 10
Federal Specification FF-92
Federal Specification QQ-B-654, Class 1 or 3
Federal Specification QQ-P-416b, Class 2 or 3, Type II
Federal Specification SS-T-312
Federal Specification TT-E-527
Federal Specification TT-P-38
Federal Specification TT-P-664
Federal Specification WW-T-799
ICEA S-19-81
ICEA S-66-524
IEC 77
IEC 349
IEC 623
IEEE 11
IEEE 16
IEEE 43
IEEE 112
IEEE 383
IEEE 488
IEEE P1115
Industrial Fastener Institute 1970 Fastener Standards
International Institute of Welding's "Collection of Reference Radiographics of Welds"
ISO 2631
Metric Fastener Standards, Industrial Fasteners Institute
MIL type GB or GH
MIL-C-5015
MIL-C-27072
MIL-C-55302
MIL-C-7438G
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MIL-ENE
MIL-HDBK-132, Section 2, Protective Finishes
MIL-I-46058
MIL-M-81531
MIL-N-25027
MIL-P-8053
MIL-P-13949
MIL-P-23469
MIL-Q-6858
MIL-R-5757
MIL-R-6106
MIL-S-3950
MIL-S-8805
MIL-S-83502
MIL-S-83731
MIL-S-83734
MIL-STD-105
MIL-STD-1472
MIL-STD-1782
MIL-STD-275
MIL-STD-410
MIL-STD-461A
MIL-STD-882B
MIL-STD-883, Method 5004, Reliability Class B
MIL-STD MS-25036
MIL-T-6845
MIL-T-8504
MIL-T-16366F
MIL-T-7928G
MIL-T-55164A
MIL-W-22759/6B
MIL-W-22759/16 (AS)
MIL-W-6858
MIL-W-16878/5
MIL-W-81381/22 (AS)
MIL-W-81822/1A
MS-21044
MS-25036
National Bureau of Standards Voluntary Product Standard (American Plywood Association) PS 1-83
National Fire Protection Association's Publication NFPA No. 130
National Fire Protection Association's Publication NFPA No. 70
NEMA MG1
NEMA Standards Publication No. LD-3
NEMA Standard 250
NTT EMC Standards for Procurement of New Technology Trains, Rev. 1.0
Reliability Design Handbook No. RDH376, from ITT Research Institute
RS-232 Computer Input/Output Interface
RS-422 Computer Input/Output Interface
SAE 1020
SAE 1045
SAE J343
SAE J356
SAE J524
SAE J533b
SAE J535
SAE J516
SAE J517
SAE J579
SAE J580
SAE J585
SAE J588
SAE J592
SAE J671
SAE J914
SAE J953
SAE J994
SAE J1273
SAE J1398
SAE J1405
SAE Recommended Practice ASP 1393, 5/3/76
UL Standard 6
UL Standard 465
UL Standard 900
UMTA-MA-06-0153-85-6
UMTA-MA-06-0153-85-8
UMTA-MA-06-0153-85-11
UMTA Publication IT-060026-73-3, Investigation of the Voltage Transients & Spikes in Direct Current Rapid Transit Systems
UNS S20100
U.S. Department of Transportation's "Recommended Fire Safety Practices for Rail Passenger Vehicles"
APPENDIX C

NYCT STANDARDS, SPECIFICATIONS AND PUBLICATIONS

(Attached to Request for Best and Final Offer)

New York City - Rapid Transit Noise Code, Chapter 736
NYCT (NTT) Conducted EMI Test Procedures (CETP), Revision 1.2
NYCT Cleaners and Related Material Qualified for Car Equipment Use
NYCT Internal Specification 2069-PROD-91, Composite Brake Shoe Specification, Rev. E MOD 02
NYCT List of Lubricants for All Car Classes, Rev. A, April 1993
NYCT MW-1 Track Standards and Reference Manual, 1997 MOD 02
NYCT SMS Generic Car Workscope and Time Intervals, Document No. 89-005, Rev. E MOD 02
NYCT Specification 1000-MMD-89, Multivolume Illustrated Parts Catalog MOD 02

NYCT Specification 7029-FACIL-78 Furnishing and Delivering Fuses MOD 02
NYCT Specification 2011-PROD 97, Wrought Wheels MOD 02
NYCT Specification 2071-PROD-91, Battery Storage Nickel-Cadmium, Steel Case Cell and Accompanying Battery Tray, Rev. E MOD 02
NYCT Specification 2083-PROD-95, Doppler Speed Indication Systems, Rev. B MOD 02
NYCT Specification 2086-PROD-96, Air Brake Hose and Hose Assemblies MOD 02
NYCT Specification 3059-MATL-86, Cross-Linked Polyolefin Wire MOD 02 2)
NYCT Specification 3061-MATL-87, Interior Rail Self-Adhesive Stickers, Rev. E MOD 02
NYCT Specification 6010-PRCS-89, Noise Test on Ring Damped Wheels, Rev. A MOD 02
NYCT Specification 8003-GENL-87, Work Manual, Rev. C MOD 02 2)
NYCT Specification 8011-GENL-84, Wheel Supplier Qualification Procedure, Rev. B MOD 02
NYCT Specification 8004-GENL-87, Engineering Record Drawings, Rev. D MOD 02
NYCT Specification 8013-GENL-90, Requirements for Video Training Tapes MOD 02
NYCT Specification 8018-GENL-97, Development of New York City Transit's RTO Train Operator Training Simulator, dated February 18, 1997 MOD 02

NYCT Standards, Specifications & Publications, "Standard Specifications for Track & Structure Materials" 1) MOD 02
NYCTA/MaBSTOA #CCSS-002 Paints and Coatings MOD 02
NYCTA/MaBSTOA #CCSS-003 Restricted Chemical Substances MOD 02
NYCT Noise Test Procedure, R142 New Subway Cars MOD 02
NYCT Specification for Bar Code System, 8017 GENL-96 (No Rev.) MOD 02

NYCT Designation of Sides and Ends of Locomotives Other Than Steam MOD 02
NYCT Specification 2092-PROD-97 Heat Treated Alloy Steel Axles (No Rev.) MOD 02

1) Not included. May be obtained separately from NYCT.

2) Documents were formerly in the Appendix, but not in this Table of Contents.
APPENDIX D

CONTRACT DRAWINGS

Body Number Plate Details, Dwg. No. 604-5001, Revision Nil.
Car Sections - Drawing No. LTK 1-3, Revision C
Clearance Diagram 51'-4" Car "A"Division; Dwg. No. 205-3004, Revision A
Driver’s Cab - Drawing No. LTK 1-4, Revision C
Elevations - Drawing No. LTK 1-2, Revision C
Emergency Brake Stopping Distances for Customer Cars - Drawing No. 103-9002
Memorandum of Understanding, Emergency Stopping Distance - Misc. # 95-01
Motor Axle, Dwg. No. 704-3001, Revision H I
Performance, Speed vs. Distance Curve, Revision B
Acceleration Performance of Passenger Cars for Trip Stop System-Drawing No. 253-9014
Plan - Drawing No. LTK 1-1, Revision D
Seat Section - Drawing No. LTK 1-5, Revision A
Sections w/ Figures - Drawing No. LTK 1-7, Revision B
Standard Air Brake Shoe Key Tread Brake Unit, Drawing No. 103-7004, Revision A
Trip Device Application, Record Dwg. R-62-934
Wheel, Wrought Steel, Ring Damped; Dwg. No. 704-3035, Rev. F
Glazing, Subway Car, R62 R62A Bottom Fixed Window - Drawing No. 301-7200, Sheet 455
Glazing, Subway Car, R62 R62A Fixed Side Window - Drawing No. 301-7200, Sheet 457
Car Dimensions and Car Equipment Clearance - Drawing No. 205-3001, Revision B
New Car Acceleration Performance 253-9013

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