19 PAINTING, SIGNAGE, AND EXTERIOR

19.1 The decorative treatment (interior and exterior) of all cars shall be agreed upon between Contractor and Metra. A signage plan shall be submitted to Metra for review and approval. **[CDRL C-19-01]** Edge sealer shall be used on all exterior vinyl decals.

19.2 EXTERIOR

19.2.1 Parts under the floor or attached to the car which are constructed of metal other than stainless steel, such as underfloor equipment and trucks (except for wheel treads, axles, rubber parts, etc.), shall receive a minimum of one (1) coat of primer and a minimum of one (1) color coat of paint.

19.2.2 The carbody exterior shall be painted with an automotive quality urethane paint system consisting of primers, color basecoat(s), and clear topcoat as approved by the Customer. The paint shall provide a minimum of 5-year service life without failure or loss of adhesion. The paint shall retain a minimum of 75% of its original gloss for the duration of its expected service life considering normal exposure to the environment and the Authority's car wash system. All paint and primer used shall be lead free.

19.2.3 The car number shall be applied to in an approved location to exterior side of car. All numbers shall be ten (10) inches high, black vinyl film. The style of the numerals shall be as agreed between Contractor and Metra.

19.2.4 A black eight inch RTA logo per drawing M-272 shall be applied to an approved location of the car exterior.

19.2.5 A sign with the car number, 2" high shall be provided on each body end of trainset car, both inside and outside, located where passengers/crew can see and to be approved by Metra.

19.2.6 All cars shall be provided with two "Owner Plates" per Metra drawing M-318. The plates shall be located to the left of each side entrance doorway when facing car from the exterior, on the skirting.

19.2.7 The water filling boxes located under the floor shall be marked by use of vinyl signs located on the side sill adjacent to the box or valve location.

19.2.8 All valves on the underside of car shall be tagged with a stainless steel plate having depressed letters. The plates shall be securely fastened to a suitable bracket adjacent to the valve.

19.2.9 An instructional decal for emergency door operation per APTA and FRA requirements shall be applied on the exterior of the car where applicable.

19.2.10 An instructional decal for removing windows in an emergency per APTA and FRA requirements shall be applied on the car body below each emergency ingress/egress window equipped with a pull grip on filler strip.

19.2.11 A decal with the words "Step Down Ahead" per drawing M-551 shall be applied on the exterior of each end door adjacent to the window, if needed.

19.2.12 A decal with the words "Door Opens Quickly" per drawing M-359 shall be applied on each exterior lift switch cover.

19.2.13 A black letter "F" per drawing M-286 shall appear in an approved location on lower deadlight or side sill, directly under the side cab windows of cab control cars, visible to a person on the ground. It shall be applied to resist peeling in the normal operating environment.

19.2.14 The nose of the cab control cars shall receive alternate red and white 12 inch wide reflective striping arranged in 45 degree diagonal pattern. Final styling shall be approved by Metra.

19.3 INTERIOR

19.3.1 All decorative interior surfaces shall not require painting except where an approved application of interior finish material requires painting, as the application dictates. The material shall be primed and finished with two coats of approved synthetic enamel to commercially acceptable standards.

19.3.2 On all cars, carbon steel parts located in the electric lockers shall be galvanized or prime painted prior to installation.

19.3.3 Electrical lockers shall be finished inside with a top coat of white or light colored insulating paint. The edges of grille cutouts and hardware located on the inside surfaces of the locker doors shall be painted with aluminum colored synthetic enamel.

19.3.4 Two (2) Contractor's nameplates may be provided in the car. These shall be located above the passenger side entrance openings in an approved location.

19.3.5 The car number shall be applied in an approved manner, using two (2) inch high numbers near the car Contractor's plate, over each set of side entrance doors inside the car.

19.3.6 All system components shall be labelled in a way that they last the lifetime of the vehicle. The labelling shall be part of the final design review.

19.3.7 The electrical cabinets shall be labeled with the following information:
- Cabinet Type
- Car Type
- Revision Index of the electrical schematics

High contrast printed labels can be used for this purpose.

19.3.8 Four (4) stainless steel "No Smoking Please" signs, per drawing M-384 shall be provided in locations approved by Metra.

19.3.9 (deleted)

19.3.10 The cover of the emergency tool cases shall be labeled with appropriate access instructions. An "Illinois Law" decal, per drawing M-1186 shall be placed adjacent to each emergency tool case. The perimeter of the emergency tool cases shall be marked with APTA compliant HPPL material. In addition, tool case signage and locator decals manufactured of APTA compliant HPPL material shall be provided.

19.3.11 A "Priority Seating" decals per drawing M-1681 and M-1682 shall be provided in an approved location on each side of the car at the ADA positions.

19.3.12 Electric Locker Doors shall be labeled "Danger High Voltage" vinyl decal

19.3.13 A decal with the words "Emergency Exit" per drawing M-310 shall be provided at each emergency window per APTA & FRA requirements

19.3.14 The following decals of photo luminescent material complying with FRA requirements and APTA standards shall be provided:

19.3.14.1 Exit, per drawing M-1145 above each end door

19.3.14.2 Emergency sash operating instructions on each emergency sash, braille sign shall be applied in addition

19.3.14.3 Pictorial emergency sash operating instructions adjacent to each emergency sash

19.3.14.4 Instruction for opening side entrance door in an emergency. Braille sign shall be applied in addition to.

19.3.14.5 Emergency Exit Route Evacuation Maps (Signs) and shall be provided and constructed of HPPL material per APTA requirements.

19.3.15 One (1) "Emergency Brake Valve" decal and one (1) "Danger Do Not Touch" decal, shall be applied adjacent to each B-3-B valve.

19.3.16 Two (2) emergency exit placards shall be applied. Placard graphics and location are subject to Metra's approval.

19.3.17 Two (2) International Handicap Symbol Decals shall be applied where applicable.

19.3.18 The following items shall be labeled with an approved vinyl decal:

19.3.18.1 Overhead Heaters
19.3.18.2 Air Filters
19.3.18.3 Electrical Lockers (labeled with designation only).

19.3.19 "WARNING" decals, per drawing M-537 shall be applied where applicable.

19.3.20 A "Caution Please Do Not Lean On The Doors" decal, per drawing M-532 shall applied to the inside surface of each side loading door leaf, just below the door window.

19.3.21 Low-Location Exit Path Marking (LLEPM), complying with APTA-SS-PS-004-99 shall be provided using High Performance Photo Luminescent Material.

19.3.22 End doors, passenger compartment doors and entrance doors shall be marked in accordance with the latest revision of APTA Standard SS-PS-004-99. The entire arrangement shall be subject to Metra's approval.

19.3.23 On cab control cars, all controls and indicators shall be labeled in an approved manner.

19.3.24 On cab control cars, a stainless steel nameplate with the wording "Emergency Brake Valve", etched and painted red, shall be provided adjacent to the emergency brake valve on the observer's side of the control station.

19.3.25 A stainless steel sign with the car number, 2" high, laser etched and painted black, shall be provided in an approved location in the cab.

19.3.26 A "Please Do Not Put Personal Belongings In Front Of Door" sign, per drawing M-225 shall be applied in an approved manner to passenger compartment side of each cab door and end doors.

19.3.27 A "Lavatory" sign, per drawing, M-397, shall be applied to the toilet room door in an approved manner.

19.3.28 A digital display sign shall be used on the exterior of the car body to display the "Metra" logo and other advertisements. Display shall be easily programmable and link to the cars GPS, passenger counting, and infotainment system. **[COPL CO-19-01]**

19.4 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-19-01	Signage Plan

19.5 CONTRACT OPTIONAL PROPOSAL LIST

COPL	Title
CO-19-01	Exterior Digital Display Sign

20 ENVIRONMENTAL EFFECTS

20.1 GENERAL REQUIREMENTS

20.1.1 The Contractor shall ensure that the trainset and its equipment are designed and built so that the noise criteria outlined in this section of the specifications are not exceeded. Methods shall be incorporated into the car design to attenuate equipment noise which does not meet the noise level limitations indicated.

20.1.2 Unless otherwise stated, noise herein shall mean a sound pressure level as defined in the latest revision to American National Standards Institute (ANSI) S1.4 for General Purpose Sound Level Meters. All noise levels listed are in decibels referred to 0.0002 microbar as measured on the "A" scale of a standard sound level meter, abbreviated "dbA" respectively. Unless otherwise specified, the "slow" meter scale shall be used.

20.1.3 Noise criteria specified are based on measurements taken in essentially a free field environment, as per the U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, D.C., Railroad Noise Emission Standards, Title 40, Part 201, Subpart C, entitled "Measurement Criteria". The free field environment, such as outdoors, will be away from any reflective surfaces other than ballast and tie track bed and the adjacent ground. The subject cars shall comply with any FRA noise criteria which may be in effect at the time of construction.

20.1.4 For tests and measurements, the Contractor shall use a sound level meter which complies with the requirements of the latest revision of ANSI S1.4, Specifications for General Sound Level Meters.

20.2 AUDIBLE NOISE REQUIREMENTS

20.2.1 The Contractor shall verify to Metra that all cars built to the specification set forth herein, meet the requirements for noise abatement of this section. Sound insulation should be a continuous improvement task in the design of new vehicles.

20.2.2 An audible noise proposal shall include estimated noise levels at a location one (1) foot away from any car body surface, while the car is parked, without any passengers on board, and all systems operating (including the air conditioning system at maximum capacity) and estimated interior noise levels at a location one (1) foot away from any car body surface, excluding the return air grill, while the car is operating at 65 MPH without any passengers on board, and all systems operating (including air conditioning system at maximum capacity). In addition, Proposal shall include documentation demonstrating the ability to have designed and built passenger Cars with low interior noise levels (and improvements over specified maximums). **[PDRL P-20-01]**

20.2.3 The subject cars shall comply with any FRA noise criteria which may be in effect at the time of construction, including, but not limited to, 49 CFR 210 and 49 CFR 229.

20.2.4 Builder shall develop and submit for Metra's approval, the procedures for conducting this test. **[CDRL C-20-01]**

20.2.5 Verification exterior sound level measurements shall be taken at one hundred (100) feet perpendicular to the longitudinal centerline of the car, on both sides of the car, at a point five (5) feet above top of rail, while the car is parked, with all systems operating (including the air conditioning system at maximum capacity). The noise levels shall not exceed 70 dbA.

20.2.6 Interior noise levels shall not exceed 65 dbA at a minimum at a location one (1) foot away from any car body surface, while the car is parked, without any passengers on board, and all systems operating (including the air conditioning system at maximum capacity). Metra would prefer that that noise levels inside the compartment not exceed 60dBA in a steady and/or steady but intermittent sound level classification and a preference that noise levels not exceed 70dBA in a time varying and impulsive sound classification.

20.2.7 Below is an example of sound classifications and operational activities:

20.2.7.1 Steady sound levels (such as from onboard HVAC equipment).
20.2.7.2 Steady, but intermittent sound levels (such as from consist locomotive).
20.2.7.3 Time varying sound (such as trains passing on an adjacent track, wheel squeal through curved track, movement over switches, frogs and at grade crossings).
20.2.7.4 Impulsive sound signals (such as consist stopping, starting and coupling).

20.2.8 Interior noise levels shall not exceed 70 dbA at a location one (1) foot away from any car body surface, with track quality compliant to international standard ISO 3095:2013 Section 6.2.5 and to ISO 3095:2013 Section 6.3.6, excluding the return air grill, while the car is operating at 65 MPH without any passengers on board, and all systems operating (including air conditioning system at maximum capacity).

20.2.9 The passenger boarding/alighting area is to be included as part of the car interior for audible noise criteria. The noise level for the passenger boarding/alighting area (with the car standing and all systems operating) shall not exceed 75 dbA.

20.2.10 All equipment shall be designed to eliminate rattling and resonance at all speeds up to the maximum running speed by the use of damping, gaskets, resilient mounts or similar methods. Included in this requirement, but not limiting the generality thereof, are the following accessories:

20.2.10.1 Windows
20.2.10.2 Seats
20.2.10.3 Wiring
20.2.10.4 Ventilating Ducts
20.2.10.5 Doors
20.2.10.6 Parcel Racks
20.2.10.7 Light Fixtures
20.2.10.8 Stanchions
20.2.10.9 Partitions
20.2.10.10 Fire Extinguishers
20.2.10.11 Panels
20.2.10.12 Air Conditioning Units

20.3 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-20-01	Audible Noise Proposal

20.4 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-20-01	Noise Level Test Procedure

21 MATERIALS AND WORKMANSHIP

21.1 GENERAL REQUIREMENTS

21.1.1 Workmanship and Quality shall conform to the best manufacturing practices in all respects. All work shall be performed by qualified personnel, using correct tooling and procedures, and be properly trained and skilled in the tasks they will be performing.

21.1.2 Surfaces exposed to passengers, crew, or maintainers shall be smooth and free of burrs, sharp edges or corners, and dangerous protrusions. The vehicle design shall avoid pinch points, tripping hazards, snagging points, water traps, and debris accumulation points.

21.1.3 Car body structural parts that are permanently covered and concealed after assembly shall not be made of copper, brass, bronze, silver, or nickel.

21.1.4 Foreign matter, such as shavings, chips, etc., shall be completely removed from all parts of the vehicle, its components, assemblies and subassemblies, whether hidden or exposed.

21.1.5 Materials for the construction of the vehicle shall be in accord with the stated specification or cited standard, unless the Contractor obtains Metra's approval for a substitution in writing. Alternate standards may be proposed. Approved alternative standards in previous US projects for the same product platform are applicable if the contractor can provide a standard comparison matrix..

21.1.6 All materials shall perform safely and satisfactorily within their operating environment and in accordance with their intended function.

21.1.7 Whenever a commercial material is not covered by a specification or standard, the Contractor shall identify the material by the commercial trademark, name, and address of the supplier. The Contractor shall submit a description, and the technical data specifications, of the material composition for approval. The Contractor shall maintain records that trace all materials to their manufacturers and shall verify compliance with quality standards specified or cited in these Provisions.

21.1.8 Single-source materials shall not be permitted unless approved by Metra. Approval shall be determined on a case-by-case basis. Specification equivalency and benefit data for any substitution to a cited standard shall be submitted to Metra for review and approval.

21.1.9 The following materials shall not be used in the construction of the vehicle:

21.1.9.1 PVC
21.1.9.2 Asbestos
21.1.9.3 Cadmium (except for battery)
21.1.9.4 Lead (except for lead solder on the printed circuit boards)
21.1.9.5 PCBs
21.1.9.6 Carcinogenic materials as listed by current Publication of American Conference of Governmental Industrial Hygienists (ACGIH)
21.1.9.7 Materials listed in 29 CFR 1910.19
21.1.9.8 All CFC and HCFC compounds except R-22 and R134a
21.1.9.9 Chlorinated fluorocarbons that may cause environmental problems or handling hazards
21.1.9.10 Materials that, in their normal installed state, emit products that are known to be toxic or irritants

21.1.9.11 Materials that, in their normal installed state, emit products that are known to be toxic or irritative

21.1.9.12 Beryllium

21.1.9.13 In addition, Metra does not accept other restricted materials (restricted due to safety, environmental, and/or regulatory reasons) as well as materials that require stringent Personal protective equipment (PPE) such as face protection, special cloths during handling, removal and/or application by Metra. On a limited and case by case basis, Metra may approve the use of such material and in these cases the Contractor shall be required to submit a waiver in writing to Metra for approval prior to any use of such material. The Contractor's waiver request shall include the justification(s) for using the material, total weight of the material, location(s) and distribution on the vehicles, material safety and data sheets, and current test reports. In addition, the Contractor shall submit a letter from an independent material safety professional indicating their review of the Contractor's waiver request and their professional conclusions regarding the request and the safety, environmental and regulatory implications involved for Metra throughout the life of the vehicles.

21.1.10 The Contractor shall keep on file Safety Data Sheets (SDS) for all chemical materials (paints, solvents, adhesives, caulking, etc) used in the manufacture of the vehicle, and provide SDS information as requested by Metra for any additional material in question. A copy of each SDS shall be submitted to Metra for review and approval.

21.1.11 The Contractor shall keep a running list of all materials used in the vehicle in matrix format (matrix shall contain; material name, specification or material ID number, application, approval status, correspondence number, etc.). The Contractor shall submit this matrix along with material certifications and material property test reports to Metra for review. **[CDRL C-21-01]**

21.1.12 The Contractor shall submit for approval joining and fastening data, specifications, and standards for all types and methods of fastening and joining used.

21.1.13 All name and rating plates shall be permanently attached using mechanical fasteners. Exceptions may be made for small components and circuit boards.

21.1.14 All materials shall be new and of recent manufacture. Material, which is found to be defective and subsequently repaired, cannot be used unless specific approval is granted by Metra.

21.1.15 All materials used shall be inherently corrosion resistant or be suitably finished with a corrosion resistant finish to minimize corrosion and degradation of appearance or function.

21.1.16 Materials that require overhaul/reconditioning periodically shall be available in the United States and overhaul/reconditioning shall be performed in the United States. All repair for major electric/electronic equipment shall be completed within one (1) month.

21.2 STORAGE OF MATERIAL

21.2.1 All stored material subject to corrosion shall be adequately protected by waterproof covers, coatings, or packaging to prevent damage.

21.2.2 Equipment covers, cable entrances, and openings shall be suitably closed to prevent ingress of water or dirt.

21.2.3 All dated material shall have the expiration date clearly marked. Expired material shall not be used as long as not specifically approved by the material supplier and validated by Metra.

21.2.4 Material or components, which require maintenance during storage, shall be properly maintained per the component(s) manufacturer's instructions. The Contractor shall document such maintenance, and provide these records as requested by Metra. **[CDRL C-21-02]**

21.2.5 Rejected or damaged material shall be clearly marked, dispositioned, and stored separately from all other material.

21.3 STAINLESS STEEL

21.3.1 When used, types and grades of stainless steel shall be stated in all drawings. Material certifications and test reports including chemical analysis, physical properties shall be submitted to Metra. **[CDRL C-21-03]**

21.3.2 Certified copies of test reports covering each coil of steel to be used shall be submitted to Metra by the Contractor. Each test report shall list chemical analysis, physical properties, weight, mill coil number, invoice number, date and mill order number of each coil. For sheet stock, a ladle analysis and single physical property test on each heat and each size shall be made and shall be submitted. **[CDRL C-21-04]** All austenitic stainless steel shall be free from precipitated carbides, and all stainless steel shall be free from scale.

21.3.3 General requirements for stainless steel are:

21.3.3.1 Gauge tolerance (standard for industry)
21.3.3.2 Color and finish (must match samples)
21.3.3.3 Flatness - coil stock (standard mill flatness)
21.3.3.4 Flatness - sheet stock (stretcher level quality)
21.3.3.5 Camber (standard for industry).

21.3.4 Buffing and polishing of stainless steel, if required, shall be done without any use of composition containing iron or iron oxide.

21.4 LOW ALLOY HIGH TENSILE STEEL

21.4.1 High Strength Low Alloy (HSLA) steel structural shapes, plates, and bars shall, as a minimum, conform to the requirements of ASTM A6 or EN10025.

21.4.2 Types and grades of steel shall be stated in each drawing.

21.4.3 Material certifications and test reports including chemical analysis, physical properties shall be submitted to Metra.

21.5 STEEL/STAINLESS STEEL CASTINGS (if used)

21.5.1 The contractor shall provide casting specifications/procedures, requirements, test requirements/methods and acceptable criteria including cast surface and machining surface if steel or stainless castings are used. Metra may add extra requirements before Notice to Proceed (NTP)

21.5.2 Weld repairs of castings shall be allowed, provided that repairs are performed in accordance with an approved written procedure, and by welders qualified to ASTM A488 or ISO

11970. For stainless steel casting, provide written procedure and its justification. The contractor shall provide a standard comparison, if non-US standards will be used.

21.6 ALUMINUM (if used)

21.6.1 When used types and grades of aluminum shall be stated in each drawing. Metra may request the material certification and test report including chemical analysis, physical properties.

21.6.2 Aluminum forgings shall comply with DIN EN 586-1, ASTM B247 or Aluminum Association Standards for Aluminum Mill Products, alloy, and temper 6061-T6. The contractor shall provide a standard comparison, if non-US standards will be used.

21.6.3 Aluminum castings shall comply with EN 1706, ASTM B26, ASTM B85, ASTM B108, or Aluminum Association Standards for Aluminum Mill Products alloy and temper 356-T6, 364-T5, or 356-T6 respectively, and shall be free from blowholes, cracks, shrinkage, and other defects. The contractor shall provide a standard comparison, if non-US standards will be used.

21.6.4 Dissimilar materials such as aluminum and stainless steel may not contact directly. Bolts and nuts, screws or other fasteners used with aluminum alloys shall suitably protected against corrosion. The corrosion protection concept shall be part of a review and approval by METRA. [CDRL C-21-28].

21.7 ELASTOMERS

21.7.1 The Contractor shall submit test reports for mechanical elastomer properties proposed.

21.7.2 Glazing strips for side and end windows shall be molded or extruded Neoprene conforming to ASTM C-542, with ends vulcanized together to form one continuous piece.

21.7.3 Elastomers must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification.

21.8 GLAZING MATERIALS

21.8.1 Glazing materials shall be proposed and approved by Metra. Window glazing facing to outside of car shall meet 49 CFR 238 Part 223. The end door under/next to the cab control room if any, the end door and windshield shall meet 49 CFR 238 Part 223 large impact test with retention.

21.8.2 All material must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification

21.9 WOOD, PLYWOOD, PLYMETAL, COMPOSITE MATERIALS (if used)

21.9.1 Wood

21.9.1.1 Any pieces of wood entering into construction of cars shall be select grade, shall be thoroughly seasoned by air of kiln drying, and shall be dressed on all surfaces to dimensions.

21.9.2 Plywood

21.9.2.1 And All plywood must be exterior "BB" grade, DFPA marked, 100% waterproof bond, formed from Group II wood species for inside finish panels, as described in the American Plywood Association, Specification PS 1-83 (or later revision).

21.9.2.2 Except where used in the construction of plymetal panels, all plywood must be treated to resist decay and mold. Treatment materials must be nontoxic to man and non-corrosive to car body materials.

21.9.3 Metal Faced Plywood – Plymetal

21.9.3.1 The term plymetal refers to metal faced plywood (described above). Whenever the metal surface of a plymetal panel is faced Melamine, it shall be applied in accordance with Section 21.10 of these specifications.

21.9.3.2 The strength evaluation of plywood structures shall follow APA PS1-95 or EN 636 or another standard mutually agreed between METRA and the Contractor.

21.9.3.3 All exposed edges of the panels, drilled holes, fastener heads, openings, or cutouts within the panels shall be waterproofed and sealed with an approved sealant as soon as possible after fabrication, and prior to installation.

21.9.3.4 The overall flatness shall not exceed a maximum deviation of 0.015" per lineal foot, with a maximum of 0.125" deviation of any point on the panel measured from a reference plane taken from any three corners. The overall deviation of the panel thickness shall not exceed 0.031" (1/32").

21.9.3.5 All material must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification.

21.9.4 Metal Faced Composite Materials

21.9.4.1 Metal faced composite materials shall perform ASTM C297, or DIN 6701 testing for boding strength to avoid delamination. A minimum of 6 samples shall be tested each category. The strength of the bonded components including the bonding material has to be strength evaluated according to the material data sheet or the applicable standard in this specification.

21.10 PLATICS (if used)

21.10.1 Thermoplastics

21.10.1.1 Thermoplastic sheet shall be homogeneous and extruded from virgin stock which does not include any regrinding of vacuum formed parts. Color pigments shall be UV stabilized. The color and surface finish of parts, manufactured from this material, shall be approved by Metra prior to a production run of parts. **[CDRL C-21-09]** Finished parts shall be free of waves and quilting. Voids, lumps and contamination shall be no larger than 0.01 in with a maximum of one defect in a 4.0 ft2 area.

21.10.1.2 Thermoplastic materials shall comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 18.16 of this specification, and with the requirements listed in Table 21-3 below:

Table 21-3

Physical Property	Test Method	Performance Requirement Value
Specific Gravity	ASTM D792	1.20 to 1.36
Hardness, Rockwell	ASTM D785	90 to 100, R-Scale
Tensile Strength	ASTM D638	5,500 psi (38 MN/m^2) minimum at 73°F (23°C)
Flexural Modulus	ASTM D790	320,000 psi (2206 MN/ m^2) minimum elasticity at 73°F (23°C)
Flexural Strength	ASTM D790	10,000 psi (68,947.6 kPa) minimum @ 73°F (23°C)
Impact Strength (@ 73°F notched IZOD)	ASTM D256	6.6 foot pounds per inch of notch minimum.
Heat Shrinkage	None	15% maximum, 10 minutes @ 380°F (193°C)
Thickness	None	3/32 inch (2.38 mm) minimum

Independent laboratory test certificates shall be provided stating that the thermoplastic sheet complies with the requirements of the following standards. **[CDRL C-21-10]**

21.10.2 Fiberglass Reinforced Plastics

21.10.2.1 This material shall be laminated polymeric reinforced material. Resins shall be thermosetting, fire-resistant polyester. Fiberglass content by weight shall be 25% minimum unless otherwise specified. Parts may be produced by resin transfer molding, compression molding, vacuum bag molding, open mold hand layup, or other methods approved by Metra..

21.10.2.2 Exposed fiberglass surfaces shall have a smooth matte finish. Embossed surface will be permitted in order to assure that finished surfaces are resin rich to obtain uniform color without visible glass fibers.

21.10.2.3 All material must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification.

21.10.2.4 The Contractor shall submit for approval certificates verifying that reinforced plastic materials comply with the minimum requirements needed for its application. **[CDRL C-21-11]**

21.10.2.5 Pre-test conditioning of test specimens shall conform to ASTM D618.

21.10.3 Melamine

21.10.3.1 Melamine shall be laminated to aluminum sheets. The melamine impregnated, colored papers shall be directly molded to aluminum sheets at a temperature not less than 270 degrees F and at a pressure not less than 1,000 psi. The characteristics shall not be less than that required of general purpose type in NEMA Standard LD-3-2005 (or latest revision). Gloss finish melamine shall not be used unless otherwise approved, and melamine with a rough textured finish is likewise restricted.

21.10.3.2 All material must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification. The Contractor shall submit for approval certificates verifying that bond between the melamine and the aluminum complies with the minimum requirements needed for the application. **[CDRL C-21-12]**

21.10.3.3 Un-backed balanced melamine panels may be used in the car interior. The characteristics shall not be less than that required of general purpose type in NEMA Standard

LD-3-2005 (or latest revision), or EN 438. The contractor shall provide a standard comparison, if non US standards will be used.

21.10.3.4 The bond between the melamine and the aluminum shall meet the minimum requirements needed for the application.

21.11 UPHOLSTERY MATERIAL

21.11.1 Upholstery material for vehicle sears shall be approved transportation grade material and shall be able to be cleaned by at least three widely available commercial industrial cleaning agents that are known to be chemically compatible. The contractor shall propose the material with technical information including physical properties. All material must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification.

21.12 PIPING, TUBING AND PRESSURE VESSELS

21.12.1 Air or hydraulic hose applications shall not be permitted in locations where adequate visual inspections cannot be made. Hose installations shall be located/arranged in such a manner as to prevent accidental cross connections to other hoses located in the same general area.

21.12.2 Hose installations shall be such that kinking, rubbing, straining, and unnecessary swinging are precluded. Routing that requires other piping, or cables, as the sole means of support shall not be accepted.

21.12.3 The Contractor shall perform a leak test on the final air or hydraulic piping system, with all components installed, on each vehicle in accordance with IEC 61133. The Contractor shall submit a copy of the test procedure for approval. **[CDRL C-21-13]** A copy of the test report for each vehicle, including retest reports if appropriate, shall be included with each Vehicle History Book.

21.12.4 Loss of main reservoir air pressure due to cumulative leakage in the entire pneumatic system, not including that required for system functioning, per vehicle, shall not exceed 10 psig in 15 minutes, following a 5-minute settlement period from the point at which the system was fully charged and the air compressor was shut off.

21.12.5 The Contractor shall submit piping, tubing, and pressure vessel specifications and data for approval. **[CDRL C-21-14]**

21.12.6 Piping and Tubing

21.12.6.1 Piping and tubing shall be adequately supported at least every 24 inches [610 mm] throughout its length as practicable and at connections and must not interfere with the removal of or access to other components. A minimum clearance of 3 mm [0.125 in] shall be maintained on all piping and tubing used in the vehicle.

21.12.6.2 Attachment shall be by securely fastening with elastomeric or polymeric lined, steel clamps, or an approved equivalent, between the pipe and clamp to prevent chafing and vibration.

21.12.6.3 All piping shall be seamless stainless steel or precision steel as determined by the application. All brake piping shall be seamless stainless steel pipe.

21.12.6.4 Stainless steel fittings must be used with stainless steel piping and tubing. Forged steel fittings, zinc plated to ASTM B633, Type II, Yellow, SC3 / SC4, or ISO 2081 Fe/Zn8/C.

21.12.6.5 All piping, tubing, valves, fittings, installation and testing methods, shall comply with ASME B31.1, DIN EN 10297-2, DIN EN 10305-1, or DIN ISO 1127.

21.12.6.6 Joints that serve the sole purpose of connecting straight runs of pipe shall not be used. Unavoidable joints in piping shall be made in an approved manner. All inaccessible runs of tubing or piping shall be without joints.

21.12.6.7 Piping segments shall be deburred and blown out after cutting, and thoroughly cleaned and capped after fabrication. Metra reserve the right to verify piping cleanliness is to its satisfaction at any time during the production process.

21.12.6.8 All pipes shall be fully flushed and cleaned before installation on the train and sealed to avoid debris within the pneumatic system after installation. The Contractor shall submit for approval by Metra the proposed flushing and cleaning procedures for the piping and piping system. **[CDRL C-21-15]**

21.12.6.9 Following installation, piping systems shall be pressure tested in accordance with ASME B31.1 or other approved method.

21.12.6.10 All leaks, which appear during pressure testing, shall be repaired to the Metra's approval and re-tested until acceptable under the approved test criteria.

21.12.6.11 All hoses used shall comply with AAR M-618, DIN 20 066, or DIN EN 854. All hose fittings shall be of an approved reusable type. Iron pipe fittings used with steel piping shall be AAR approved, with additional corrosion resistance as approved by Metra.

21.12.6.12 All piping shall be installed in accordance with AAR 2518 as incorporated in Standard S-400 (AAR Manual E) or in accordance with DIN EN 10297-2, DIN EN 10305-1 and DIN ISO 1127 and in such a manner as to provide drainage to prevent freezing.

21.12.7 Air Filters

21.12.7.1 The replaceable filter element shall be a common production type, commonly available through various sources.

21.12.7.2 Access to the filter element for replacement purposes shall be possible without requiring the opening of any pipe fittings. Filters shall not be located in inaccessible locations for routine maintenance access.

21.12.8 Pressure Vessels

21.12.8.1 Unfired pressure vessels shall comply with Section VIII and IX of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels or the EN 286.

21.12.8.2 A test report shall accompany each pressure vessel received by the Contractor, and a copy of the test report shall be included in the appropriate Vehicle History Book. Each pressure vessel shall be stamped by the testing facility, whether it is the manufacturer or a third party, as verification of unit testing. Any data plates mounted to a pressure vessel must be sealed to prevent corrosion between the pressure vessel and the data plate mounted to it.

21.12.9 Drain cocks shall be provided at the low points of all reservoirs.

21.13 BEARINGS AND LUBRICATION

21.13.1 All bearings and lubricants shall be readily available in the United States. US Standard grease fittings or plugs shall be provided for all bearings not internally splash- or bath-lubricated.

21.13.2 All rotary shafts shall be supported by cylindrical or tapered roller bearings where practicable. Ball bearings may be used, subject to approval. Rotary / Motor shafts shall be suitably protected against corrosion to allow unencumbered removal of bearings.

21.13.3 Bearings subject to atmospheric or liquid contamination shall be sealed by labyrinth, lip, or face seals. Bearings installed in a vertical application shall have suitable protection to prevent moisture or contaminants from accumulating on, or entering, bearing.

21.13.4 Bearings that are not splash- or bath-lubricated shall be provided with standard grease fittings and drain plugs or pressure-release devices for re-lubrication. Ball bearings of 25 mm [1-in] shaft size and smaller may be factory lubricated-for-life, subject to approval.

21.13.5 Bearings shall be installed and removed without major disassembly of related components. Thrust style bearings shall be used whenever there is an axial load on the rotating shaft carried across rolling elements.

21.13.6 Sleeve bearings shall be used for shafts with rotary motion of less than one full revolution. Sleeve bearings shall be adequately lubricated. Sleeve bearings supporting ferrous shafts shall be composed of bronze, brass, or aluminum alloys as approved. Sleeve bearings may be used to support rotary shafts if space limitations preclude the use of anti-friction bearings.

21.13.7 Self-lubricated bushings (sintered metal) shall be used in accordance with the manufacturer's recommendations but shall not be used for shafts with speeds greater than 500 rpm.

21.13.8 The Contractor shall submit bearing specifications and data for approval. **[CDRL C-21-16]**

21.13.9 All lubricants shall be products approved by the supplier of the parts on which the lubricant is to be used. All lubricants shall, as a minimum, conform to applicable ANSI and ASTM specifications. Multi-purpose lubricants shall be used where possible. The Contractor shall submit for approval data on lubricants recommended for bearings and bushings.

21.14 CURED MATERIALS

21.14.1 All materials that are applied prior to curing shall be applied according to the OEMs full recommendations, including surface preparation, mixing criteria, application temperature, shelf life limits, pot life limits, curing temperature, curing exposure (before handling, or loading), etc.

21.14.2 All uncured material shall be stored and applied according to the OEM's full recommendations. All materials shall be used within the specified shelf life limits; material that has exceeded the shelf life shall not be used.

21.14.3 Preparation prior to bonding or painting the surface shall be prepared according to ASTM D2651 or according to the adhesive manufacturer's approved instructions. Thorough adhesion type testing must be carried out to validate each unique substrate's suitability for safety-critical or structural adhesive bonds with the chosen adhesive, which shall be part of a review and approval by METRA. [CDRL C-21-29].

21.14.4 Paint & Primer

21.14.4.1 The Contractor shall submit for approval data on all paints, primers, and application processes or procedures to be used for the Authorities vehicle. The undercoating material shall be applied according to the manufacturer's instructions.

21.14.4.2 All dents, roughness, or other surface imperfections shall be corrected after the initial corrosion-protection primer layer and prior to the application of the secondary priming coat.

21.14.4.3 Primer, finish paint, and related components shall be supplied as a complete system, manufactured by a single manufacturer. All mixed paint materials shall be used within the first 70% of the mixed pot-life time. Paint shall be applied within the manufacturer's recommended temperature range, but at a temperature no less than 55□F.

21.14.4.4 Preparation for paint application shall follow the paint manufacturer's recommendations. As a minimum, prior to paint application, surfaces shall be cleaned to remove all traces of contamination, and properly treated to promote paint adhesion.

21.14.4.5 Paint shall be applied evenly, and the finished surface shall be free of dirt, runs, appreciable "orange peel", or other imperfections. Paint inspection and acceptance criteria subject to Metra approval. **[CDRL C-21-17]** Paint quality control samples may be proposed to establish acceptable color, gloss, smoothness, orange peel and dry film thickness parameters. Cosmetic coatings of paint shall have specified gloss levels for the appearance desired. The gloss levels shown in Table 21-6 are defined according to common terminology, with the following criteria based upon the ASTM D 523 – 60° axis angle with equivalents shown for 80° and 20°.visual acceptance criteria, subject to Metra approval.

Table 21-6

Gloss Level Definition	Glossmeter Setting and Gloss Value		
	20 degree	60 degree	85 degree
- High Gloss	85-90%	90-95%	95-100%
- Semi Gloss	0-10%	20-30%	50-60%
- Flat Gloss	0%	0-10%	10-20%

21.14.4.6 At least two coats of finish paint shall be applied, with appropriate surface preparation between coats.

21.14.4.7 Touch-up paint shall be identical in all respects to the original paint. Color chips for color match may be provided by the contractor for Metra approval, to establish acceptable color match tolerances. It is the Contractor's responsibility to ensure that the color match is acceptable. It may be required that the color match be made according to ASTM D 2244. In no case shall color mismatch detract from the overall appearance of the equipment.

21.14.4.8 Prior to assembly, all low-alloy steel areas shall be painted with one coat of an approved etching primer followed by one coat of an approved sealer to prevent rusting. Other methods of corrosion protection can be used according to the approved corrosion protection concept.

21.14.4.9 All coatings used are to be EPA compliant.

21.14.4.10 Painted surfaces shall develop full adhesion to the substrate to which they are applied. Testing for adhesion between the paint and the substrate surface will be done on a random basis and shall conform to ASTM D 3359, 3a Classification, using Permacell□ #99 adhesion test tape.

21.14.5 Powder Coating

21.14.5.1 Powder coating if used, shall be polyester-epoxy hybrid based for interior surfaces at risk of vandalism, polyester based for interior surfaces without risk of vandalism (e.g. the operator's cabin), acrylic based for exterior surfaces at risk of vandalism, and polyester based for exterior surfaces with no risk of vandalism. Finished film thickness shall be 3.5 mil (0.089mm) □ 1.0 mil (0.025mm), or according to the powder manufacturer's recommendations. The surface preparation and pre-treatment shall be according to the powder manufacturer's recommendations.

21.14.5.2 Powder coating finish gloss level for cosmetic surfaces shall be a silk-gloss finish of R65-R85 (60°) for exterior surfaces and a matte finish of R15-R35 (60°) for interior surfaces, according to ASTM D523.

21.14.6 Adhesives

21.14.6.1 Adhesives to be used for installation of floor covering, panels, insulation, and vibration isolation materials shall have a satisfactory history of performance in a rail transit environment. A list of all adhesives to be used, including location, material safety data sheets, technical data & specification sheets, and flammability properties, shall be submitted for approval. **[CDRL C-21-18]** Adhesives used in small quantities may not require flammability data, subject to Authorities approval.

21.14.6.2 Joining of components by adhesives shall be completed within the maximum working times as follows; the application and aligning of bonded components shall be completed within 70% of the adhesives maximum working time, considering application conditions. When two-part compounds are being used, only the amount of adhesive that can be used within 70% of the maximum recommended pot life shall be mixed.

21.14.6.3 Adhesives that use atmospheric or humidity cure shall be installed such that the air circulation to fully cure the adhesive is possible, or a moisture-containing booster component is to be used when thick bonded joints or limited air circulation is possible. The moisture-containing booster component shall be provided by the same manufacturer as the adhesive and applied according to their recommendations.

21.14.6.4 Adhesive selection and bonded joint design shall consider MIL-HDBK-691B or DIN 6701.

21.14.7 Sealants and Caulking

21.14.7.1 The use of caulking and sealing compounds shall be minimized.

21.14.7.2 Caulking and sealing compounds shall be applied in accordance with the manufacturer's instructions and recommendations, shall be non-staining, and shall be supplied in colors closely matching those of adjacent materials and surfaces. Caulking used in exterior

applications shall be ultraviolet light (UV) resistant. If butyl-type is used, it shall be extruded polyisobutylene sealer compound of 100 percent solids.

21.14.7.3 Caulking primers shall be quick-drying, colorless, non-staining sealers of a type and consistency recommended by manufacturers of caulking materials for the particular surface involved.

21.14.7.4 Packing (backstop) shall be non-staining, resilient material, such as fiberglass roving, neoprene, butyl, closed-cell foams, or other compressible materials compatible with the caulking compound used. Joints, spaces, and junctures to be packed and caulked or sealed shall be completely cleaned of dirt, dust, oil, and other foreign materials that would adversely affect caulking quality. Suitable primer shall be used to achieve full adhesive bond.

21.14.7.5 Surfaces shall be thoroughly dry before caulking compounds are applied. Caulking compound application shall be compatible with prior or subsequent paint application. When so stipulated by the sealant manufacturer, paint and other protective coatings shall be removed from surfaces to be caulked prior to priming and application of sealants.

21.14.7.6 Compounds shall be applied with pneumatic guns. Where the use of a caulking gun is impracticable, suitable hand tools shall be used.

21.14.7.7 Unless otherwise indicated, the entire perimeter of each opening shall be caulked. The finish of caulking joints on flush surfaces and in internal corners shall be neatly pointed; excess material shall be removed; and, where exposed, the caulking shall be free of wrinkles and uniformly smooth.

21.14.7.8 Application of polysulfide or silicone compounds shall be in accordance with the OEM's instructions and recommendations.

21.14.7.9 Compounds shall not be used when they become too gelled to be discharged in a continuous flow or exceed their stated shelf life, and they shall not be modified by addition of liquids, solids, or powders. Compounds shall be installed within the manufacturer's defined temperature range.

21.14.7.10 Installation and working of compounds shall be completed within the maximum working times as follows; the application and working of caulking material shall be completed within 70% of the minimum "skin" time, considering application conditions. When two-part compounds are being used, only the amount of caulking that can be installed within 70% of the maximum recommended pot life shall be mixed.

21.14.7.11 Adjoining surfaces, finishes, and fixtures shall be carefully protected throughout caulking operations. Stains, marks, or damage as a result of caulking and sealing work shall be removed.

21.15 INSULATION

21.15.1 Insulating materials shall be fire-retardant, non-carcinogenic, non-hygroscopic, resistant to fungus, and provided with a vapor barrier as required to prevent the entry of moisture, oil, gases, and dust. The materials shall not absorb fluids and gases and shall possess the required properties to meet the noise and vibration requirements of this specification. The method of insulation retention in the car-shell, for all insulating materials, shall be subject to Metra approval. The Contractor shall submit for approval data on thermal and acoustic insulation materials and application processes. **[CDRL C-21-19]**

21.15.2 Acoustic Insulation

21.15.2.1 Sound damping material used in the fabrication of the vehicle shall be resistant to diluted acids, greases, gasolines, fuel oils, aliphatic oils, and vermin; and must be resistant to fungus; and must not support combustion. The material shall not be affected by sunlight or ozone, and shall not become brittle with age

21.15.3 Thermal Insulation

21.15.3.1 Thermal insulation materials shall be transportation grade of the rigid, non-rigid, or spray-on type. Insulation shall be installed with a vapor barrier to preclude moisture accumulation. The type of thermal insulation to be used shall not be susceptible to mold or rot and shall not absorb water. Metals, which are attached to the insulation, shall be corrosion resistant, and not settle under vehicle vibration. The vehicle thermal insulation shall not have an odor or be capable of absorbing odors and shall not sustain vermin. Urethane foam insulation is expressly prohibited.

21.15.3.2 (deleted)

21.16 FIRE SAFETY

21.16.1 All materials used in the cars shall be selected to minimize combustion and propagation of fire both inside and outside cars. The Contractor shall ensure that all materials which are subject to specific fire safety requirements and guidelines in 49 CFR 238.103, Appendix B to Part 238, and NFPA 130 - 2023 have been properly tested and certified by a recognized independent laboratory. All test reports shall be submitted to Metra for approval and shall include Pass/Fail conclusions per the applicable performance criteria and shall include certification from the recognized independent laboratory that the test results were obtained after testing in accordance with the procedures and equipment specified in the test methods.

21.16.2 All test reports shall also be accompanied by a certification from the Contractor that representative samples of combustible materials have been tested by a recognized independent testing laboratory and that the results show the representative samples comply with the 49 CFR 238.103, Appendix B to Part 238, and NFPA 130 - 2023 requirements as well as the Toxicity requirements of this specification.

21.16.3 The name, address, qualifications, and contacts of all laboratories used shall be provided to Metra and the laboratory selected shall be subject to Metra's approval. A disapproval must be mutually agreed upon.

21.16.4 In case that a test report is does not fulfill the necessary scope of testing (such as testing of representative material was not performed, compliance criteria and conclusions are not provided in the test reports, certifications not provided, test reports are over 5 years old, regulations/requirements have changes since testing was conducted etc.). Metra has the sole right to determine if test reports are acceptable or if additional testing is required.

21.16.5 All materials used in the subject cars shall be in compliance and be tested in accordance with FRA Regulation 49 CFR 238.103, Appendix B to Part 238, and NFPA 130 - 2023. The fire safety and flammability tests shall also be performed for sealants, caulking, and adhesive materials. In case materials are not listed in these standards, the Contractor shall contact Metra for approval with the proposed performance criteria they plan to use. In addition, the Contractor or an independent fire safety professional shall conduct the fire safety analysis as required by Section 238.103[c].

21.16.6 All test results should be completed and submitted to Metra prior to delivery of the first vehicle in the order. No vehicle will be utilized in revenue service until all test results have been submitted, reviewed and approved by Metra and a complete fire safety analysis per 238.103[c] and NFPA 130 has been submitted, reviewed and approved by Metra. **[CDRL C-21-20]**

21.16.7 All materials used in car construction shall be tested for the emission of toxic gases during combustion using the NBS Smoke Chamber, bellows pump, and the appropriate Draeger tubes for the gases involved. Bombardier SMP 800-C maximum values shall be used to determine the acceptability of products.

21.16.8 The tests are to be run in the flaming mode, with sampling done after 240 seconds. The test report shall show the maximum concentration (ppm) for each of the following gases:

21.16.8.1 Carbon Monoxide (CO)
21.16.8.2 Sulfur Dioxide (SO2)
21.16.8.3 Hydrogen Cyanide (HCN)
21.16.8.4 Carbon Dioxide (CO2)
21.16.8.5 Hydrogen Chloride (HCl)
21.16.8.6 Oxides of Nitrogen (NOX)
21.16.8.7 Hydrogen Fluorine (HF)
21.16.8.8 Hydrogen Bromide (HBr)

21.16.9 On a limited and case by case basis, Metra may approve the use of material that have been verified as not having alternatives and have not passed the specified performance requirements. In these cases, the Contractor shall be required to submit a waiver in writing to Metra for approval prior to any use of such material. The Contractor's waiver request shall include the justification(s) for using the material, total weight of the material, location(s) and distribution on the vehicles, material safety and data sheets, and current test reports. In addition, the Contractor shall submit a letter from an independent material fire safety professional indicating their review of the Contractor's waiver request and their professional safety analysis and conclusions regarding the request and the safety, environmental and regulatory implications involved for Metra throughout the life of the vehicles.

21.17 JOINING AND FASTENING

No protruding screws, rivets, mounting bolts, or similar items shall be permitted on the exterior of the vehicle, except where approved by Metra. The use of exposed fasteners on the vehicle interior shall be minimized. Interior fasteners shall be countersunk where possible or low profile heads where countersink is not possible. Interior fasteners shall not protrude enough to become a tripping or snagging hazard.

21.17.1 Fastening to Structural Members

21.17.1.1 Fastening to structural members shall be done only on the low stress portion of the member and shall be determined during the design review.

21.17.1.2 The Contractor shall ensure that any fastening or joining to structural members does not result in moisture accumulation within any structural member. To this end, fastenings to hollow, closed section structural members shall not be accomplished using drilled holes in the structural member.

21.17.2 Threaded Fasteners

21.17.2.1 The number of different sizes and styles of fasteners used shall be minimized. A single standard, US (ANSI/SAE/IFI), or ISO, shall be adopted for the fasteners used. Fasteners shall be properly marked per the system adopted. All threaded fasteners shall comply with ANSI B1.1 class 2 requirements, unless otherwise specified or approved. All structural threaded fasteners shall have rolled threads.

21.17.2.2 Self-tapping or thread forming screws may be used with Metra approval only, on a case-by-case basis.

21.17.2.3 Use of special or non-standard fasteners shall require Metra approval. Threaded inserts or non-standard fasteners that have a service proven history of at least ten (10) years shall not require approval. The Contractor shall still be required to provide documentation on all threaded inserts or non-standard fasteners.

21.17.2.4 At least 1 1/2 threads shall be visible beyond all nuts. Bolts smaller than 6 mm [0.25 in] shall not project more than 1 1/2 thread plus 6 mm [0.25 in]. Bolts 6 mm [0.25 in] or larger shall not project by more than 8 threads.

21.17.2.5 Fasteners exposed to public view shall be treated as follows:

21.17.2.5.1 On the vehicle interior, all exposed fasteners shall be stainless steel with flat or oval heads, properly countersunk.

21.17.2.5.2 On the vehicle exterior, all exposed fasteners shall be stainless steel, unless otherwise specified.

21.17.2.5.3 Exposed screws shall be of an approved tamper-proof type.

21.17.2.5.4 Fasteners and fastener components used on the vehicle underfloor or roof areas shall be stainless steel except in cases where high strength fasteners such as SAE grade 8 are required. The contractor shall provide a list of all threaded fasteners, fastener classification, material, finish, and location used, for Metra approval. **[CDRL C-21-21]**

21.17.3 Fastener Materials

21.17.3.1 Fastener component materials (screws, nuts, washers, etc.) shall be properly selected for the application and shall not be mixed within an assembly unless approved by Metra. All fasteners shall be stainless steel, or steel finished with protective coating such as passivation, dichromate, or zinc plating, depending on the specific application.

21.17.3.2 Threaded aluminum fasteners shall not be used except in tapped holes in solid aluminum structures, subject to approval.

21.17.3.3 Stainless steel nuts and bolts shall be used for stainless-to-stainless joints. Anti-seize compounds shall be used on all stainless steel fasteners threaded into stainless steel, or using stainless steel nuts.

21.17.4 US Standard

21.17.4.1 Threaded fasteners shall conform to current SAE J429 standards for externally threaded fasteners and SAE J995 standards for internally threaded fasteners. Steel fasteners ¼" diameter and above shall be SAE grade 5 minimum.

Metric:
Carbon steel Metric threaded fasteners shall conform to the following current standards; ANSI B1.13M (ISO-metric), and SAE J1199, or the current equivalent, specified, DIN or ISO standards. Carbon steel fasteners 6mm diameter and above shall be property class 8.8 minimum for external threads, property class 8 minimum for nuts, per ISO 898/1 and ISO 898/2. Nuts shall be selected to provide the suitable matching strength, material, and finishing, compatible with the mating fastener.

21.17.4.2 Stainless steel fasteners shall be manufactured from austenitic stainless steel alloys, according to ASTM F 593, with a nominal tensile strength of 100 ksi. All fasteners shall be clean and free of manufacturing scale.

Metric:
Stainless steel fasteners shall be manufactured from A2 or A4 grade, austenitic stainless steel with a minimum property class of 70 per ISO 3506, with a minimum nominal tensile strength of 700 MPa.

21.17.4.3 Non-structural screws, such as Phillips or slotted head screws smaller than ¼" diameter may be SAE grade 2 minimum.

Metric:
Non-structural screws, such as Phillips or slotted head screws smaller than 6mm diameter may be property class 4.8 minimum for steel, property class 50 for stainless steel. Manufacturing tolerances shall be according to DIN 267, part 2, m (medium class).

21.17.5 Locking Requirements

21.17.5.1 All threaded fasteners shall be self-locking or provided with locking devices. Locking devices shall be lockwire, lock washers, torque patch, or prevailing torque type locknuts as appropriate for the application or service. Lockwire, if used, shall be stainless steel.

21.17.5.2 Prevailing torque locknuts shall be of the nylon collar insert type. Previously installed and removed locknuts shall not be re-used. High temperature applications may use metallic distorted thread locknuts upon Metra approval.

21.17.5.3 Bolts for use with locknuts shall not be drilled for cotter pins or in heat related applications.

21.17.5.4 All locknuts shall comply with the Industrial Fasteners Institute requirements regarding to locking ability.

21.17.5.5 When oversized or slotted holes are provided for installation tolerance allowance, flat washers, of suitable size to cover oversized holes, or slots shall be used in all locations adjacent to the hole. In this case, at least one hole shall be of close tolerance to ensure accurate positioning of component. If slotted holes are provided as a means of adjusting a piece of equipment, a secure method of fixing the adjustment shall be provided, such as adjustment screws, ribbed or toothed adjustment washers, Drilled holes and pins, etc.

21.17.6 Plating & Treatment of Fasteners

21.17.6.1 All steel fasteners shall be zinc plated with the highest protective service condition available per thread configuration. Stainless steel fasteners shall be passivated. If stripping and re plating of fasteners is required to meet the aforementioned criteria,

documentation must be made available to verify that all applicable post plating treatments and standards have been met. Metra may require batch testing of stripped and re-plated fasteners to ensure there is no hydrogen embrittlement.

21.17.6.2 After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ASTM B633, Type II - Yellow (please refer to table for thickness).

21.17.6.3 After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ISO 4042, (refer to Table 21-7 for plating thickness).

Table 21-7

Plating Thickness for Steel Fasteners, Zinc, Yellow Chromate Conversion			
Bolt size	**Metric DIN 267**	**US ASTM B633**	**Thickness (Micrometer / inch)**
Dia, up to #8 (M3)	A1L	-	3µm / .00012"
Dia. >#8 (M3) to 5/16" (M8)	A2C or A2L	SC1	5µm / .00020"
Dia. >5/16" (M8) to 7/8" (M22)	A3C	SC2	8µm / .00031"
Dia. >7/8" (M22) to 1-1/8" (M33)	A4C	SC3	13µm / .00051"
Dia. >1-1/8" (M33) and greater	A5C	-	15µm / .00059"

21.17.7 Hydrogen Embrittlement

21.17.7.1 Fasteners or fastener components with hardness greater than or equal to 320 HV (32 HRC) are susceptible to hydrogen embrittlement when these parts are pickled and/or electroplated. This may cause these fasteners to fail at relatively low loads even if stress relief annealing (baking) is performed after plating. Examples of hardened fasteners are steel bolts - US Grade 8 (Metric property class 10.9), hardened steel washers, spring washers, etc. These types of fasteners shall be mechanically plated to avoid hydrogen embrittlement per ASTM B695, Type II, or ISO 10683 flZnL/nc/480h with a minimum thickness per Table 19-5, (e.g. with the thickness increasing as appropriate for class of thread fit)..

21.17.8 Torque Marking/Indexing

21.17.8.1 The Contractor shall ensure the proper application of all threaded fasteners. Torque marks or stripes extending from the secured hardware to the surrounding surface shall be applied to all safety related hardware, including truck, door, and brake equipment bolts. Tightening indication may be required on other non-safety related hardware upon the Authorities' request.

21.17.9 Bolts and Nuts

21.17.9.1 All high risk fasteners as defined in DIN 25201-1 used in this project shall require a submittal of Certifications of Compliance (C of C) with each shipment of hardware to the end user. The C of C shall be traceable to a manufacturer.

21.17.9.2 High strength fasteners such as SAE grade 8 hardware shall be used for mounting the traction motors to the trucks, and for all truck mounted appurtenances, unless specifically allowed otherwise by Metra.

21.17.10 Electrical and High Temperature Connections

21.17.10.1 Plated steel screws or bolts, nuts, flat washers, and lock-washers used in mounting and in making connections to resistors and other heat-producing apparatus shall be suitable for high temperatures without degradation of the strength of the hardware or its corrosion resistance. Flat washers shall be used on both sides of all electrical connections (under bolt head and under nut).

21.17.11 Riveting

21.17.11.1 Rivet holes shall be accurately sized, located, and aligned for the intended rivet. Rivet holes that have been repaired, or the rivet removed shall be reamed to the next larger rivet size, and the next larger rivet installed. Rivets exposed to passengers on the outside of the vehicle shall be stainless steel.

21.17.11.2 (deleted)

21.17.11.3 Two part rivets consisting of a pin and collar (such as Huck-Bolt types) shall be installed such that the pin breaks flush with the end of the collar.

21.17.11.4 Blind rivets may be used subject to Metra approval. Blind rivet materials may be stainless steel, or plated carbon steel with plated steel or stainless steel mandrels compliant with IFI 114. The mandrel shall break flush or slightly below the surface of the rivet head but shall remain locked in place as a structural part of the rivet assembly. All rivets shall be installed according to the rivet manufacturer's instructions, using equipment approved by the rivet manufacturer.

21.17.11.5 The rivet nut hole shall be made per the rivet nut manufacturer's recommendations.

21.17.11.6 Aluminum alloy rivets shall comply with Aluminum Association Standards for Aluminum Mill Products alloys and tempers 6061-T6 or 6053-T61 EN ISO 14588, EN ISO 15973, EN ISO15974 or similar.

21.18 WELDING, BRAZING AND SOLDERING

21.18.1 All welding practice not specifically covered in this Section shall be in accordance with the applicable requirements and recommendations of the EN 15085, EN ISO3834, American Welding Society (AWS), as contained in the latest revisions of the "Structural Welding Code" (AWS D1.1), "Aluminum Welding Code" (AWS D1.2), "Structural Welding Code - Sheet Steel" (AWS D1.3), Structural Welding Code – Stainless Steel (AWS D1.6), “Sheet Metal Welding Code” (D9.1), “Recommended Practices for Resistance Welding" (AWS C1.1), "Railroad Welding Specification" (AWS D15.1) and the AWS "Welding Handbook" (AWS WHB). Where non-AWS or EN 15085 welding is used, the supplier shall demonstrate equivalence. The contractor shall demonstrate compliance with AWS or EN 15085 welding requirements and standards.

21.18.2 The Contractor shall be responsible for the quality of all welding and brazing, including the welding and brazing of its suppliers and subcontractors.

21.18.3 Prior to welding, all surfaces shall be thoroughly cleaned to remove corrosion, rust, scale, slag, grease, oil, water, paint, and other foreign materials in accordance with applicable parts of AWS D1.1, Section 8.5 on Workmanship and Technique or EN 15085.