21.18.4 Parts to be joined by welding shall be supported and held in position by tables, jigs, or fixtures to prevent warping. Weld joint design and welding method shall be selected to include provisions for shrinkage and warping due to the welding process. Welding shall be applied in a manner to minimize distortion. Acceptable distortion levels shall be submitted for Metra approval.

21.18.5 All Weld quality shall be in accord with acceptable weld criteria as defined in EN ISO 10042, EN ISO 5817, or AWS welding Codes.

21.18.6 The Contractor shall submit welding procedures specifications (WPS) and Procedure Qualification Records (PQR) to Metra for review and approval. **[CDRL C-21-22]**

21.18.7 Welder Qualification

21.18.7.1 Welders shall be tested and certified to verify their proficiency for producing sound welds, for each weld type performed by the welder to each applicable Welding Procedure Specification (WPS). Welder qualification tests shall be performed in accordance with the applicable requirements of EN, ISO, or AWS standards, or other approved equivalent standards. Welder qualification tests for pressure vessel welding shall be in accord with applicable requirements of ASME Section IX, or other approved specifications.

21.18.7.2 Welders shall be certified to AWS or equivalent welding societies and an identification number from the society shall be provided.

21.18.7.3 The Contractor and all suppliers and subcontractors shall retain records of welder qualifications and shall make these records available to Metra upon request.

21.18.7.4 Metra shall have the right to require the making of test welds by any welder, whether under the direct control of the Contractor or a supplier or subcontractor, to ascertain his/her competence and to determine the suitability of the welding procedure used.

21.18.8 Welding Procedures

21.18.8.1 All welding practices not specifically covered in other sections shall comply with EN 15085 series AWS-D1.1, AWS-D1.2, or AWS-D1.3 and the EN, ISO, or AWS Welding Codes as appropriate to the applicable AWS welding standard(s). Requirements for dynamically loaded structures shall be applied. The contractor shall provide a standard comparison, if non US standards will be used.

21.18.8.2 Resistance welding shall be in accordance with AWS D17.2, EN ISO 18595, or EN ISO 14373. Resistance welding operations shall be undertaken using only equipment fitted with meters or readouts and adjustments for time, current, and pressure. The contractor shall provide a standard comparison, if non US standards will be used.

21.18.8.3 The method used in depositing weld metal shall be one that reduces warping and residual stresses. To achieve this, tack welding, offset welding, skip welding, and other devices and sequences well known to the craft shall be used where appropriate.

21.18.8.4 Machine welds of any thickness may be made with one or more passes as per the Procedure Qualifications Record (PQR) for the weld joint.

21.18.8.5 The Contractor shall submit a procedure qualification record (PQR) for all weld joints to be used or pre-qualified per AWS codes and all Weld Procedure Specifications (WPS) for the project, or equivalent specification and qualification according to the EN ISO 15614. The contractor shall provide a standard comparison, if non US standards will be used.

21.18.8.6 Procedures used for the welding of metal combinations not specifically covered by the AWS or EN standards (i.e. stainless steel to steel) shall be approved by Metra. Stainless steel to steel welds shall use austenitic stainless steel filler metal. The contractor shall provide a standard comparison, if non US standards will be used.

21.18.9 Welding Electrodes

21.18.9.1 The choice of welding rod or wire filler metal shall be made with consideration of the make, type, size, composition, and suitability to the application and shall be in accordance with "Specification for Filler Metal" AWS A5.0, or the EN ISO 18273 and EN ISO 14341. Welding electrodes shall be stored in a dry, closed environment to prevent contamination in accordance with AWS recommended practices for filler material storage. Welding electrodes shall be clearly marked. All low-hydrogen electrodes shall be kept in a dry-rod oven to keep moisture from the electrodes. The electrodes shall now be exposed to the atmosphere for longer than a period of four hours. Low-hydrogen electrodes soak atmospheric moisture and stays in the flux. When welding with an electrode with moisture in the flux can cause excessive surface and/or subsurface porosity and can cause slag entrapment. The contractor shall provide a standard comparison, if non US standards will be used.

21.18.10 Weld Repairs

21.18.10.1 Weld repairs shall be performed in accordance with approved procedures, which comply with AWS D1.1, the EN 15085, or the AWS Code applicable to the welded material. When a production weld has been determined to be substandard, all production since the previous acceptable production quality control test shall be segregated, and disposition shall be recommended to Metra for approval. All parts with substandard welds shall be rejected or repaired by weld removal, re-weld, and inspection. Re-weld, inspection, and any Non-Destructive Examinations (NDE) required by the applicable AWS, or EN welding standard regarding repairs. The contractor shall provide a standard comparison, if non US standards will be used.

21.18.11 Welding Inspection and Examination

21.18.11.1 The Contractor shall inspect all welds to their classification and operating grade,. to verify compliance with these provisions and specifications. For the classification purposes EN 15085 in conjunction with the EN 12663-1 shall be applied.

21.18.11.2 Welding inspection procedures and welding inspector qualification tests shall be performed in accordance with the applicable requirements of the AWS standards for weld inspection,or for welds according to the EN 15085, according to the classification of the specific weld in accordance with the EN 15085.

21.18.11.3 The Contractor shall use and demonstrate the use of personnel qualified to perform weld inspection. An AWS Certified Senior CWI or EN ISO 14731 certified inspector shall lead all welding matters. An AWS or EN ISO 14731 Certified Welding Inspector (CWI) shall be utilized for inspection and oversight of welding inspection. All welding must be inspected by a CWI and the CWI stamped inspection reports shall be provided. This requirement applies to all welding work performed under the contract.

21.18.11.4 Non-destructive examination and testing of welds and welder qualification tests shall be performed in accordance with the applicable requirements of the AWS Welding and Brazing Handbook , EN 13018, EN ISO 17637, or the EN ISO 9712.

21.18.11.5 Personnel performing NDT shall have documented qualifications in accordance with American Society of Non-destructive Testing (ASNT), TC-1A or EN ISO 9712..

21.18.11.6 In addition to visual inspection requirements specified by the AWS welding codes, EN ISO 3452, or EN ISO 9934, non-destructive surface inspection (dye penetrant or magnetic particle methods, as appropriate) shall be used to inspect all first-production welds.

21.18.11.7 The Contractor shall specify additional non-destructive inspection requirements for subsequent welds. If the Contractor elects to inspect less than 100 percent, then the Contractor shall submit a random sampling inspection plan for approval by Metra. In no case shall the length of weld non-destructively inspected be less than one percent of the total weld length.

21.18.11.8 All welds designed to carry primary stresses in members such as side sills, end frames, bolsters and other important truck and frame members, shall be inspected by the Contractor for defective welding.

21.18.11.9 Critical areas of all such welds shall be magnetic particle or dye penetrant or ultrasonic tested and radiographic tests shall be used on a random sample basis.

21.18.11.10 The following defects in excess of limits indicated or established in the approved procedures shall be cause for rejection of the work affected: cracks, regardless of length, magnitude or location; overlaps; lack of penetration; incomplete fusion; inclusions except if they do not materially affect the strength of the welded joint and do not indicate improper technique or an unsatisfactory procedure; undercuts; poor surface appearance; or improper size of weld.

21.18.11.11 On the first structure or component, all full-penetration welds shall be non-destructively, volumetrically inspected (ultrasonic or radiographic methods). The Contractor shall specify a random sampling plan for volumetric inspection of subsequent full-penetration welds for approval by Metra. **[CDRL C-21-23]**

21.18.11.12 With the approval of Metra, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements.

21.18.12 Heat Treatment

21.18.12.1 Where required by specifications or drawings, welded assemblies shall be stress-relieved by heat-treating in accordance with AWS D1.1. Chapter 4, Part A or applicable EN standards. Heat treatment procedures shall be documented and submitted for review for first piece/part processing. All heat treatment documentation (results) shall be retained by the Contractor.

21.18.13 Brazing

21.18.13.1 The Contractor shall maintain a brazing program similar to the welding program specified in the welding portion of this specification.

21.18.13.2 All brazing, qualification of braziers, and repair of brazing defects shall be in accordance with the requirements and recommendations specified in the AWS Welding and Brazing Handbook or the DIN8593-7.

21.18.13.3 The Contractor shall maintain quality control procedures necessary to ensure high-quality brazing. The Contractor shall submit brazing specifications, procedures, and certifications to Metra for review and approval. **[CDRL C-21-24]**

21.18.14 Soldering

21.18.14.1 Soldering of electronic equipment shall comply with the requirements of ANSI J-STD-001B or ROHS. The Contractor shall submit soldering specifications, procedures, and certifications for approval.

21.19 CORROSION CONTROL

21.19.1 All materials used shall be either inherently corrosion resistant, or suitably treated, or coated to resist corrosion. Equipment located in areas highly susceptible to corrosion shall be made from inherently corrosion resistant materials. Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids. The Contractor shall be responsible for verifying that all such areas are protected through communications with Metra.

21.19.2 Except as otherwise indicated, all aluminum exposed to view in finished work in the interior of the vehicle shall have a protective anodized coating.

21.19.3 The recommendations contained in "a Corrosion Control Manual for Rail Rapid Transit", UMTA-DC-06-0152-83-1, shall be used, except as otherwise directed by Metra.

21.19.4 The Contractor shall prepare a Corrosion Control Plan, which shall locate all materials that require treatment to prevent corrosion due to atmospheric exposure, and areas of dissimilar metal or other material joining which could result in galvanic action and material deterioration. This plan shall document the methods used to preclude failure due to corrosion for any of the above conditions. The Contractor shall update this document as materials and treatments change. The Corrosion Control Plan shall be submitted to Metra for review and comment. **[CDRL C-21-25]**

21.20 DISSIMILAR METAL TREATMENT

21.20.1 Direct contact between electrically dissimilar metals is prohibited except as approved by Metra for electrical connections between copper and aluminum where appropriate joint compounds are used as specified herein. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times.

21.20.2 All metals used in the fabrication process shall be surface treated with corrosion-resistant materials prior to assembly, with consideration being given to the severity of exposure to which the surface shall be subjected.

21.20.3 The joining of incompatible metals and materials shall be minimized as much as possible. When such metals must be joined, provision shall be made in accordance with MIL-STD-889 to prevent chemical reactions between the metals.

21.20.4 Surfaces of aluminum alloy parts secured to ferrous parts shall be protected with one-part polysulfide or silicone sealant used as joint compound, or with joint material that is non-hygroscopic and is free from chlorides and heavy metal ions.

21.20.5 Fibrous joint material shall be impregnated with bitumen or other water-repellant substance, which shall completely cover interfacing surfaces.

21.20.6 All ferrous metal surfaces, other than stainless steel, shall be protected by painting or zinc plating as defined in this specification, unless otherwise specified. Steel surfaces not

requiring protection shall be galvanized by the methods and requirements described in ASTM A123. Minor damage to galvanized coatings shall be repaired with an approved zinc rich paint.

21.21 WIRING REQUIREMENTS

21.21.1 Wire sizes, insulation requirements, materials, shielding methods, and identification of wire and cable used for primary, auxiliary, control, and communications applications shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature, and flexibility requirements of AAR, ASTM, ICEA, NFPA, MIL, NFPA 70, or EN 50343 specifications. Wire, cable, and bus bars shall be copper. All wiring not explicitly referenced in other parts of this specification shall meet at a minimum the latest revision of APTA specification PR-E-RP-009-98, Recommended Practice for Wire Used on Passenger Equipment. or EN50343.

21.21.2 All wire and cable insulation shall meet NFPA 130. The wire and cable selected shall be rated by the manufacture to last the life of the vehicle, the lifetime of power cables shall be agreed between Metra and the contractor.

21.21.3 The Contractor shall mark each wire, by wire type, at an interval of 12 inches, and mark each wire end with a function code using a scheme subject to approval by Metra.

21.21.4 Metra shall approve all electrical wire and cable used in the vehicle. The Contractor shall submit samples and specifications of each size and type of wire and cable proposed for use in the vehicle for Metra approval. **[CDRL C-21-26]**

21.21.5 Braided copper wire, or wire rope, shall be used in all ground strap applications. Flexible stranded copper wire is acceptable in other applications.

21.21.6 All conductors of multi-conductor cables shall be terminated.

21.21.7 Conductors

21.21.7.1 Maximum current capacities shall conform to APTA PR-E-RP-009-98, EN 50343 or based on approval from the cable supplier..

21.21.7.2 Except as otherwise specified, conductors shall be of soft, annealed, tinned copper stranded in accordance with ASTM B33, or mutually agreed between METRA and the Contractor..

21.21.7.3 Where appropriate, selected cables shall be agreed between METRA and the Contractor.

21.21.8 Wire & Cable Insulation

21.21.8.1 Each conductor shall be separately covered with insulation. Flat cables are prohibited, except for specific data/communications applications where other arrangements are impractical.

21.21.8.2 Wire and cable insulation used for car-body wiring shall be flexible, crosslinked polyolefin, or equivalent. Wire and cable shall comply with the requirements of NFPA 130. Wire and cable shall comply with applicable sections of NEMA WC 70, NEMA WC 71, and AAR RP-585 or equivalent standards as is appropriate for the application and subject to Metra review.

21.21.8.3 Wires within enclosed equipment or suitably protected locations shall comply with MIL-W-81044, or as otherwise approved.

21.21.8.4 For general-purpose wire and cable, the insulation shall be of heat and moisture proof material suitable for a continuous temperature rating of 167□F (75□C) minimum in dry and wet locations. For high-temperature applications, such as connecting to heaters and resistors, the insulation shall be suitable for a maximum conductor temperature of 230□F (110□C).

21.21.8.5 Asbestos, urethane, and polyvinylchloride (PVC) based insulations or jacket materials shall not be used.

21.21.8.6 Outer jacket material of multi-conductor cable shall be the same as that used to insulate individual conductors, unless physical considerations indicate a different material with superior characteristics.

21.21.8.7 Multi-conductor cables shall provide at least 10 percent spare wires

21.21.8.8 Shielding shall be used over multi-conductor cable for safety-critical circuits. Shielding material shall be woven wire providing not less than 60 percent coverage and shall be soft, annealed, tinned copper of an area equal to or greater than the largest conductor.

21.21.8.9 Non-conducting separators and fillers may be applied between conductor and insulation on conductor sizes greater than No. 5 AWG.

21.21.8.10 Leakage between primary wiring and vehicle body shall be measured in accordance with IEEE 16, IEC 62497 or EN 50124.

21.21.8.11 Hi-Pot shall be accomplished on all primary power wiring for 1 minute per IEEE 16.

21.21.8.12 General car-body wiring insulation shall be flame-retardant, extra-flexible, cross-linked polyolefin material. General car-body wiring insulation and/or jacketing shall be free of halogens, phosphorus, sulphur and nitrogen (combined to less than 1% by weights), or otherwise be subject to NFPA 130-2023.

21.21.9 High-Temperature Wire & Cable

21.21.9.1 Insulation for all wires in high-temperature applications, including but not limited to those connecting with heaters, resistors, or lights shall be appropriately designed. The cable list for high-temperature applications shall be part of a review and approval by METRA. [CDRL C-21-30].

21.21.9.2 (deleted)

21.21.9.3 (deleted)

21.21.10 Communications Wire & Cable

21.21.10.1 All car-body wire and cable applicable to the communications equipment shall follow the communications system manufacturer guidelines or recommendations according to APTA PR-E-RP-009-98, Rev. 2 where applicable and it is subject to METRAs approval.

21.21.10.2 All communications wire and cable shall be installed in raceways, conduits or as otherwise approved.

21.21.10.3 Where required, the jacket shall be waterproof and abrasion-resistant and shall provide insulation resistance greater than 1 MOhm/ft between shield and water.

21.21.11 Conduit & Wire Channel

21.21.11.1 All conduits and wire ways shall be free of burrs, sharp edges, and square corners. Conduit welded into the car-body shall not have any burn-through of weld, or any other penetration into the interior of the conduit. The ends of the conduits and wireways shall be suitably rounded to prevent edge contact with the wire. Conduit radius shall be sufficiently large enough to allow easy pulling of the wire.

21.21.11.2 Wires and cables installed in flexing applications shall be housed in abrasion resistant, flexible conduit or sheathing designed for the application, and installed such that there is no pinching, stretching, or kinking under all ranges of motion.

21.21.11.3 The Contractor shall ensure that wireways, conduits, and piping, that is susceptible to corrosion shall be suitably protected from corrosion such as zinc plating per ASTM B633 Type II yellow, SC4, or receive a minimum of one coat of primer and one coat of an approved paint, or according to manufacturer specifications or guidelines. This priming and painting can be accomplished either before or after installation of the item on the car-body.

21.21.12 Application & Installation

21.21.12.1 All wiring shall be performed and directed by experienced personnel using appropriate tools for stripping insulation, cutting, soldering, and attaching mechanical crimp-type terminals with correct dies.

21.21.12.2 All car wiring connected to a given piece of electrical apparatus shall be insulated for the highest voltage supplied to that apparatus. Wires operating with potential differences of 50 volts or more shall not be cabled or routed together. Signaling, LVDC, AC, and HVDC wiring shall be separated.

21.21.12.3 Wiring for any communications system equipment shall be done in an approved manner to conform to the requirements established by the supplier of that equipment.

21.21.12.4 All circuits shall be adequately protected and insulated from ground with exception of 24V circuits. All circuits and branches must be separable by a switch or terminal board to isolate their grounds when troubleshooting is required.

21.21.12.5 Wiring shall be fabricated into standard harnesses, and installed in prefabricated groupings, and standardized locations in the vehicles.

21.21.12.6 Car wiring shall comply with NEC Code, Chapter 3 (NFPA 70), and with the AAR Manual of Standards, Section F, S-538, Wiring Practice, or EN 50343 and Rolling Stock Standard, except where otherwise specified.

21.21.12.7 Circuit protection shall comply with NEC Code, Chapter 2 or EN 50153.

21.21.12.8 Electrical circuits and associated cabling shall be designed with clearance and creepage distance between voltage potentials and car-body ground in accordance with the environmental conditions to which the circuits and cabling will be subjected, and in accordance

with NFPA 130, Chapter 4 or equivalent IEC, or EN standards or APTA PR-E-RP-004-98, Rev. 3.

21.21.12.9 Electric apparatus shall be housed in sealed enclosures to remain clean and dry. Cooling air shall be filtered to remove all conductive and non-conductive dust.

21.21.12.10 The layout of wiring shall be designed in advance of its installation and in cooperation with those furnishing the related equipment.

21.21.13 Undercar and Roof Wiring Installation

21.21.13.1 All wiring shall be run in insulated metal raceways and/or wire ducts with securely fastened but easily removable metal covers.

21.21.13.2 Wire and cable shall be securely anchored in an approved manner in the ducts to prevent chafing from relative motion.

21.21.13.3 Minimum wire size for under car wiring shall be 14 AWG for power and 16 AWG for control circuits. Within equipment enclosures, minimum wire size shall be 22 AWG.

21.21.13.4 When physical strength is required, No. 6 AWG or larger wires may be used and supported in place without any type of enclosure by using molded rubber cable support blocks. This method is also acceptable in protected areas that may be subject to damage or vandalism.

21.21.13.5 The wire glands shall be of waterproof construction. Watertight strain-relief bushings with insulated throat liners shall be provided at carbody entrance and exit points. Bushings shall be sized such that the wire and lug may be removed through the bushing for applications, where the cable has to be removed for preventive maintenance purposes.

21.21.13.6 Wires or cables shall not pass through the battery compartment.

21.21.13.7 Floor wiring shall be run in conduits or ducts and may be run through partitions, but only if suitable bushings are provided at such points of passage.

21.21.13.8 Sufficient slack and wire length shall be provided to prevent breaking or pulling out of bushings or terminals, and to allow for a serviceability loop long enough for three re-terminations.

21.21.13.9 Drip loops shall be provided where appropriate.

21.21.14 Power Cables

21.21.14.1 HVDC power cables (with the exception of cables passing through or above the floor) that are No. 6 or larger shall be cleated in place.

21.21.14.2 The cleats shall be positioned at intervals in accordance with EN 50343, and adequate clearance shall be maintained between cables and any structural members, components, or items of equipment.

21.21.14.3 Where mechanical protection is required, short lengths of conduit may be employed, one conduit per wire, subject to approval.

21.21.15 Cable Connectors

21.21.15.1 All cable connectors shall be of watertight design, unless enclosed in interior areas, with removable / replaceable crimp contacts of the correct size for the wire being terminated.

21.21.15.2 Cable connectors shall be equipped with sealing gaskets. Extension bodies shall be used if necessary to ensure that there is sufficient room to terminate the cable wires within the connector body.

21.21.15.3 The cable jacket shall extend within the body, shall be held by a clamp, and shall have a gasket seal at the entrance.

21.21.15.4 (deleted)

21.21.15.5 Measures shall be in place to prevent erroneous connection of adjacent connectors.

21.21.15.6 Connectors installed in exterior locations shall comply with MIL-DTL-5015. All other connectors shall comply with an equivalent standard, as approved by Metra.

21.21.16 Terminals

21.21.16.1 Terminations and connections throughout the vehicle shall be with insulated ring tongue connectors of the compression (crimp) type where applicable.

21.21.16.2 Quick-disconnect (fast-on) terminals with locking features may be used, subject to approval, provided that the type of fast-on has demonstrated a satisfactory service in a similar fashion. Materials such as phosphor bronze shall be shown to be suitable for repeated use.

21.21.16.3 Terminals shall not utilize PVC insulation.

21.21.16.4 Terminals shall be attached to the wiring with the crimping tools and dies recommended by the connector manufacturer.

21.21.16.5 The terminal used shall be of the type that securely grips and holds the insulation of No. 10 AWG wire or smaller. The crimp terminal shall be rated to match the wire conductor diameter and the insulation diameter.

21.21.16.6 Conductors that will be subjected to motion shall utilize the proper strain relief mechanism recommended by the manufacturer.

21.21.16.7 Spare terminals shall be provided in each cabinet or enclosure up to an amount off 10 percent. The spare terminals setup is subject to METRAs approval.

21.21.17 Conduit and Raceway Requirements

21.21.17.1 All car wiring shall be housed in metal raceways. Open metal raceways and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall be so designed that the sections can be mechanically and electrically coupled, while the wires are protected from abrasion.

21.21.17.2 High voltage wiring, (i.e., wiring in excess of 120 volts) shall not be run in the same cable ducts, conduits, or raceways as low voltage wiring.

21.21.17.3 All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes and shall be supported to the car body at least every 610 mm (24 in).

21.21.17.4 Wires in conduits, ducts, and raceways shall be free of kinks, insulation abrasions, and insulation skinning.

21.21.17.5 Where cables come through the flooring appropriate measures have to be taken to prevent water or cleaning chemicals from draining onto the below-floor cables.

21.21.18 Wire Harness

21.21.18.1 The layout of wiring, for both vehicles and equipment, shall be designed in advance of its installation and in cooperation with the suppliers of the related equipment. Wiring shall be prefabricated into standard harnesses, wrapped and tied with wire ties or a high strength, waxed lacing cord designed not to invade the wire insulation. Harnesses shall be installed with identical arrangement and location in each vehicle 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 separable by means of terminal boards to isolate portions from others for troubleshooting. All circuits subject to periodic high potential tests shall be arranged so that they can be conveniently isolated for the tests.

21.21.18.2 Alternative methods for fabricating and installing wiring, which are standard car builder practice, will be submitted for consideration at the appropriate design review.

21.21.18.3 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% spares.

21.21.19 Cleating

21.21.19.1 Split block cleats of molded neoprene rubber or an approved equivalent shall cleat all cable and wiring not installed in conduits. A nonflammable insulating material with a durometer reading of 50 to 60 Shore A hardness, or an approved alternative shall be used for cleating.

21.21.19.2 The holes in the cleat shall be sized for the individual wires and cables. Hole edges shall be radiused to prevent square edge contact with cable insulation.

21.21.19.3 Each cleat shall have a stiffener on the side away from the mounting bracket that will act to spread the bolt clamping force over the entire length of the cleat.

21.21.19.4 Bolts shall have lock nuts of approved design.

21.21.19.5 Cable and wiring, other than HVDC, using cleating shall be supported to the car body at least every 610 mm (24 in).

21.21.20 Equipment Enclosures & Junction Boxes & Fittings

21.21.20.1 Boxes, covers, and fittings of ferrous metal shall be galvanized inside and outside after fabrication, treated appropriately or made of stainless steel. All box covers shall be marked according to section 19.3.7. All box covers shall be marked with the vehicle

number, all like covers shall be interchangeable. The box covers shall be held in place with latches or blunt end screws. Self-tapping screws shall not be used for box covers.

21.21.20.2 Screws and other hardware shall be made of stainless steel.

21.21.20.3 All undercar and roof-mounted junction boxes shall be waterproofed where required and vented and shall protect enclosed equipment and connected conduits from water seepage.

21.21.20.4 All electrical cabinets shall be designed for creepage and clearance distances according to APTA PR-E-RP-004-98, Rev. 3 or EN50124.

21.21.21 Wire Identification & Terminal Markings

21.21.21.1 Wire terminal designations shall be assigned to all electrical conductors, whether individual wires or cables, within the entire car.

21.21.21.2 All wires and cable shall be marked within 305 mm (12 in) of the end of the wire.

21.21.21.3 Wires shall be identified according to circuit function, wire number, wire segment, and gauge. Wire identification shall be subject to approval by Metra.

21.21.22 Splicing and Taping

21.21.22.1 Splicing and taping shall not be allowed unless expressively approved by Metra on a case by case basis.

21.22 CIRCUIT PROTECTION

21.22.1 Handles shall indicate ON, OFF/TRIPPED positions. All circuit breakers shall be molded-case type, multi-pole, with frame size suitable for continuous current and interrupting duty.

21.22.2 Each pole shall be equipped with a trip mechanism consisting of an inverse time element for overload protection and an instantaneous magnetic element for short circuit protection.

21.22.3 Each pole shall be equipped with adequate means of arc extinction to prevent flashover.

21.22.4 Multi-pole breakers shall operate contacts simultaneously.

21.22.5 Breaker current rating shall be clearly visible after installation and shall comply with UL 489, ANSI C37.13, C37.14, or C37.16 or IEC 60947.

21.22.6 Continuous current rating shall be selected in accordance with APTA PR-E-RP-009-98 or EN 50343 and for load and type of service indicated.

21.22.7 Electrically controlled breakers shall be equipped for operation from the LVPS

21.22.8 Circuit breakers shall be properly coordinated with protective devices.

21.22.9 Other than high speed circuit breakers (HSCBs) used for HVDC circuits, circuit breakers shall not be used for protection on HVDC circuits.

21.22.10 Fuses shall be avoided where possible except for indicator type fuses within electronic assemblies, high voltage circuit protection, and special applications with approval.

21.23 GROUNDING

21.23.1 Grounding connections shall be made through copper or bronze pads, tinned, and silver soldered to the car body.

21.23.2 The copper pads shall be tinned or silver electroplated after attachment. Stainless steel ground pads may also be used, subject to Metra approval.

21.23.3 Low voltage and high voltage circuits shall not be grounded to the same grounding pad, if such grounding is permitted by this specification.

21.23.4 All ground pads shall be visible and accessible for inspection and troubleshooting. The ground connections shall be attached by an approved bolt, washer, and nut designed for the purpose.

21.23.5 Resiliently-mounted equipment shall be grounded with flexible strap-type grounding leads bolted between a car body grounding pad and the equipment's grounding pad. Strap flexibility and length shall be sufficient to prevent failure from fatigue. Fixed equipment maybe grounded by flexible straps or properly terminated wire of the same type used for car wiring.

21.23.6 The ground strap termination method shall form a gas-tight, uniformly distributed connection with the conductive surface. Current density shall not exceed bonding requirements below.

21.23.7 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 50 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 kilohertz for any applied AC voltage.

21.23.8 All ground pads shall be readily visible and accessible for inspection and troubleshooting.

21.23.9 All equipment enclosures and shock-mounted equipment shall be grounded with tinned, braided copper, flexible strap grounding leads bolted to a car body grounding pad.

21.23.10 Ground cables and shunts shall be extra-flexible, tinned, non-insulated, stranded copper cable and shall be terminated by approved crimped ring terminals on both ends.

21.23.11 Ground cables and shunts shall be sized to withstand, without failure, the maximum failure current that could be anticipated should the return wiring totally fail.

21.23.12 In no case shall the size of a ground cable or shunt be less than No. 10 AWG.

21.23.13 The Contractor shall ensure that all metal parts inside and outside the vehicle that could be touched by passengers or operating personnel, including equipment boxes, panels, and test receptacles in the passenger or operator areas, shall never exceed car body potential.

21.24 ELECTRICAL COMPONENTS

21.24.1 Electrical components, which are singly replaceable, shall be connected to car wiring through individual, removable connections, or "pigtails" with connectors. Replaceable

components shall not be connected to car wiring using soldered connections. Electrical components installed on the vehicle without protective enclosures, including, but not limited to inductors, transformers, resistors and capacitors, shall be designed, selected and installed to make them impervious to the effects of Metra's railroad environment and operations. This shall include, as a minimum, the effects of extreme weather, water, snow and ice, extreme temperature swings and possible impact by debris. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by Metra.

21.24.2 Relays and Contactors

21.24.2.1 Contactors and relays shall meet or exceed IEC 60077.
21.24.2.2 Low-current relays (less than 10 Amp per pole) shall have silver-alloy contacts.
21.24.2.3 Signal relays shall have gold-plated, silver-alloy contacts.
21.24.2.4 Relays and contactors that have not been proven in rail service shall comply with MIL-PRF-6106 or EN50155.
21.24.2.5 Relays shall be capable of at least one million electrical operations at rated contact capacity with the exception of those operating on the order of 1000 times per day being capable of at least ten million electrical operations at rated capacity.
21.24.2.6 Plug-in relays shall be secured in their sockets by mechanical restraint.
21.24.2.7 Relay and contactor coils shall be suppressed to mitigate transient voltage spikes, with the suppressing network mounted as close to the coil as possible.
21.24.2.8 Relays and contactors, except low-power miniature relays mounted on printed-circuit boards, shall incorporate means of either visually or by contactor monitoring to determine whether contacts are picked up or dropped out for functional operation or maintenance activities.
21.24.2.9 Relays used in safety-critical circuits with single point failures shall comply with the AREMA Signal Manual, Volume 2, Section 6, unless otherwise approved.
21.24.2.10 Contactors used to interrupt HVDC circuits shall be equipped with blowout coils or other means of service proven design.

21.24.3 Pushbutton Switches and Indicators

21.24.3.1 Switches shall be heavy-duty, with electrical characteristics, ratings, and accessories as required for circuit application.
21.24.3.2 Pushbutton (including illuminated) switches shall have silver-plated or silver-alloy terminals.
21.24.3.3 Indicators and pushbutton switches shall have insulation resistance of at least 1 MOhm to case at 500 VDC. Re-lamping of indicators shall be from front.
21.24.3.4 Contacts shall have maximum resistance of 0.10 ohm at 3 VDC and 10ma load. Minimum open contact resistance shall be 50 MOhm.
21.24.3.5 Contact shall be rated for inductive loads. The contacts shall normally operate at not more than 20 percent of the manufacturer's inductive rating for 25,000 cycles of operation at 25o C. The electrical-contact material shall be silver or silver with a gold flash or gold plate and be normally a break-before-make type.
21.24.3.6 Indicators shall be LED type where possible.

21.24.4 Inductors

21.24.4.1 The insulation of power inductors shall comply with EN 50124.

21.24.5 Transformers

21.24.5.1 Transformers shall have vacuum-impregnated windings and have a minimum inter-winding breakdown voltage of 1,500 VDC. Exceptions to this requirement may be granted on a case by case basis, upon approval by Metra.

21.24.6 Resistors

21.24.6.1 Panel mount Resistors other than power/braking resistors shall be derated 50 percent minimum.

21.24.7 Capacitors

21.24.7.1 (deleted)

21.24.8 Motor Starters

21.24.8.1 Starters shall be rated for continuous duty at service indicated, shall be equipped with magnetic holding coils, and shall be capable of resetting automatically upon loss of supply voltage. Starters shall be equipped with sufficient auxiliary contacts to comply with requirements for annunciator circuits, as indicated. Thermal overload protection shall be provided. Three-phase starters shall be three-pole.

21.24.9 Environmental Conditions for Electronic Systems

21.24.9.1 When not in conflict with or specified otherwise in component portions of this specification, "normal railroad operating environment" for electronic systems shall be defined by referring to criteria in relevant sections of standard EN 50155 Railway applications – Electronic equipment used on rolling stock, including:

21.24.9.1.1 IEC/EN 61373 Railway applications – Rolling stock equipment – Shock and vibration tests

21.24.9.1.2 EN 50121-3-2 Railway applications – Electromagnetic compatibility: Rolling stock – Electronic subsystems, Metra requires test procedures and reports to demonstrate EMC compatibility. Prior procedures and reports may be reviewed by Metra if the contractor demonstrates that the subsystem or device has not changed. If, upon review, Metra finds that the testing procedure is not sufficient or there are demonstrable changes in form, fit, or function, contractor to submit revised test procedure and perform testing for this project. The acceptance of a declaration of conformity, without a test report, needs to be approved by Metra on a case by case basis.

21.24.9.1.3 (deleted)

21.25 ELECTRONIC COMPONENTS

21.25.1 Electronic components shall be free of storage and handling damage. Where possible, components shall be clearly and permanently labeled with values or type identification.

21.25.2 Power semiconductor devices (traction- and auxiliary converters) shall be available from two or more qualified manufacturers. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by Metra.

21.25.3 (deleted)

21.25.4 (deleted)

21.25.5 (deleted)

21.25.6 Printed Circuit Boards

21.25.6.1 Printed circuit boards (PCBs) shall be of glass epoxy construction, or other service proven design, complying with NEMA LI1, grade FR-4, or equivalent standard such as IEC 249.

21.25.6.2 PCBs shall be uniformly coated.

21.25.6.3 Conductor materials shall be determined on the basis of current carrying capacity and in accordance with IEC 326-3, IEC 61188 or IPC 2221 or equivalent standards.

21.25.6.4 Edge connectors and boards shall be keyed to prevent insertion of any board in wrong a position and mounted for ease of board removal and replacement.

21.25.6.5 To the greatest extent practicable, component labeling shall be provided on PCBs.

21.25.7 Semiconductor/Integrated Circuits Requirements

21.25.7.1 The Contractor shall be responsible for ensuring that all electrical and electronic circuitry, including those of suppliers and subcontractors, as a minimum meet the criteria for the use of semiconductors and/or integrated circuits listed in this section, unless otherwise approved.

21.25.7.2 Suppression devices shall be provided, where necessary, to protect the devices and limit the circuit voltage.

21.25.7.3 (deleted)

21.25.7.4 Semiconductors and integrated circuits within a temperature regulated area shall comply with OT3 (-25°C to +70°C), uncontrolled temperature areas shall comply with OT4 (-40°C to +70°C), acc. EN 50155.

21.25.7.5 (deleted)

21.25.7.6 Contractor shall propose a list of critical integrated circuits which shall be screened for defects, subject to Metra approval. The Contractor shall submit for approval screening methods based on a minimum of a 48-hour burn-in for the completed assembly. Alternate screening methods may be submitted to Metra for review and approval.

21.25.8 Microprocessor-Based System Requirements

21.25.8.1 Microprocessor-based components, assemblies, and power supplies shall be provided with voltage/current regulation and protection to ensure proper operation.

21.25.8.2 All interfacing wiring shall be protected against interference from other on-car or wayside electrical radiation.

21.25.8.3 The microprocessor shall be of a family shown to be suitable for the rugged environmental conditions encountered in rail applications and shall be supported by software development language and diagnostic programs, which are acceptable to Metra.

21.25.8.4 The microprocessor assembly shall be housed in an enclosure, which shields the microprocessor assembly and the surrounding circuits from EMI radiation and interference.

21.25.8.5 The microprocessor shall have external buffers provided and shall be protected from external voltage and current transients and EMI.

21.25.9 Software Requirements

21.25.9.1 Where the software is essentially a modification of an existing product to meet the Metra's requirements, the design process, and documentation, shall be submitted for review and approval by Metra.

21.25.9.2 The Contractor and/or supplier shall submit a Software Quality Assurance Plan **[CDRL C-21-27]** for approval complying with IEEE 730, EN 50657 or equivalent, and containing, as a minimum, the following documentation requirements:

21.25.9.2.1 Software Requirements Specification
21.25.9.2.2 Software Design Description
21.25.9.2.3 Software Verification and Validation Plan
21.25.9.2.4 Software Verification and Validation Report
21.25.9.2.5 User Documentation

21.25.9.3 Source code shall be written in a high-level language such as C. All source code, properly documented, shall be placed in Agency approved third-party escrow when the last vehicle exits its warranty period.

21.25.9.4 The Software Design Description, in (b) above, shall comply with IEEE 1016, EN 50657 or equivalent.

21.25.9.5 The requirements of this section shall be presented to Metra at the Design Reviews. Metra shall be properly notified of meetings and reviews scheduled to determine progress with respect to the software requirements and the software design description by the Contractor. It is recommended that the Contractor establish a Software Management Plan.

21.25.9.6 The contractor shall support a Windows 10 Operating System software compatibility on future operating system on laptop.

21.26 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-21-01	Material Certifications
C-21-02	Material Maintenance
C-21-03	Interior and Exterior Stainless Steel Samples
C-21-04	Stainless Steel Coil Test Reports
C-21-05	LAHT Tension and Bend Test Reports
C-21-06	Casting Qualification Report
C-21-07	Elastomer Certification
C-21-08	Visual Inspection Criteria for Glazing

C-21-09	Thermoplastic Sheet Color and Surface Finish Samples
C-21-10	Thermoplastic Test Certifications
C-21-11	Fiberglass Reinforced Plastic Test Certifications
C-21-12	Melamine Test Certifications
C-21-13	Leak Test for Air and Hydraulic Piping System
C-21-14	Piping, Tubing, and Pressure Vessel Specifications
C-21-15	(deleted)
C-21-16	Bearing Specification and Data
C-21-17	Paint Inspection and Acceptance Criteria
C-21-18	Adhesives Utilized
C-21-19	Insulation Application, Retention, and Data
C-21-20	Fire Safety Analysis
C-21-21	Threaded Fastener Data
C-21-22	Welding Documentation
C-21-23	Welding Inspection Plan
C-21-24	Brazing Documentation
C-21-25	Corrosion Control Plan
C-21-26	Wire and Cable Data and Specifications
C-21-27	Software Quality Assurance Plan
C-21-28	Corrision Protection Concept
C-21-29	Surface Preparation for Bonding or Painting
C-21-30	Cable List for high-temperature Applications

22 INSPECTION AND TESTS

22.1 INSPECTION

22.1.1 It is the intent of these Specifications that inspection of the car and its components be the responsibility of the Contractor and the Manufacturers, and that inspections be performed at the plants of the Contractor and the Manufacturers so that corrections can be made under factory conditions.

22.1.2 Metra shall have one or more duly authorized inspectors in the Contractor's plant or any sub-contractor's plant to check on and review all details involved in the construction of the cars and to be responsible for engineering liaison between Contractor and Metra and for approval of designated changes as necessary.

22.1.3 The Contractor shall provide adequate work space and provide digital access to all non-proprietary of all designs and drawings in the latest released revision, and testing facilities, as necessary for execution of representative's inspection.

22.1.4 The scheduling of Metra personnel for station inspection and in-process testing shall be done in a timely fashion, with not less than 24 hours notice (written or oral) being given by the Contractor. Requests for weekend coverage shall be made only when absolutely necessary. Such requests must be made in writing by 3:00 PM of the preceding Thursday and must contain eight (8) hours of inspection and/or test work for Metra personnel.

22.1.5 The Contractor's gauges and other measuring and testing devices shall be made available for use by Metra to verify that the cars conform to all specification requirements. If necessary, the Contractor's personnel shall be made available to operate the devices and to verify their condition and accuracy.

22.1.6 Inspection stations shall be at the best locations to provide for the work contents and characteristics to be inspected. Stations shall provide the facilities and equipment to inspect structural, electrical, pneumatic, and other components and assemblies for compliance with the design requirements. Stations shall also be at the best locations to inspect or test characteristics before they are concealed by subsequent fabrication or assembly operations. Metra reserves the right to establish as many inspection stations it deems necessary. Metra also reserves the right to conduct such inspections independent of the manufacturer's representative or with a restricted number of the Contractor's personnel.

22.1.7 The presence of Metra's representative in the plants of the Contractor shall not in any way supplant the Contractor's own inspection nor lessen the responsibility of said Contractor in respect to meeting all requirements of these Specifications.

22.1.8 Metra shall have the right to reject any design, workmanship or material which does not conform to this specification, approved CDRLs and applicable standards and regulation, to the design of the Contractor or any subcontractor supplying materials or components to the Contractor, or to these Specifications. Any such rejection shall be corrected by the Contractor according to the specifications and drawings.

22.1.9 Inspections of the first article produced, of certain major components and assemblies shall be made at the Manufacturer or Subcontractor source or at the Contractor's shop. The Contractor shall notify Metra at least ten (10) working days in advance of the date on which inspection by representatives of Metra may be made, of the first article produced at the source plant or Contractor's shop, of the following components and assemblies:

22.1.9.1 List of FAI (First Article Inspection) items

22.1.9.1.1 Carbody shell
22.1.9.1.2 Driver's Desk Pre-Assembly Unit
22.1.9.1.3 Windshield and Windows (FRA Type I and Type II)
22.1.9.1.4 Truck Frame / Truck Bolsters / Spring Plank (if used)
22.1.9.1.5 Wheel and Axle Assemblies
22.1.9.1.6 Traction Motor / Gear Unit
22.1.9.1.7 Truck Assembly
22.1.9.1.8 Couplers, and Draft Gear Systems
22.1.9.1.9 Wheel Slide Control System, if equipped
22.1.9.1.10 Air Brake System
22.1.9.1.11 Passenger Seats
22.1.9.1.12 Cab Seats
22.1.9.1.13 HVAC System, Controls and Temperature Controls
22.1.9.1.14 Lighting System
22.1.9.1.15 Communication System
22.1.9.1.16 Electrical Panels
22.1.9.1.17 Converter, Overvoltage Limiter, Batteries and Onboard Charging System
22.1.9.1.18 APS
22.1.9.1.19 Front Pilot and Snowplow (if equipped)
22.1.9.1.20 Exterior Passenger Door System
22.1.9.1.21 Interior Passenger Door System
22.1.9.1.22 Alerter / Speedmeter / Overspeed
22.1.9.1.23 Event Recorder System
22.1.9.1.24 DVR System
22.1.9.1.25 PTC System
22.1.9.1.26 Windshield wipers
22.1.9.1.27 Floors
22.1.9.1.28 Mobility Aid Lift
22.1.9.1.29 (deleted)
22.1.9.1.30 Toilet System
22.1.9.1.31 Wall Panels

Metra may add additional components/systems in mutual agreement with the Contractor and latest by end of the FDR phase.

22.1.10 The Contractor shall notify Metra at least twenty (20) working days prior to completion of the first trainset at which time a sample car inspection will be made at the plant of all parts and performance, including such running tests as can be made at the Contractor's plant. All clearances and dimensions shall also be checked.

22.1.11 Representatives of the manufacturers and subcontractors, and any others, Contractor or Metra feels are necessary, shall be present at the sample car inspection at Contractor's shop.

22.1.12 Metra's Chief Mechanical Officer, Program Manager, Project Manager or their duly authorized representative shall be authorized to release the cars for delivery and shall be authorized to approve the pre-delivery acceptance tests per special conditions section 2.5

(delivery and acceptance).. Upon request to the quality assurance supervisors, Metra inspectors shall have access to the Contractor's quality assurance files related to this procurement. These files shall include non-proprietary drawings, assembly procedures, , parts lists, inspection processing and reports, and record of defects.

22.1.13 All requests from regulatory and other agencies to inspect any of the work shall be made through Metra rather than directly to Contractor.

22.1.14 Inspection costs incurred by Metra shall be borne by Metra, and no provision for such costs shall be made by Contractor in its proposal price.

22.2 TESTS

22.2.1 The Contractor shall perform all tests specified herein unless the Contractor can furnish test reports acceptable to Metra which indicate that the equipment furnished under this contract is identical to equipment which has been tested for the same application and that these tests demonstrate compliance with the requirements of these specifications.

22.2.2 The Contractor shall prepare and submit a Master Test Plan to Metra for review and acceptance. **[CDRL C-22-01]** It shall be the Contractors responsibility to prepare a test plan, which includes all necessary testing to prove compliance with all requirements of this Specification.

22.2.3 The Contractor and his subcontractors may, at their option, conduct additional tests as part of their Quality Assurance program.

22.2.4 Unless indicated otherwise, all costs associated with any of the tests performed shall be borne by the Contractor. In the event of failure to meet the specification requirements in any test, the Contractor, at his expense shall make the necessary correction and rerun the test in its entirety (again at his expense). The Contractor shall give at least a twenty (20) working day notice to Metra prior to the start of any test.

22.2.5 The cost for train crews and alike used to perform pre-qualification testing and witness testing shall be borne by Metra for the first set of such tests. For any re-testing required by the Contractor, Metra may invoice the Contractor for such services.

22.2.6 The Contractor shall prepare detailed procedures for all tests described herein. Each procedure shall be submitted to Metra for review and approval not less than sixty (60) calendar days prior to the first test. **[CDRL C-22-02]**

22.2.7 The Contractor shall provide a written report of each in-process test, including non-proprietary test data, to Metra. In the case of tests which are performed on all trainsets or all components, the report of tests shall be included in the appropriate car history book. All testing shall be for this contract. (Previous test reports not accepted). Pass/Fail conclusions must be stated in each test report.

22.2.8 QUALIFICATION TESTS (One Time Tests)

22.2.8.1 Metra may add additional qualification tests dependent upon final design of the car.

22.2.8.2 The first truck frame and bolster shall be stress tested under load conditions to approximate the conditions to be encountered in service (including impact loads, curving forces

and braking forces). A minimum of fifty (50) strain gauges shall be used per truck type (two truck types = total one hundred (100) strain gauges). Strain gauges shall be located based on stress calculations, stress-coat testing and previous experience. The evaluation shall be done according to EN13749. Test results and reports from previous projects can be used. Metra shall be advised at least twenty (20) days prior to this test.

22.2.8.3 The car body structure shall be tested compliant to 49 CFR Appendix G to Part 238, EN 12663-1 (vehicle category P-II) and EN 15227 (vehicle category C-I). Test results and reports from previous projects can be used as a reference. The analysis and testing concept shall be reviewed and approved by Metra. [CDRL C-4-02].

22.2.8.4 The Contractor shall submit a test procedure [CDRL C-4-02] and a stress analysis of the carbody structure prior to commencing manufacture of any carbody structural parts in accordance with APTA Standard SS-C&S-034-99, Rev. 2, Sections 7.1 to 7.3 or in accordance with 49 CFR Appendix G to Part 238 - Alternative Requirements for Evaluating the Crashworthiness and Occupant Protection Performance of Tier I Passenger Trainsets requirements. The stress analysis shall be used to design the car structure to obtain the lightest weight vehicle possible within the criteria set by these specifications.

22.2.8.5 An electric heating system test (Cold Room Test) shall be conducted on a single car to demonstrate continuous operation and specification compliance of the heating system under the extreme ambient environment for at least eight (8) hours continuous. The test chamber shall be capable of maintaining any temperature from 50oF to -20oF for this test. Electrical power consumption shall be recorded.

22.2.8.6 An air conditioning (Hot Room) Test shall be conducted on a single car to demonstrate continuous operation and specification compliance of the air conditioning and ventilation system under extreme ambient environment for at least eight (8) hours continuous. The test chamber shall be capable of maintaining any temperature from 110oF to 70oF and a relative humidity of 30% to 90%. Electrical power consumption shall be recorded.

22.2.8.7 An air flow test shall be conducted with all of the car's doors and windows closed and the ventilation system operating at normal capacity. Total Fresh Air Flow, Total Return Air Flow and Pressurization shall be recorded:

22.2.8.8 In conjunction with both the Hot Room and Cold Room the mobility aid lift (if equipped) shall be tested to verify operation at extreme temperatures.

22.2.8.9 The intensity of the various lighting systems, including emergency lighting, shall be measured and verified with the illumination levels specified herein.

22.2.8.10 The sound levels in the cab and in the passenger seating area shall be measured and verified with the levels specified herein. Tests shall be conducted with all systems running. Tests shall be run both statically and as part of a running test.

22.2.8.11 In addition, an air brake system performance test ~~of a six-car consist,~~ shall be conducted on Metra property to demonstrate compliance with specified braking performance parameters and to verify system design and component interaction characteristics. Testing shall be scheduled at times convenient for Contractor and Metra jointly. If equipped, a wheel slide system test shall be performed. In order to provide a test of the operation of the wheel slide protection system under actual operation conditions, facilities shall be provided for a test of this system during the road brake tests. Wheel slides shall be induced by apparatus installed on the vehicle that will spray a water soap solution on the track ahead of the lead wheels on each truck.

22.2.8.12 A curve negotiating and clearance test shall be conducted on coupled cars and the cars shall successfully pass this test to comply with the requirements as described in Section 3.2.

22.2.8.13 Metra shall request to verify conformance to the ride quality requirements, one of the first trainsets shall be subjected to ride quality road tests. At a minimum, the ride quality tests shall consist of testing of one or more cars on minimally compliant track that conforms with all FRA track standards for the classes of track over which the cars are designed to operate. The car or cars shall also be tested on a major segment of track over which the cars are intended to operate in revenue service, making all local stops while operating at normal scheduled speed, under AW0 and AW1 load conditions. The Contractor shall submit a Ride Quality Testing Plan for submittal to Metra for review and approval, specifying the start and end points, speeds, test methodology, measurement parameters and criteria, and method of instrumentation for the ride quality tests. Results from previous ride quality tests that closely simulate Metra's revenue service environment may, at the sole discretion of Metra, be accepted in lieu of additional ride quality testing.

22.2.8.14 Instrumentation capable of measuring and charting the magnitude and frequency of the vertical and lateral shocks expected, up to 1.00 g (0.04 oz) and 0.5 to 50 Hertz, shall be provided and operated by the Contractor, who shall reduce the raw data for presentation to Metra. Sensing units shall be located on the car floor above the intersection of the car longitudinal center line and each truck transverse center line. Weights used in simulating the AW1 load, as well as their loading and unloading, shall be provided by the Contractor.

22.2.8.15 In the event, the dynamic behavior of the trainset is non-compliant in any respect with requirements, the Contractor shall submit to Metra within 30 calendar days, a program containing root cause analysis analysis of the problem and a course of action for its correction. If Metra approves the analysis and corrective measures, those corrective measures shall be made effective on the pilot trainsets within 90 calendar days at the expense of the Contractor, the car shall be retested, and if the measures are successful, they shall be applied to all trainsets. If not, the analysis and correction steps shall be repeated, resubmitted and retested until the requirements are met.

22.2.8.16 EMI/EMC Test.

Contractor shall develop and submit to Metra for review and approval an Electromagnetic Compatibility Control Plan (EMCCP) which describes the Contractor's organization to achieve EMC in accordance with APTA PR-E-S-010-98,latest revision. **[CDRL C-22-03]** The Contractor shall conduct and document all plan requirements to the integrated vehicle, all subsystems, and suppliers. The Contractor shall ensure that all equipment, both individually and as part of the trainset assembly, complies with the EMC requirements. The EMCCP shall address all requirements in the Specification and in 49 CFR 238 including scope, purpose, project organization, schedule deliverables, EMC design reports, EMI Safety Analysis, and emissions limit test procedures and plans and testing. The plan shall include requirements for system integration and cover all EMC critical components and electronic subsystems for each vehicle type.

22.2.8.17 List of Qualification Tests

Metra may add additional qualification tests dependent upon final design of the car.

22.2.8.17.1 Carbody / Parts Qualification
22.2.8.17.1.1 FRA/APTA Carbody Structural Tests
22.2.8.17.1.2 APS System
22.2.8.17.1.3 Battery System
22.2.8.17.1.4 Propulsion System
22.2.8.17.1.5 Truck Assembly
22.2.8.17.1.6 ADA Lift

22.2.8.17.2 Completed Car Qualification at Manufacturer
22.2.8.17.2.1 Hand Brake / Parking Brake Holding Force Measurement
22.2.8.17.2.2 HVAC Air Flow & Pressurization Measurement
22.2.8.17.2.3 Filtration System
22.2.8.17.2.4 Hot Room Test including Parts functions
22.2.8.17.2.5 Cold Room Test including Parts functions
22.2.8.17.2.6 Weighing -each type
22.2.8.17.2.7 Static Sound Level
22.2.8.17.2.8 Lighting -Intensity Level Measurement
22.2.8.17.2.9 Clearance Check

22.2.8.17.3 Qualification Test on Metra Property / Metra Track
22.2.8.17.3.1 Curve Negotiation
22.2.8.17.3.2 Dynamic Sound Level (Noise Measurement)
22.2.8.17.3.3 Riding Quality Test
22.2.8.17.3.4 Air Brake Test
22.2.8.17.3.5 Curve Clearance Test
22.2.8.17.3.6 Emergency Lighting Test – Battery Cycle & Capacity
22.2.8.17.3.7 Cab Signal Qualification
22.2.8.17.3.8 TIMS/ACORN Qualification
22.2.8.17.3.9 Acceleration/Deceleration
22.2.8.17.3.10 EMI/EMC
22.2.8.17.3.11 PTC
22.2.8.17.3.12 DVR
22.2.8.17.3.13 Battery Charging / Discharging

22.2.9 IN-PROCESS TESTS (All Cars)

22.2.9.1 Each car shall successfully pass the following tests conducted in accordance with an approved test procedure:

22.2.9.2 Car body water tightness tests shall be conducted on the car body shell and the completed car. The shell test is intended to demonstrate water tightness or car body construction before application of thermal insulation and finish panels. Complete car test shall demonstrate water tightness of finished car simulating passage through rainstorm at maximum speed of 79 MPH.

22.2.9.3 Air brakes shall be statically tested per FRA Regulations to verify all functions of the brake system under all conditions (service, emergency, release, and charging, function, conductor's valves, and all other combinations).

22.2.9.4 All circuits, including locomotive and car control elements, are to be tested for continuity, grounds, voltage drop, and function. Tests shall be conducted individually as well as simultaneously. Megger and high potential tests will be conducted on all circuits and equipment as appropriate

22.2.9.5 Functional tests of the following systems shall be conducted to demonstrate compliance with these specifications. Metra may add additional functional tests:

22.2.9.5.1 Communication System
22.2.9.5.2 Air Conditioning
22.2.9.5.3 ADA System
22.2.9.5.4 Heating System
22.2.9.5.5 Emergency Lighting System
22.2.9.5.6 Pressurization
22.2.9.5.7 Door operation
22.2.9.5.8 Handbrake/Parking Brake
22.2.9.5.9 Anti-Freeze System
22.2.9.5.10 Video System (cab cars)
22.2.9.5.11 Cab Signal System (cab cars)
22.2.9.5.12 Alerter/Event Recorder (cab cars)
22.2.9.5.13 Locomotive Control (cab cars)
22.2.9.5.14 Headlights, Ditch lights, Oscillating light, Marker lights (cab cars, includes aiming of headlight & ditch lights)
22.2.9.5.15 Horn Testing per 49 CFR Part 229.129 (cab cars) using Metra Horn Sound Level Test Form
22.2.9.5.16 Emergency Signage for Egress/Access of Passenger Rail Equipment per latest revision of APTA Standard PR-PS-S-002-98 (Batch of Cars) Batteries and Battery Charger (& LVPS on cab cars)
22.2.9.5.17 Positive Train Control System (cab cars)
22.2.9.5.18 Emergency Lighting Standards per latest revision of APTA standard PR-E-S-013-99 (Batch of Cars) using Metra Form RC100212
22.2.9.5.19 LLEPM Standards per APTA Standard PR-PS-S-004-99, latest revision
22.2.9.5.20 Wheel Slide System (If Equipped)
22.2.9.5.21 Electrical Function
22.2.9.5.22 Water System/Toilet System
22.2.9.5.23 TIMS
22.2.9.5.24 Trainline
22.2.9.5.25 APS System
22.2.9.5.26 Propulsion System
22.2.9.5.27 Air Supply System
22.2.9.5.28 Door System
22.2.9.5.29 Truck System
22.2.9.5.30 Battery System
22.2.9.5.31 Carbody Dimensional Measurement
22.2.9.5.32 Software / Firmware verification

Metra may add additional functional tests dependent upon final design of the car.

22.2.10 POST-DELIVERY TESTS: CONDITIONAL ACCEPTANCE

22.2.10.1 Metra may add additional post-delivery tests.

22.2.10.2 In accordance with 49 CFR Part 238.111 Metra will conduct acceptance tests on each delivered car. Metra shall complete these tests completed within fifteen (15) calendar days after notice of fitness for testing is issued and shall be conducted in accordance with written test plans. These tests will also identify defects that have become apparent between the time of the car's release and delivery to Metra. The post-delivery tests shall include visual inspection and operations. Generally, post-delivery test shall apply criteria that are similar to the criteria applied in an analogous IN-PROGRESS test (if any). However, Metra reserves the right to conduct any additional test to ensure that the completed cars have attained the desired quality and have met the requirements of these specifications.

22.2.10.3 Reports covering Conditional Acceptance testing shall be prepared by the Contractor.

22.2.10.4 Tests will include, but are not limited to the following:

22.2.10.4.1 Communication Equipment (including Information Systems)
22.2.10.4.2 Trainline Compatibility
22.2.10.4.3 HVAC System Functions
22.2.10.4.4 ADA System Functions
22.2.10.4.5 Running Tests
22.2.10.4.6 Cab Signal Functional Test
22.2.10.4.7 PTC Functional Test
22.2.10.4.8 TIMS/ACORN Functional Test
22.2.10.4.9 Door Functional Test

Metra may add additional post-delivery tests.

22.3 CONTRACT DELIVERABLES REQUIREMENTS LIST

CDRL	Title
C-22-01	Master Test Plan
C-22-02	Test Procedures
C-22-03	Electromagnetic Compatibility Control Plan