Mechanical Department

Technical Specification for Battery Powered Trainset

SPECIFICATION No. M-22-001

REVISION: Revision D

DATE: 01/22/2024

RECORD OF REVISIONS

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First Issue	F. Mascarenhas	1/24/2022	Spec for Battery Powered Trainset	Francis Mascarenhas	1/24/22
A	F. Mascarenhas	04/22/2022	Removed original Section 1.3.4 Revised Sections 1.3.4; 1.3.5; 1.3.7; 1.3.8; 8.1.1.2; 8.6.3.5; 15.3.1.3; 15.7.1; 16.8.1; 17.1.1.3; 19.3.19; 22.1.14; 23; 23.10.1.13; 23.10.2.4; 23.10.4.5; 23.10.4.6; 23.10.5.4; 23.10.5.13.2	Francis Mascarenhas	4/22/22
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NOTE: This document is to be considered “uncontrolled” when printed as a hardcopy from the network. The revision level must be verified prior to use.

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1 GENERAL REQUIREMENTS

1.1 GENERAL REQUIREMENTS

1.1.1 This specification covers battery trainsets to be used in transporting passengers in the greater Chicago Metropolitan Area and its environs. The trainsets are designed to be operated in trains that can range in size from two cars minimum to four cars maximum in single traction. The design shall provide a safe, comfortable ride at all speeds up to Metra's maximum authorized operating speed (79 mph). The car shell and trucks shall be designed for speeds up to 100 miles per hour.

1.1.2 For the purposes of this specification, a trainset is defined as a collection of passenger cars which are permanently coupled to create a fixed consist to be used for a particular train application and a car is defined as that portion of the trainset which is located between coupling arrangements.

1.1.3 The trainset shall have cars in two configurations: Cab Cars and Intermediate Cars, single level seating configuration.

1.1.4 Trainset in its shortest form shall be two powered end cars. The trainset configuration as a two, three or four car consist shall be fixed and a reconfiguration is not needed.

1.1.5 The intention of a multiple unit trainset is in general to keep the consist length over the lifespan of the vehicle. But individual cars from a trainset may be separated and configurations of trainsets modified, but it is assumed that such operations will generally be performed as part of a major overhaul including major steps like for example Software Updates and Re-Commissioning of the trainset.

1.1.6 Individual cars from a trainset are not required to function as stand-alone cars when not assembled as trainset

1.1.7 Individual cars from a trainset are not required to be intermingled with Metra's existing cars. However, the trainsets shall be configured to allow interoperability with existing Metra fleet for emergency towing purposes.

1.1.8 The trainsets are to be built in accordance with the requirements described in these specifications and shall comply with all Federal Railroad Administration (FRA) regulations in effect at the time the Notice to Proceed is issued as well as the applicable standards of the Association of American Railroads (AAR) and/or American Public Transportation Association (APTA) in effect at the time the Notice to Proceed is issued.

1.1.9 All documents, correspondence, meetings, and technical information shall be offered and conducted in the English Language. US customary system of weights and measures will be applied wherever possible in combination with metric if needed.

1.1.10 Drawings and other data contained herein are considered part of these specifications. In case of conflict, these specifications shall govern. Where these specifications conflict with FRA regulations and/or AAR, APTA and EN standards (or conflict between regulations and standards) the following hierarchy shall apply: 1) FRA Regulations, 2) these Specifications, 3) APTA and EN Standards, and 4) AAR Standards. The Contractor and the Contracting Authority will jointly resolve any conflicts that exist.

1.1.11 As part of the design review the Contractor shall submit the drawings and documentation as required in sections 1.5 and elsewhere in this specification where terms “approved”, “approved manner”, “approved by the Contracting Authority”, “subject to approval” and “The Contracting Authority approval” appear. The Contractor shall also provide additional non-proprietary information or documentation related to the design and production of the vehicles if requested to do so by the Contracting Authority. Metra shall review all documents submitted. All submittals will be documented as:

1.1.11.1 Approved: defined as the Contracting Authority concurs with the information in its submitted form. The material may be incorporated into the program.

1.1.11.2 Approved/Conditionally: defined as the Contracting Authority agrees in principle with the submitted information. However, some details must be revised to make the information fully approved. The material must be resubmitted in revised form for approval.

1.1.11.3 Disapproved: defined as the Contracting Authority does not concur with the submitted details. The Contractor shall not incorporate the material into the program. The Contracting Authority’s objections must be reconciled and the material must be resubmitted in revised form for approval.

1.1.11.4 Insufficient Information: defined as the information provided was illegible or insufficient to enable a complete review. The Contracting Authority will respond within 20 working days to any review submittal, calculated from the date of receipt of documents by Metra to the date a response is sent to the Contractor, provided the Contractor submits such review material in a reasonable time sequence and manageable volume. Revisions to the Contracting Authority approved documents and the Contractor's internal change requests affecting the Contracting Authority approved documents, shall be submitted to the Contracting Authority for approval as they are issued. No more than three drawing alterations (change requests) shall remain unincorporated on any drawing at any time, and no change request shall remain unincorporated into a drawing for a period greater than two months from the date of approval. Approval does not relieve the Contractor of the obligation of meeting all the requirements of this Contract. Approval of a drawing which contains a deviation from, or violation of these Specifications does not constitute authority for that deviation or violation unless such deviations have been specifically requested in writing and specifically granted by the Contracting Authority in writing according to all contract requirements.

1.1.12 The Contractor shall prepare and submit to each Contracting Authority for approval, prior to construction of the trainsets, copies (electronically in searchable original PDF format) of each drawing required by these specifications and all drawings necessary to demonstrate compliance with these specifications. This shall include, but not be limited to as long as the information is not proprietary: clearance drawing, arrangement drawings, assembly drawings, sub-assembly drawings, integrated wiring schematics, and drawings of major equipment and apparatus. **[CDRL C-1-01]** Drawings submitted by Subcontractors and Suppliers shall be thoroughly checked by the Contractor to ensure that they conform with the requirements of these specifications prior to submittal to the Contracting Authority. Drawings shall be comprised of not more than four (4) sizes with "D" size (22" X 34") being the largest drawing size permissible.

1.1.13 The Contractor shall submit, prior to the car body testing, the current status of the stress analysis of the complete car body structure and supports for equipment weighing over two hundred (200) pounds in a comprehensive overview presentation. This analysis shall show the calculated stresses, allowable stresses and the margin of safety for the most critical elements for the specified load conditions. All critical joints shall be included in this analysis (manual calculations if necessary). In addition, conformance to all referenced standards shall be

demonstrated. The analysis shall, as a minimum, consist of a finite element analysis using recognized computer programs (Simulia Abaqus, Altair Hyperworks etc.). **[CDRL C-1-02]**

1.1.14 A post-award conference shall take place no later than 20 working days after Notice To Proceed, at Metra's or the Contractor's facilities, as directed by METRA, to accomplish the following:

1.1.14.1 Introduce Metra's key personnel to the Contractor

1.1.14.2 Confirm the Contractor's management team and key staff and the scope of supply of subcontractors, if already defined by the Subcontractor at this point.

1.1.14.3 Establish formal channels of, and procedures for, communication (e.g. letter and meeting numbering)

1.1.14.4 Establish an understanding of the Contractor's project control methodology and plans for initial activities before the start of formal progress reporting

1.1.14.5 Discussion to familiarize the Contractor with Metra's intended operations and maintenance environment

1.1.14.6 Identify the early information needs and decisions required by the Contractor from the Contracting Authority

1.1.15 The Contractor shall hold formal design review meetings with the Contracting Authority. The purpose of these meetings is to ensure that the requirements of these specifications are being met by the design. The schedule and location for these meetings shall be by mutual agreement. Design review material shall be submitted no later than 15 working days prior to each review meeting, and shall include the drawings, technical data, analyses, calculations, presentations, and other items required for the review. Four types of design reviews shall be held:

1.1.15.1 Preliminary design review (PDR): Preliminary design review of system components shall be made at the approximately 30% level of designs. The PDR shall include a review of the design concept, written descriptions of the functionality, schematics of the system wiring and drawings or pictures based on 3D CAD models of each component showing dimensions and structural elements in draft version. The Contracting Authority retains the right to redline, comment, and request changes to improve design and/or functionality.

1.1.15.2 Intermediate design review (IDR): An intermediate design review (IDR) shall be held when the design of the trainset is approximately 60% complete. This shall represent an advancement of design of the trainset from the preliminary design stage to development of draft production drawings, arrangements, component and material specifications and schematics for all systems, subsystems and components, which will be used by the Contracting Authority to evaluate the proposed design of the trainset to a level of detail sufficient that the Contractor shall be able to proceed with the development of the trainset design to the 95% draft final stage.

1.1.15.3 Mockup development and review: Upon completion of the IDR stage of the design review process, the Contractor shall complete the assembly of full size mockups hard mockups of the following areas and systems of the trainsets. References, or already built projects can be used to present the systems instead of full size mockups. Additionally virtual reality can be used to support the design process; according the drawings as reviewed and approved at the IDR, for the Contracting Authority review and comment:

1.1.15.3.1 Passenger seats

The purpose of the mock-up is to approve colors, fabrics and confirm the seating comfort. Therefore, as part of the base order the Contractor shall present the passenger seats, with the METRA specific colors and fabrics on a simplified seat support structure.

1.1.15.3.2 Sidewall panels, passenger windows, and window gaskets

The purpose of the mock-up is to approve colors, surface structure and window-tinting. Therefore, as part of the base order the Contractor shall present a mood board with material samples for the wall panels, window glass and window gasket. If similar or identical components have been used in previous projects, the Contractor may present the systems or the components on an actual project.

1.1.15.3.3 ADA System (see also **Error! Reference source not found.**)

he purpose of the mock-up is to approve for conductors to see operating controls, functionality and the preventive maintenance accessibilities.

1.1.15.3.4 Toilet System (see also **Error! Reference source not found.**)

he purpose of the mock-up is to release the general design in terms of colors and surface structures including functionalities and preventive maintenance accessibilities. Therefore as part of the base order the Contractor shall present a mood board with material samples for the different visible surfaces. As reference, already built project with a similar or identical toilet design could be feasible for mock-up purposes to present the functionalities and preventive maintenance accessibilities.

1.1.15.3.5 Electrical Cabinet

The purpose of the mock-up is to mainly show the general design of the electrical cabinets, cable routing and preventive maintenance and troubleshooting accessibilities. A reference, already built project with similar or identical electrical cabinet designs could be feasible for mock-up purposes.

1.1.15.3.6 Door System (see also **Error! Reference source not found.**)

he purpose of the mock-up is to mainly show the general design and functionalities of the door system. A reference, already built project with a similar or identical door design could be feasible for mock-up purposes to present the functionalities and preventive maintenance accessibilities as well.

1.1.15.3.7 Driver Desk

The purpose of the mock-up is to mainly show the general design and functionalities of the driver desk. A reference, already built project with a similar or identical driver desk design could be feasible for mock-up purposes. The METRA specific adaptions of the driver desk can be covered with 3D-visualizations.

1.1.15.3.8 (deleted)

1.1.15.3.9 Propulsion system including battery system:

The purpose of the mock-up is to mainly show the general design and functionalities of the propulsion chain and to present the functionalities and preventive maintenance accessibilities. A reference, already built project with a similar or identical propulsion system design could be feasible for mock-up purposes. The zero emission propulsion chain consists of several new developments, therefore the overall mock-up concept could be a combination of already built projects, 3D visualization in CAD programs or components in the first article stage:

- Reference project: motor, converter, cable routing
- 3D visualization, first article stage: battery packs, connection box

1.1.15.4 Final design review (FDR): Final design review (FDR) of system components shall be held at approximately 95% or greater level of design. The FDR shall include a review of all documents and plans for the design as revised, including the written descriptions of the functionality, schematics of the system wiring, drawings of each component showing

dimensions and structural elements. Redlines and comments from the IDR and mockup review shall be reviewed. Metra retains the right to provide additional comments during this process as production progresses of the pilot vehicle, if the design shows major issues in terms of manufacturability or maintainability.

1.1.16 Progress review meetings shall be held at mutually agreed to time periods either at the Contracting Authorities' headquarters or at the Contractor's (or its subcontractors') facilities or online via Teams as deemed necessary.

1.1.17 Whenever in this specification one or more brands, trade names, or catalog numbers of specific manufacturers are mentioned, it is in the intent of establishing identification, a basis of quality and durability and though the term "or approved equal" may not be inserted, it may be implied. Only substitutions equal to the specified items will be allowed and only when such substitution is necessary. Before furnishing and/or installing any product that is a substitution for the specified item, proof of equality shall be furnished by the Contractor by providing the technical documentation of the product, and the approval of the Contracting Authority's designated Mechanical officer must be obtained in writing before any such substitution is made.

1.2 PROJECT DRAWING DELIVERABLES

1.2.1 Project drawing deliverables shall comply with project specific specifications, the applicable Contracting Authority quality management plans, contractually required procurement documents, and this document. All contract drawing submittals to the Contracting Authority shall consist of electronic formats, which shall conform to the requirements of this section.

1.2.2 Disposition for Problems, Questions, and Discrepancy

1.2.2.1 When problems, questions, and/or discrepancies are identified between this document, contractual documents, etc., the Contractor must inform the Contracting Authority and the work must be performed in accordance with the instruction for disposition from the Contracting Authority's Project Manager.

1.2.3 Submittal Intervals

1.2.3.1 As drawings for a project are developed, the Contractor shall periodically submit drawing set(s) to the Contracting Authority for review and comment. The submittal intervals shall be defined by the contract documents and/or agreement by the Contracting Authority with the Contractor.

1.2.4 Reviews and Approvals

1.2.4.1 Drawings will only be approved or accepted by the Contracting Authority as to arrangement and conformance to the specifications and related drawings. Approval or acceptance shall not be construed as relieving or mitigating the Contractor of their responsibility for design verification, dimensional accuracy, adequacy and suitability of materials and / or the equipment represented thereon, or for compliance with contract requirements.

1.2.5 Electronic Delivery Media

1.2.5.1 Electronic delivery media shall be coordinated with the Contracting Authority's Project Manager to ensure compatibility with the Contracting Authority's hardware and software. Accepted media or file transfer methods:

- USB 2.0 Drive or better
- Establishment of a secure FTP site

1.2.6 Media Labeling

1.2.6.1 All media shall have a label containing under consideration of the maximum possible labeling length, but not limited to:

1.2.6.1.1 Preparation date of the media.

1.2.6.1.2 The project description.

1.2.6.1.3 Contractor name and contract reference.

1.2.6.1.4 Contract transmittal number.

1.2.6.1.5 (deleted)

1.2.6.1.6 (deleted)

1.2.6.1.7 (deleted)

1.2.7 Electronic File Preparation.

1.2.7.1 All electronic files shall be delivered in the Contracting Authority approved formats. Deliverable file format shall be coordinated with the Contracting Authority's Project Manager to ensure the Contracting Authority's ability to use the delivered files. Before a file is placed on the electronic delivery media, the following procedures shall be performed:

1.2.7.1.1 Drawing files shall be in their native format, not DXF, or other neutral format. File format must be approved by the Contracting Authority.

1.2.7.1.2 (deleted)

1.2.7.1.3 (deleted)

1.2.7.1.4 Ensure all external reference files are attached without device or directory specifications. Include a list of files included in the deliverable in a text document on the media.

1.2.7.1.5 All deliverables shall be certified virus-free.

1.2.8 Documentation.

1.2.8.1 All drawing packages submitted to the Contracting Authority shall include, but not be limited to, a transmittal containing the same information as on the external media label, and:

1.2.8.1.1 A digital list of files included in the deliverable.

1.2.8.1.2 (deleted)

1.2.8.1.3 Person designated as point of contact.

1.2.8.1.4 Certification in the form of a signed statement, that the delivery data is free of known computer viruses, including the name(s) and release date(s) of the virus scanning software used to check the media.

1.2.9 Quality

1.2.9.1 As part of their contractual requirements to the Contracting Authority, the Contractor will be responsible for the quality assurance and quality control of the drawings, CADD files and other documents submitted to the Contracting Authority as part of the contract. The Contractor shall ensure compliance to this document, the Contracting Authority project specifications, applicable Contracting Authority quality management plans, and other contractually required documents. The Contracting Authority's review of the submittals shall not be construed as relieving or mitigating the Contractor of this responsibility.

1.2.10 Ownership

1.2.10.1 The following shall apply to the Contracting Authority contracts with electronic drawing deliverables:

1.2.10.1.1 (deleted)

1.2.10.1.2 Metra shall have authorization to take pictures/videos of Metra's materials with Metra's electronic devices at the Contractor's facilities. In addition, Metra requests authorization to take pictures of Metra's materials at the subcontractor's facilities at FAI. Metra will ask the product / area of pictures before taking pictures/videos. Metra shall have the right to use such media at anytime and anywhere in accordance to the confidentiality rights of this contract..

1.3 QUALITY ASSURANCE

1.3.1 The Contractor shall have a quality assurance program conforming to the FTA Quality Management System Guidelines, FTA-PA-27-5194-12.1 latest issue attached Quality Assurance Requirements. On a case-by-case basis, the Contracting Authority may approve the use of other quality guidelines recognized in the United States such as the quality assurance guidelines published by the Association of American Railroads. In addition, the Contractor's management shall submit a declaration of their commitment to quality and the implementation of the contractually required MQP and FTA QMS guidelines.

1.3.2 The contractor shall submit a copy of their quality assurance plan to the Contracting Authority for review. Metra shall be the sole judge of compliance of the Contractor's project specific quality assurance plan and program to the Contracting Authority's requirements and the appropriate quality assurance standards.

1.3.3 The Contractor shall provide an organizational chart to the Contracting Authority. The organizational chart shall depict the Contractor's overall management structure, reporting lines, authority and accountability among the Contractor's staff, subcontractors and the interfacing relationships between the Contracting Authority and the Contractor. A list of personnel assigned to the Contracting Authority's contract, their education, experience, accountability, and authority level shall also be provided.

1.3.4 Submission of a proposal gives the Contracting Authority the authority to perform assessments and inspections of the Contractor's and their subcontractor's facilities in order to perform a quality audit (s). Audit (s) shall be scheduled no later than 14 days from the Contracting Authority's notice to perform the audit.

1.3.4.1 The Contracting Authority may inspect tooling, procedure manuals, training programs, worker certification records, test gauges, inspection procedures, and subcontractor qualifications.

The audit will be styled after ISO 9001 and/or FTA Quality Management System Guidelines, FTA-PA-27-5194-12.1,

1.3.5 The Contracting Authority's authorized representative(s) shall have, at all reasonable times, access to the Contractor's and their subcontractor's facilities for the purpose of inspecting materials, workmanship, quality, and compliance to this specification. Refusal to permit such inspection may be construed as non-compliance with the Contracting Authority's specification and risks in cancellation of the proposal.

1.3.6 The presence of the Contracting Authority's representative(s) at the contractor's facility shall not in any manner supplant the contractor's own inspection, nor lessen the responsibility to meet all requirements of this specification. The Contracting Authority shall have the right to

reject all products, material and/or workmanship that does not conform to this specification or accepted practices.

1.3.7 The Contractor shall submit the following with CDRLs after 60 days of NTP for review, the Contracting Authority shall be the sole judge of compliance of the Contractor's submittals to the Contracting Authority's requirements and the appropriate quality assurance standards:

1.3.7.1 Contractor's Quality Assurance Program Plan and Procedures **[CDRL C-1-03]**
1.3.7.2 Contractor's organizational chart with personnel assigned to Metra's contract **[CDRL C-1-04]**
1.3.7.3 Contractor's management's declaration of their commitment to quality and the implementation of the contractually required MQP and FTA QMS guidelines **[CDRL C-1-05]**
1.3.7.4 Contractor's Project Quality Plan and Procedures **[CDRL C-1-06]**
1.3.7.5 Contractor's ratio of Inspection to Production Personnel **[CDRL C-1-07]**
1.3.7.6 Contractor's Software Quality Assurance Plan **[CDRL C-1-08]**
1.3.7.7 Contractor's System Supplier Qualification, Quality Compliance, and Management Plan and Procedures according to ISO 9001-2015 **[CDRL C-1-09]**
1.3.7.8 Contractor's List of all System suppliers , their qualifications, and quality certifications according to ISO 9001-2015 **[CDRL C-1-10]**
1.3.7.9 Contractor's First Article Inspection (FAI) Plan and Procedures **[CDRL C-1-11]**
1.3.7.10 Contractor's MRB Plan and Procedures **[CDRL C-1-12]**
1.3.7.11 Corrective and Preventative Plan and Procedures **[CDRL C-1-13]**

1.3.8 The proposer shall correct all deviations or deficiencies determined by the Contracting Authority. Failure to correct such deficiencies or repetitive notation of deficiencies shall be cause for cancellation of the contract.

1.3.9 Only substitutions equal (or better in comparison) to the specified items will be subject for approval by the Contracting Authority's designated Mechanical officer and only when such substitution is necessary. Before furnishing and/or installing any product that is a substitute for the specified item, proof of equality and quality shall be furnished by the Contractor. Then the written approval of the Contracting Authority's designated Mechanical officer must be obtained before any such decision is made. The Contacting Authority shall have the right to reject or accept the proposed substitution.

1.4 SYSTEM ASSURANCE

1.4.1 RELIABILITY PROGRAM

1.4.1.1 The Contractor shall incorporate reliability features into the trainset designs that minimize the type and impact of component failures, eliminate single point failures and identify critical components that affect system operation during the trainset useful life. These reliability features include:

1.4.1.1.1 Utilize mature designs for systems and components
1.4.1.1.2 Select suppliers with effective parts control programs
1.4.1.1.3 Minimize design complexity and dormant failure possibilities
1.4.1.1.4 Consider parts obsolescence in design process
1.4.1.1.5 Ensure component duty cycles do not exceed limits
1.4.1.1.6 Ensure heat sources are properly insulated from critical components
1.4.1.1.7 Ensure components are isolated to minimize shock and vibration:
1.4.1.1.8 Use EMI protection on all electronic equipment according to EN 50121
1.4.1.1.9 Use best reliability design practices.

1.4.1.2 The required reliability shall be achieved by utilizing components and subsystems of established and known reliability which have been demonstrated in revenue operation prior to Contract award. For new technologies (e.g. propulsion including battery system), which are not entirely service proven yet, the system reliability has to be checked by a theoretical analysis..

1.4.1.3 Reliability Requirements

The following specifies the revenue fleet reliability requirements:

	MDBF (miles)	MDBSI (miles)
After one month in service:	2,000	16,000
After 12 months in service:	4,000	32,000
At end of reliability demonstration period:	8,000	48,000

For the overall calculation only Chargeable failures will be considered.

Failure Classification:
MDBF - Mean Distance Between Failure (causing non service interruption).
MDBSI - Mean Distance Between Service Interruption (causing service interruption).

Non Service Interrupting Failures are defined as:
Failures that do not affect vehicle operation, or can be temporarily bypassed, reset or corrected by the train operator (following standard operational procedures) within 6 minutes, to allow continued service.

Service interrupting failures are defined as:

- An unscheduled maintenance action requiring the vehicle to be taken out of service.
- An unscheduled delay of six minutes or greater as a result of component failure.

The above failures exclude any failures due to third party influence or external factors.

Chargeable failure:
When assessing whether a chargeable failure has occurred, delays that are not a consequence of a defect in the vehicle (for example, delays caused by vehicle ahead or caused by vehicle operator/driver, or train master) should not be considered as a Chargeable Failure. The Authority and the operators are obliged to present information about the length of the delay related to a technical failure.

A chargeable failure of an item is a failure that results in a loss of function of that item, which requires maintenance, repair or replacement of a vehicle component, including:

a) A fault of an item while operating within its design and environmental specification limits.
b) Item degradation discovered during the recommended preventative maintenance interval or unscheduled maintenance repair activities.
c) Consumable items requiring replacement for abnormal service life depreciation, or which are not achieving its design life.
d) Loss of function resulting from the required resetting of circuit breakers, or similar re-initialization of systems, including the restarting of system software.
e) Failures caused by software.
f) A failure caused by human actions as a result of inadequate or improper Contractor documentation, training, or system indication.
g) Repeat failures, with the same root cause, on vehicles not removed from service or

returned to service without maintenance action shall be considered a single chargeable failure.

Non-chargeable failure:
A failure or condition of an item due to the following:

a) A failure caused by human error, except where due to inadequate or improper Contractor documentation or training.
b) A failure caused by Authority personnel not complying with the Contractors documentation, which has been approved and accepted by the Authority.
c) A failure caused by accidents not associated with the normal operation of the item, such as collision or strike.
d) A failure caused by operating the item outside of design or environmental specification limits.
e) Failure of consumable items requiring replacement during specified preventative maintenance, or which should have been replaced during previously scheduled preventative maintenance intervals and were not.

The following list contains examples of components that are excluded from Chargeable Failure.
The reason for excluding these components is that the replacement of these is a needs-based issue and that it is better to replace them, from a financial aspect, when they are defective or worn beyond a certain limit than to set a fixed preventive maintenance interval. This means the replacement/maintenance of these components is to be treated as remedial maintenance measures but not categorized as Faults. Before starting the validation, the Authority and the Contractor are to agree on a final version of this list:

- Windscreen wiper blades
- Interior lamps
- Lamps headlight
- Wheels
- Brake discs
- Brake pads
- All wear parts

The average train speed is determined to be thirty (30) miles per hour. The value will be used to convert to and from Mean Distance Between Failures (MDBF) and Mean Time Between Failures (MTBF).

1.4.1.4 (deleted)

1.4.1.5 The Contractor shall submit to the Program Manager for review and approval a Reliability Program Plan covering the design, manufacture, test and warranty phases of the project. **[CDRL C-1-14]**

The Plan shall include the following information as a minimum:

1.4.1.5.1 he identity of the Contractor's reliability engineer, the individual's qualifications, functions, responsibilities, and authority.

1.4.1.5.2 A description of the means by which the Contractor will control the design, manufacture, and testing of the vehicles to assure that they meet the reliability requirements of these Specifications.

1.4.1.5.3 The means by which this control will be exercised over subcontractors, suppliers, and vendors.

1.4.1.5.4 A description of the interfaces with other engineering activities and how they shall maximize the benefit of efficiency of all assigned engineering resources.

1.4.1.5.5 A description of the techniques to be used in the reliability analyses including Fault Tree Analysis (FTA) Fault Tree Analysis (FTA) shall be kept current with design iterations.

1.4.1.5.6 A Failure Reporting and Corrective Action System (FRACAS), including all procedures required to track defective parts, the equipment and facilities required for failure analyses, the procedures for developing corrective actions, and a discussion of the circumstances under which the Contractor will require and implement the corrective action.

1.4.1.5.7 A description of the interfaces with other engineering activities and how they shall maximize the benefit of efficiency of all assigned engineering resources. Other concurrent engineering activities addressed shall include maintainability, system safety and quality assurance.

1.4.1.6 The Contractor shall submit to the Program Manager for review and approval a Reliability Prediction Analysis report **[CDRL C-1-15]** for the following systems, demonstrating that the specified reliability requirements at the end of the Reliability Demonstration Period listed in section 1.4.1.3 will be met or exceeded:
- Trucks and Suspension
- Propulsion System
- Control Systems
- Auxiliary operating equipment
- Monitoring and Diagnostic Equipment
- Lighting System
- HVAC System
- Passenger Door System
- Communication and Information System
- Air Supply System
- Friction Brake System
- Coupler & Draft Gear
- Toilet System

The theoretical calculation of the MDBSI value shall use the following formula for prediction purposes:

$$MDBSI_{(c_1;c_n)} = \left(\sum_{k-1}^{n} \frac{1}{MDBSI_{(c_k)}}\right)^{-1}$$

1.4.1.7 The analysis shall be performed in accordance with EN 50126 to the Line Replaceable Unit (LRU) level. Fault Tree Analysis, FMECA and RAM/LCC calculations shall be considered where applicable. Wherever possible, the reliability prediction shall be supplemented by actual field data for the system or subsystem.

1.4.1.8 The Reliability Prediction Analysis shall be maintained and updated through the entire design phase. Updates shall report on design change, or problems that may affect trainset reliability.

1.4.1.9 The Contractor shall submit to the Program Manager for review and approval a Failure Mode Effects and Criticality Analysis (FMECA) **[CDRL C-1-16]** at train level The FMECA will be detailed to the LRU level for each subsystem and identify the failure effects at the LRU level, subsystem level and the train level.

1.4.1.10 The reliability of the cars, their components, and subsystems shall be demonstrated during revenue operation. The reliability demonstration shall commence with the Approval for Revenue Service of the first car and continue for a period of two (2) years. The system reliability values shall be calculated for each failure type as the sum total of all mileage traveled by all vehicles during a given time period, divided by the total number of each type of failure that occurred during the twelve (12) month moving window period.. The demonstration results shall be documented in a Reliability Demonstration Report. **[CDRL C-1-17]** All system failures during vehicle burn-in shall be reported and recorded, but not counted in establishing Reliability values. Determination of pass or fail will be assessed only at the end of the reliability demonstration.
During the demonstration, the trains shall be maintained by qualified maintenance personnel according to the maintenance plan and maintenance manuals provided by the Contractor.
The Reliability data is calculated as the ratio of the total operating distance (d), accumulated by all vehicles during the Reliability Demonstration Test, to the total number of chargeable failures (F) occurring on all vehicles during the distance (d). The calculation shall be:
MDBF = d (miles) / F (number of failures causing non service interruption)
MDBSI = d (miles) / F (number of failures causing service interruption)
For the overall calculation only Chargeable failures considered.

1.4.1.11 A Failure Review Board (FRB) shall be established. The FRB shall consist of representatives from Metra and the Contractor, and they shall review the failure report forms and logs to verify failure classifications and assign responsibility of failures. The FRB shall also continue to meet upon a mutually agreed upon interval after the conclusion of the reliability demonstration, specifically related to the failure of any items covered in the Warranty Period for Certain Components Section 2.7.3(1) of the Contract Terms and Conditions (i.e. carbody, door panels, floor materials, trucks).

1.4.2 MAINTAINABILITY PROGRAM

1.4.2.1 The Contractor shall incorporate maintainability features into the car designs that meet the testability, reparability and ease of maintenance of equipment and components that affect system operation during the car useful life according to the requirements in this specification. These maintainability features include:

1.4.2.1.1 The use of modular design
1.4.2.1.2 (deleted)
1.4.2.1.3 Accessibility of components and fasteners that are relevant for preventive maintenance tasks
1.4.2.1.4 Movability of replaceable components
1.4.2.1.5 Reparability including appropriate Maintenance Manual data
1.4.2.1.6 Appropriate self-test features
1.4.2.1.7 Built-in quick disconnect test points for air and electrical systems
1.4.2.1.8 General trouble shooting on the train shall be possible with a commissioning laptop.
1.4.2.1.9 Minimize the use of specialized tools in order to replace components
1.4.2.1.10 Equipment covers and access panels incorporate rugged, quick-removal fasteners, if it is necessary to open the covers or panels for regular preventive maintenance tasks and the quick-removal system can fulfill the structural requirements and improves the maintenance task time by more than 30%.

1.4.2.2 The Contractor may combine the details of the maintainability program into the Reliability Program Plan submittal.

1.4.2.3 The overall Mean Time to Repair (MTTR) target are 5 hours. The required special tools and fixtures for maintenance shall be subject to the Project Manager approval.

1.4.2.4 Except for daily inspections or air filter replacement, the minimum preventive maintenance interval shall not be less than 30 days.

1.4.2.5 The Contractor shall submit to the Program Manager for review and approval a Maintainability Analysis report **[CDRL C-1-18]** demonstrating that the specified MTTR requirements shall be achievable based on all LRU failure rate as well as their repair times. The report shall also include a scheduled maintenance analysis that identifies all required preventive maintenance activities, including inspections, tests, service tasks and equipment overhauls. The analysis must identify the maintenance tasks, task frequency, task times and support equipment required to perform the task. The data shall be summarized once by system and once by task frequency to identify all of the scheduled maintenance requirements. The Maintainability Analysis shall be maintained and updated through the entire design phase. Updates shall report on design change, or problems that may affect car maintainability.

1.4.2.6 A Maintainability Demonstration shall be performed to verify that the scheduled and preventive task durations fall within the times established by the Maintainability Analysis. A sample pool of maximum ten demonstration preventive maintenance tasks shall be provided to the Program Manager for selection and verification. The demonstration results shall be documented in a Maintainability Demonstration Report. **[CDRL C-1-19]**

1.4.3 SYSTEM SAFETY

1.4.3.1 The Contractor shall incorporate safety features into the car designs that minimize the type and impact of safety hazards, identify critical hazards and eliminate single point failures that affect system safety during the car useful life.

1.4.3.2 The Contractor shall submit to the Program Manager for review and approval a System Safety Program Plan covering the design, manufacture, test and warranty phases of the project. **[CDRL C-1-20]** The Plan shall include the following information as a minimum:

1.4.3.2.1 The identity of the Contractor's safety engineer, the individual's qualifications, functions, responsibilities, and authority

1.4.3.2.2 Details of the safety approach established by the Contractor in order to control the functional hazards of the new cars during their lifecycle

1.4.3.2.3 Detail procedures and resources established by the contractor in order to identify, document all hazards attributed to the new cars

1.4.3.2.4 Safety standards used by the Contractor in order to incorporate Safety during the design of the new trainsets

1.4.3.2.5 A specialized approach in order to evaluate all software hazards.

1.4.3.3 The Contractor shall submit to the Program Manager for review and approval a Preliminary Hazard Analysis **[CDRL C-1-21]** which will evaluate the control over the hazards identified during the design of the new cars. All hazards must be evaluated both at the system level as well as the car level per the requirements of MIL-STD-882. The analysis will be provided 30 days prior to PDR. Programmable safety controls shall be handled according to EN 50128 50129 (Hardware) and EN 50657 (Software). The railroad will provide the following items to the Contractor:

- Their own Part 270 approved SSP within ten (10) days after NTP for harmonization of the V-SSPP and associated safety documentation
- Lead on the Safety Committee and sufficient committee meetings to address all PHA topics in a timely manner prior all safety mile stones including PDR

1.4.3.4 The contractor must tabulate all known hazards from the Preliminary Hazard Analysis (PHA) on vehicle level into a Hazard Tracking Log **[CDRL C-1-22**], which shall be submitted to the Program Manager for review and approval. With PHA completion, the Hazard Log shall set up based on the PHA results and during design progress shall be refined via SSHA and SHA which per MIL STD are the applicable tools to analyze individual subsystems (SSHA) and their interaction in the integrated system (SHA). All new hazards identified during the design process will be added to the Hazard Log to maintain master list of all hazards. All hazards will remain open until the contractor demonstrates that the hazards have been eliminated or mitigated to an acceptable level for Metra approval. The contractor will provide a status of the Hazard Log progress in the monthly management report.

1.4.3.5 The Contractor shall submit to the Program Manager for review and approval a Fault Tree Analysis **[CDRL C-1-23]** for all applicable Category I and II hazards according the categories in Metra's SSP identified in the Preliminary Hazard Analysis. The Fault Tree Analysis shall use the component failure rate data identified in the reliability analyses to develop the probability for these hazards.

1.5 CONTRACT DELIVERABLES REQUIREMENTS LIST

CDRL	**Title**
C-1-01	Drawing Submittals
C-1-02	Car-Body Stress Analysis
C-1-03	Contractor's Quality Assurance Manual and Procedures
C-1-04	Contractor's Organizational Chart with Personnel Assigned to Metra's Contract
C-1-05	Contractor's Management's Declaration of their Commitment to Quality and the Implementation of the Contractually Required MQP and FTA QMS Guidelines
C-1-06	Contractor's Project Quality Plan and Procedures
C-1-07	Contractor's Ratio of Inspection to Production Personnel
C-1-08	Contractor's Software Quality Assurance Plan
C-1-09	Contractor's Supplier and Subcontractor Qualification, Quality Compliance, and Management Plan and Procedures

C-1-10	Contractor’s List of all supplier and subcontractors, their qualifications, and quality certifications (ANSI-ASQ ISO)
C-1-11	Contractor's First Article Inspection (FAI) Plan and Procedures
C-1-12	Contractor’s MRB Plan and Procedures
C-1-13	Corrective and Preventative Plan and Procedures
C-1-14	Reliability Program Plan
C-1-15	Reliability Prediction Analysis
C-1-16	Failure Modes, Effects and Criticality Analysis
C-1-17	Reliability Demonstration Report
C-1-18	Maintainability Analysis
C-1-19	Maintainability Demonstration
C-1-20	System Safety Program Plan
C-1-21	Preliminary Hazard Analysis
C-1-22	Hazard Tracking Log
C-1-23	Fault Tree Analysis

2 ABBREVIATIONS AND DEFINITIONS

AAR	Refers to the Association of American Railroads
ADA	Americans with Disabilities Act of 1990 as amended
ACORN	Automated Communications and On-Board Reporting Network
AISI	Refers to the American Iron and Steel Institute
AMOLED	Active-Matrix Organic Light-Emitting Diode
Amtrak	Refers to the National Railroad Passenger Corporation
ANSI	Refers to the American National Standards Institute
APTA	Refers to the American Public Transportation Association (formally known as the American Public Transit Association)
ASME	Refers to American Society of Mechanical Engineers
ASTM	Refers to American Society for Testing Materials
AWS	Refers to American Welding Society
AW0	Actual weight of empty car, ready for revenue service, but with neither crew nor passengers aboard. Includes full fresh water supply and empty waste system.
AW1	Car at seated load and no standees. Seated load is defined as all the passenger seats occupied plus one crew member per car.
AW2	Car at normal full load. Normal full load is defined as seated load plus one standee per 3 ft^2 of clear floor space.
AW3	Car at crush load. Crush load is defined as seated load plus one standee per 1.5 ft^2 of clear floor space.
BNSF RR	Refers to the Burlington Northern Santa Fe Railroad
Contracting Authority	Refers to the agency with whom the carbuilder signs a contract with
FDR	Final Design Review
FRA	Refers to the Federal Railroad Administration of the United States Department of Transportation
ICDB	Refers to the Illinois Capital Development Board
IDR	Intermediate Design Review
IDOT	Refers to the Illinois Department of Transportation

IEEE	Refers to the Institute of Electrical and Electronic Engineers
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
Low Voltage DC	Low voltage DC refers to nominal DC voltages of less than or equal to 80 VDC
Metra	Refers to the Commuter Rail Division of the Regional Transportation Authority
NEMA	Refers to the National Electrical Manufacturers Association
NS	Norfolk Southern Railroad
OLED	Organic Light-Emitting Diode
PDR	Preliminary Design Review
RTA	Refers to the Regional Transportation Authority
TOD	Train Operator Display
TFT	Thin-Film-Transistor
UP RR	Refers to the Union Pacific Railroad
US	United States of America

Contractor	Refers to the firm with whom a contract is made by Metra for the construction of the cars described in this specification
OEM	Refers to the manufacturer of one or more components to be applied to the subject cars during the work performed under this specification
Sub-Contractor	Refers to any shop, manufacturer, or other company or agency performing work on the subject cars under this specification, under contract to, or for, the Contractor.

3 DIMENSIONS AND CLEARANCES

3.1 PRINCIPAL DIMENSIONS

The principal dimensions and dimensional requirements shall be as follows:

3.1.1 The total length of the vehicle measured over the coupler shall not exceed the following lengths:
- Two (2) car unit + PowerPack: 170'
- Three (3) car unit + PowerPack: 222'
- Four (4) car unit + PowerPack: 275'

3.1.2 Width of Car: The vehicles' width and attached equipment shall be built within the outline of the Equipment Diagram, Plate C as defined by Association of American Railroads (AAR).

3.1.3 Height of Car: The vehicles height and attached equipment shall be built within the outline of the Equipment Diagram, Plate C as defined by Association of American Railroads (AAR).

3.1.4 Centerline of Coupler above top of rail: 2' – 10 ½''

3.1.5 Track Gauge: 4' – 8 ½''

3.1.6 Seating Capacity: Seated capacity to be maximized **[PDRL P-3-03]**

3.1.6.1 (deleted)

3.1.6.2 End Cars without Toilets: Seating diagram shall be submitted counting total seats and total seats + 2 ADA positions occupied.

3.1.6.3 Middle Cars with Toilets: Seating diagram shall be submitted counting total seats and total seats + 2 ADA positions occupied.

3.1.6.4 (deleted)

3.1.7 General Arrangement: Interior layout design of seating, aisle(s), and door(s) for the trainset shall be designed to allow the most efficient passenger flow possible. Along with providing general arrangement drawing, the proposer shall provide a passenger flow analysis for five different scenarios estimating the station stop time from the time doors open and passengers begin detraining/entraining until last person entrains/detrains and door closes. The five scenarios for trainset are listed below: **[PDRL P-3-04]**

3.1.7.1 60 passengers entraining/ 0 detraining
3.1.7.2 60 passengers detraining/ 0 entraining
3.1.7.3 (deleted)
3.1.7.4 40 passengers entraining/ 20 passengers detraining
3.1.7.5 (deleted)

3.1.8 (deleted)

3.1.9 Weight: Car total weight shall be minimized. Car weights shall be submitted at AW0, AW1, AW2 and AW3. The maximum axle load shall not exceed 22 tons (48,500 lbs) under AW3 loading conditions. All cars shall be weighed at Contractor's facility. Car estimated weight for

each car type shall be submitted during project execution at AW0, AW1, AW2, and AW3. **[CDRL C-3-02]**

3.1.9.1 The total weight difference between left and right vehicle side shall be less than 1,5% of total weight. The weight difference between on side of a truck to the other side of the same truck shall be less than 4%

3.1.9.2 All cars shall be within a specified weight range, to be mutually agreed upon between Metra and carbuilder during the design phase of the first production car of each type of car.

3.1.10 Passenger Weight: 165 lbs. per passenger, includes seated or standees.

3.2 CLEARANCES

3.2.1 The cars, when coupled to each other shall be able to negotiate the following:

3.2.1.1 A 300' radius curve

3.2.1.2 (deleted)

3.2.1.3 (deleted)

3.2.2 The cars, and all appliances, shall conform to the clearance outlined in Equipment Diagram, Plate C as defined by Association of American Railroads (AAR).

3.2.2.1 (deleted)
3.2.2.2 (deleted)
3.2.2.3 (deleted)
3.2.2.4 (deleted)
3.2.2.5 (deleted)
3.2.2.6 (deleted)

The clearance diagram for the car shall be submitted to the Contracting Authority for review and approval. **[CDRL C-3-01]**

3.2.3 The clearance to top of rail shall be according to CFR49 229.71. No part, or appliance except the wheels, flexible nonmetallic sand pipe extension tips, and trip cock arms may be less than two and a half (2 1⁄2) inches above the top of rail.:

3.2.3.1 (deleted)

3.3 (deleted)

3.3.1 (deleted)

3.4 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	**Title**
P-3-01	Car Width
P-3-02	Car Height
P-3-03	Seating Capacity
P-3-04	Passenger Flow
P-3-05	(deleted)

3.5 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-3-01	Clearance Diagram
C-3-02	Car Weight

4 CAR BODY EXTERIOR

4.1 STRUCTURAL FRAMING

4.1.1 The car exterior shall be constructed of an approved corrosion resistant material. The contractor shall submit as part of the proposal, a general arrangement drawing of proposed design and artist rendering of the exterior of car. The drawing shall include views to show details of end car arrangement and identify location of major components/systems. **[PDRL P-4-01]**

4.1.2 The Customer's ZEMU vehicles will be used in unit consists of two cab cars coupled to middle cars inserted between the two cab cars in sufficient quantities to meet the Customer's passenger capacity requirements. The carbodies are an integral aluminum design optimized for light weight, stiffness and structural integrity. Carbody aluminum alloys are in accordance with EN 13981, EN 755-1 and -2+9, EN 1706, EN 586-1.

4.1.3 Features important to passenger safety and comfort and to operational requirements on the Customer's system must govern the carbody design. 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.

4.1.4 Emergency roof access areas will be designed as per 49 CFR 238.123. In the vicinity of roof-mounted equipment and where maintenance personnel might stand, the roof shall support a concentrated load of 500 lbf (2,224 N) over an area of 0.75 ft2 (0.07 m2) without permanent deformation. Safety factors, such as overall carbody strength in conformance with the most recent CFR regulations, APTA standards, fatigue resistance, emergency egress openings, required by 49 CFR Part 238 Appendix B shall be considered. Design and layout of the emergency roof access shall be provided to Metra for review and approval. **[CDRL C-4-03]**

4.1.5 The car bodies shall be made out of aluminum extrusion profiles welded to an integral design..

4.1.6 The vehicle structure shall be designed to sustain collisions with other vehicles, including highway vehicles ranging from large automobiles to commercial tractor-trailer trucks without unnecessary risk of injury to passengers or Operators. The end structure shall be designed in accordance with 49 CFR 238. Operator and passenger protection shall also be designed into the carbody structure. The vehicle ends shall be designed to prevent overriding and telescoping of the vehicle into any passenger area in the event of a collision. The Contractor shall implement Crash Energy Management (CEM) designs in accordance with Appendix G of 49 CFR Part 238.

4.1.7 The draft sill arrangement and coupler shall be such as to meet the clearance requirements of section 3.2.1. Final design review of the carbody structure shall be submitted

to Metra for review and approval. **[CDRL C-4-05]** All welds shall be inspected in accordance with the Contractor's quality control plan which shall be approved by Metra.

4.1.8 Both ends of trainset shall have anti-climbing mechanism complying with FRA regulation 49 CFR Part 238. Appendix G and Section 5.5 of APTA Standard SSC& S-034-99, latest Revision. At a minimum, each end of each vehicle shall be fitted with an anti-climber having a minimum of three ribs. The height of the anti-climber shall be sufficient to ensure engagement with differences in floor height due to secondary suspension travel, track geometry, and wheel wear.

4.1.9 The vehicle shall be capable of being hoisted or jacked at designated carbody locations (including the weight of trucks) without permanent deformation, buckling, or loss of water tightness in carbody seams and joints, to facilitate routine maintenance operations, emergency lifting, or re-railing. Maximum stress level shall be fifty percent (50%) of the yield strength of the base material. Alternatively, EN 12663-1 may be applied. The location of the jacking pads will be submitted to Metra for approval. **[CDRL C-4-06]** Where practical, lifting points shall be masked or styled to match the vehicle aesthetics, but must be readily accessible with simple hand tools.

4.1.10 Rain gutters shall be provided over the passenger side entrance doors, any exterior electronic devices, and over each diaphragm. The rain gutter shall be of such design to withstand the action of car washing machines. In addition, suitable baffles shall be placed at the ends of the roof to prevent the flow of water from running off onto the top of the diaphragm.

4.2 INSULATION

4.2.1 Thermal and acoustical insulation shall be provided in order to ensure reasonable operating costs and compliance with Sections 9.0 and 20.0 of these specifications. Samples of insulating materials shall be submitted to Metra for review and approval. **[CDRL C-4-07]**

4.2.2 Insulation must not support combustion, must not absorb moisture beyond its own weight, and when wet, must not cause corrosion. Insulation must not be subject to shaking down in long service and retained by a means adequate to ensure this requirement. Insulation used must be non-corrosive to aluminum and must not require special surface treatment of aluminum. Insulation shall preferably be light in weight, and type and density shall be approved by Metra.

4.2.3 All cars shall be well insulated against sound transmission inside car to greatest extent practicable. Corrosion exposed areas on the inside surface of the outer shell of the car, including sides, ends, roof and floor areas and the underside of all metal steps shall be coated in accordance with manufacturers recommendations. For certain specific discreet areas, other materials approved by Metra may be used.

4.2.4 The floor, roof, sides and ends of the cars shall be insulated. The heat transfer through the car-body shall not exceed 1,200 Btu/hr/°F. The Contractor shall supply a thermal analysis of a completed stationary car for Metra review and approval based on the environmental conditions that will be mutually agreed upon between the Contractor and Metra. **[CDRL C-4-08]**

4.2.5 Installation of HVAC duct and piping insulation shall be subject to Metra approval. **[CDRL C-4-09]**

4.3 GANGWAY/BELLOW

4.3.1 A weather-tight, flexible diaphragm or bellow shall seal the passageway between two adjacent cars. The diaphragm or bellow shall be watertight as to prevent any water from entering the carbody using the existing Customer's car wash station, and shall comply with the fire safety requirements of Section 21.16, Flammability, Smoke Emission, and Toxicity.

4.3.2 The diaphragm or bellow shall be able to accommodate all curving and environmental conditions without interference, degrading, cracking, tearing, or separation from the vehicle. The diaphragm or bellow shall maintain a tight seal to the opposing car end diaphragm under all conditions of curvature, turnouts, and crossovers encountered in normal passenger operation. The diaphragm or bellow shall not lose its sealing ability under temperature conditions to be defined by Metra.

4.3.3 All necessary provisions shall be made to eliminate noise from the equipment. If needed, a full height vertical curtain of suitable vinyl plastic coated/impregnated material, equipped with safety release handles, or sliding doors shall be provided in between the coupled cars of a trainset. Engagement of curtains, or sliding doors shall be designed for silence during train movement.

4.3.4 Slip resistant walkway plates shall be provided at each end of each car to provide a continuous walkway from car to car when coupled together. Pinch points, formation of large gaps during operation, sharp edges, openings, or trip hazards that could cause bodily harm to passengers are prohibited. Walkway plates, hinged to the carbody, shall be provided at each non-cab end of each car to provide a continuous walkway from car to car.

4.3.5 The entire diaphragm or bellow and walkway arrangement, including construction details shall be subject to review and approval of Metra. **[CDRL C-4-10]**

4.4 WINDOWS

4.4.1 All windows including emergency sash, cab sliding sash and windshields shall be capable of withstanding external and internal pressure differentials caused by head-on pressures and passing trains, while the cars are at maximum operating speed. All glazing shall meet or exceed the requirements of FRA Regulations 49 CFR Part 223 and Part 238.

4.4.2 Passenger compartment side windows shall be single or double-paned, set in one piece and continuous. The arrangement shall utilize abrasion resistant material, gray tinted, complying with Section 21.8.1 of these specifications. The arrangement shall comply with FRA Type II requirements.

4.4.3 Ingress emergency windows shall be provided per 49 CFR Part 238.114. A decal providing instruction for window removal (ref. section 19.1.11) shall be applied to the exterior of the car, adjacent to each window. Location of these windows is subject to Metra approval. **[CDRL C-4-11]**

4.4.4 Egress emergency windows utilizing a bottom pivot escape sash, meeting the requirements of FRA Regulation 238.113 and 223 (Type II), shall be installed in each car. The egress windows shall be prominently identified to passengers, and in readily accessible locations. The sash shall be designed to be opened in an emergency with fifteen (15) pounds plus/minus three (3) pounds of force,but shall not be dislodged except through emergency procedure. Final location and design of the escape sash is subject to approval. **[CDRL C-4-12]** The glazing material for these sash shall be the same type as used in passenger compartment side windows (Section 4.4.2). Instruct ion on the procedures to open the escape sash shall be posted on the operating bar of each escape sash in photo luminescent material along with pictorial instructions adjacent to the sash. The photo luminescent instructions shall comply with

APTA PR-PS-S-002-98, latest revision, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment.

4.4.5 The toilet room shall not be provided with a window

4.4.6 On cab control cars, laminated safety glass, electrically heated windshields, complying with Section 18 of these specifications shall be provided in the end-sheet in front of the operator's and observer's positions. The arrangement shall comply with FRA Type I requirements. The windshields shall be replaceable from the outside of the vehicle.

4.4.7 On cab control cars, a horizontal pivot sash assembly shall be provided on each side of the control station. The sash assembly shall suit the minimum structural opening. Left and right hand versions shall be provided. The sash shall meet FRA Type II requirements

4.4.8 All window components shall meet the flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification.

4.5 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-4-01	Exterior General Arrangement and Rendering

4.6 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-4-01	(deleted)
C-4-02	Car-Body Strength Test Document
C-4-03	Emergency Roof Access
C-4-04	End Structure Design
C-4-05	Cross Bearer and Underframe Design
C-4-06	Jacking Pad Location
C-4-07	Insulation Samples.
C-4-08	Thermal Analysis
C-4-09	HVAC Duct and Piping Insulation Installation
C-4-10	Diaphragm/Gangway Design and Installation
C-4-11	Ingress Emergency Window Layout
C-4-12	Egress Emergency Window Layout and Design

5 SAFETY APPLIANCES AND INTERIOR HANDHOLDS

5.1 GENERAL REQUIREMENTS

5.1.1 All safety appliances and interior handholds shall comply with all FRA requirements.

5.1.2 Side sill steps shall be installed at each corner of each car, along with lower side sill. Side sill steps shall be of forged stainless steel with a satin finish, and shall be applied with stainless steel bolts. Stepping surfaces of sill steps shall not have a satin finish, but a finish designed to minimize slipping.
A waiver of the applicable CFR requirements may be applied, based on the alternative design of the trainset to negate this requirement.

5.1.3 Handholds shall be provided in an approved manner and must be of approved design. The location, application and arrangement of all these assemblies are subject to approval by Metra. **[CDRL C-5-01]** Handholds finished ground size shall be 5/8" minimum diameter, type 302 stainless steel rod or equivalent, given polishing treatment after forging to remove burrs, surface defects and discoloration and shall be applied with stainless steel bolts or cap screws. The following handholds shall be installed on the outside of car:

5.1.3.1 Two (2) vertical handholds at each side entrance door opening
5.1.3.2 Two (2) horizontal handholds above each set of side sill steps; A waiver of the applicable CFR requirements may be applied, based on the alternative design of the trainset to negate this requirement.
5.1.3.3 Two (2) horizontal handholds on each cab end at approximately 44" above top of rail on each side of coupler; A waiver of the applicable CFR requirements may be applied, based on the alternative design of the trainset to negate this requirement.
5.1.3.4 (delete)

5.1.4 A safety device shall be supplied at car ends that a crew member can utilize to prevent unauthorized entry into another car but shall not prevent emergency egress. Design of the safety device shall be subject to Metra design review and approval. **[CDRL C-5-02]**

5.1.5 The car interior must be provided with handholds, railings and stanchions as are required for safety and convenience of passengers and crew. The location, application and arrangement of all these assemblies are subject to approval by Metra. **[CDRL C-5-03]** All installations shall be free of rattles and squeaks and, comply with APTA standards for attachment of interior fittings, APTA Standard PR-CS-S-006-98 latest revision

5.1.5.1 The passenger boarding/alighting area, immediately adjacent to each set of side doors, shall be provided with stanchions and/or handholds for passenger safety. The stanchions and handrails shall meet current ADA requirements.

5.2 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-5-01	Exterior Safety Appliance and Handhold Design and Installation
C-5-02	Safety Gate Design
C-5-03	Interior Safety Appliance and Handhold Design and Installation

6 DRAFT ARRANGEMENT

6.1 GENERAL REQUIREMENTS

6.1.1 Each outermost end of the trainset shall be equipped with a fully automatic mechanical, pneumatic, and electrical coupler system of the symmetrical, automatic, slack-free type (Scharfenberg Type 10). Couplers and apparatus, including attachment to the car body and underframe, shall meet or exceed the requirements of FRA Regulation 49 CFR 238, EN 12663-1 (vehicle category P-II) or DIN 25201. Coupler, yoke, draft gear, and carrier design and their integration into the vehicle shall be submitted for approval. **[CDRL C-6-01]**

6.1.2 End couplers, intermediate coupling assemblies, draft gear and associated components shall conform to the strength requirements per FRA Regulation 49 CFR 238. If draft gears are used at the intermediate coupling assemblies, their characteristics shall be designed to take into account the overall trainset ride quality.

6.1.3 Each cab end shall be provisioned to store a Type F coupler adapter and accompanying hose connections for use in rescue operations.

6.1.4 (deleted)

6.1.5 (deleted)

6.1.6 (deleted)

6.2 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	**Title**
C-6-01	Coupler System Design

7 DOORS

7.1 GENERAL REQUIREMENTS

7.1.1 All side and end door systems shall be designed and manufactured with an emphasis on addressing the following areas of concern:

7.1.1.1 Unsafe conditions for passengers or crew members
7.1.1.2 Train delays from malfunctioning side door equipment
7.1.1.3 System reliability in adverse operational and environmental conditions
7.1.1.4 Time and effort required for troubleshooting and repairs

7.1.2 A proposal shall be submitted of all doors systems addressing the four bullet points above in 7.1.1. **[PDRL P-7-01]**

7.2 EXTERIOR PASSENGER ENTRANCE DOORS

7.2.1 Passenger side entrance doors are to be electrically operated bi-parting sliding type doors located on the side of the car. Exterior passenger entrance door systems shall utilize a linear door operator. The door system shall comply with the latest revision of APTA specification APTA PR-M-S-018-10 and APTA PR-CS-S-012-02. The door design configuration for side loading doors shall be submitted to Metra for review and acceptance. **[CDRL C-7-01]** Minimum clear door openings shall be designed to load or unload a ADA bound passenger along with a regular passenger simultaneously. As a minimum, the door header shall provide no less than 5'-10" clearance over the mobility aid lift platform when in the raised position. Door openings shall be designed in compliance with ADA & FRA requirements and allow safe passenger loading. If provision exists for passengers to operate doors, such as at a terminal, the provision shall be touchless for both interior and exterior of car.

7.2.2 The door panels shall maintain both the internal and external vehicle aesthetics to the largest extent possible when closed. Door surfaces must be flat and in plane within 1/8”. The door panels shall have a window of clear abrasion resistant polycarbonate or equivalent set in one piece, vulcanized, rubber glazing strips or aluminum sash, as required to comply with FRA Type II regulations. Doors shall be designed to provide sufficient strength and rigidity to withstand a force of 200 lbs. perpendicular to the door surface applied on an area 24" x 12", with a maximum deflection of 0.3" with the area's long axis parallel to that of the door, 2" from the door edge and centered within the height of the door. All door edges and openings shall be thoroughly sealed against moisture ingress. Each door shall be equipped with an interlocking rubber nosing, extending the full height of the door on the leading edge. When doors are closed the two interlocking nosing shall mate and form a weather-tight joint. Static seals shall be provided in the door opening to seal the door trailing edges when the doors are closed. An approved recessed door pull shall be provided on each side of each door leaf. The door pulls shall be installed in such a manner as to prevent moisture from entering into the core of the door panel.

7.2.3 The doors shall be supported from the top by means of a hanger/track assembly and shall be guided at the bottom in a manner providing freedom from rattles and squeaks. The door support and guide arrangement shall be easily available for adjustment and maintenance through the use of access doors or removable panels. Stops shall be provided at both ends of travel to protect the door and the operating mechanism. The stops shall be strong enough to withstand 8g impact of the door mass without damage. The door bottom guides shall be of a suitable type and the surface of the step tread shall be designed to minimize passenger slipping and tripping while allowing free movement of the doors. The design of both step tread and door guide shall provide for free drainage of moisture to the outside.

7.2.4 The linear door operator provided to operate the side doors shall be concealed so that it is not directly visible when the door is in the fully closed or open position.

7.2.5 The motion of the doors shall approximate simple harmonic motion and thereby provide cushioning in both opening and closing. A sensitive edge mechanism, per APTA specification PR-M-S-018-10, shall be provided in the door system to immediately reactivate the opening cycle upon striking any object. The speed of the doors shall be such that from the moment of actuating the appropriate door control buttons until the completion of the operation, including cushioning, the following times are obtained:

7.2.5.1 Opening 2.0 to 3.0 seconds
7.2.5.2 Closing 3.5 to 4.5 seconds, after time delay (reference section 7.1.7)

Adjustment shall be provided to enable these items to be maintained throughout the door operator life and shall be readily accessible.

7.2.6 The side entrance door control system shall be trainlined to permit operation of all side entrance doors on one side of the train from any individual car door control switch panel on the same side of the train. Each switch panel shall be fitted with six (6) push buttons arranged in two rows. Buttons shall be paired for opening and closing doors: 1) forward from the position, 2) locally and, 3) rearward from the position. Pairs of buttons shall be marked as follows: "LEFT", "LOCAL", and "RIGHT". The control panel shall be equipped with a key (Metra's standard coach key, Drawing M-250) operated mechanism to lock the buttons thus protecting against unauthorized operation of the doors and should have an escutcheon for the key per Metra drawing M-1952. The construction of the mechanism shall allow the key to be removed in the “OFF” position only and shall not cause the train door to change their position. The door control system shall feature a time delay for door closing. When a closing command is made (locally or trainlined) a door closing warning system consisting of an audio and visual alarm shall be activated immediately. The doors will begin closing four (4) seconds later. The door closing timing and announcement should match Metra’s current fleet configuration. The Contractor shall submit a design to Metra for review and approval. **[CDRL C-7-02]**

7.2.7 A door lock function shall positively retain the door panel in the closed position without relying on electrical power. The lock shall automatically engage when the door panels at a doorway reach the closed position. A manual release device accessible to passengers shall be provided at each door location to release the door lock and allow the door panels to be manually opened in an emergency. Instructions for opening doors in an emergency shall be provided adjacent to the handle/device. Instructions shall be printed on photo luminescent material compliant with APTA Specification PR-PS-S-002-98, latest revision, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment.

7.2.8 External access for manual release of the door lock shall also be provided. Instructions for opening doors in an emergency shall be provided adjacent to the handle/device. Instructions shall be printed on retro-reflective material. The design and location of external manual releases shall be subject to Metra review and approval. **[CDRL C-7-03]**

7.2.9 Traction interlock with door controls is required. The Contractor shall submit a design to Metra for approval. **[CDRL C-7-04]**

7.2.10 Doors shall not open unless at zero speed, except a “This Door Only” or “Local” button shall function at all speeds when the Master Door Controller is keyed up. No traction effort shall be possible when any door is open, except a door which has been opened by the “This Door

Only" or "Local" button shall remain open if the Master Door Controller remains keyed on, as long as the speed is below 20mph according to APTA PR-M-S-018-10.

7.2.11 The exterior passenger side loading doors shall have an emergency release mechanism that shall not require the availability of electric or pneumatic power per APTA standard APTA-PR-CS-S-012-02 latest revision. Neither shall the emergency release mechanism require the presence of any interlock signals (e.g. "low speed" or "zero speed" signals) for actuation. When actuated, the emergency release mechanism shall override any locks and it shall be possible to manually open the released door with a force not to exceed 35 lbf. The emergency release mechanism shall require manual resetting.

7.2.12 A system shall be provided to detect when the car is in motion per APTA Standard APTA-PR-M-S-018-10.latest revision. Motion detection may be local or trainlined. When motion is detected, opening of all doors on the car (except crew doors) shall be prevented. The Contractor shall submit a design to Metra for approval. **[CDRL C-7-05]** An exterior with a key (Metra's standard coach key, Drawing M-250) operated crew switch shall be provided to open/close for each set of side doors. The Contractor shall submit a design to Metra for approval.

7.3 INTER-CAR DOORS

7.3.1 Inter-car doors shall be capable of automatically (activation without touch) opening and closing, sliding type. Door system shall have a manual feature to open and close in case of loss of power. The automatic door shall operate the adjacent end door to enable passengers or crew members to move between cars. The doors shall slide in a straight line into door pockets placed on the inside of the end walls.

7.3.2 All doors and edges shall be sealed against moisture ingress. The door panel shall have a window of clear abrasion resistant polycarbonate set in one piece, vulcanized, rubber glazing strips or aluminum sash as required to comply with FRA Type II regulations. Glazing/elastomer materials shall meet the flammability and smoke emission standards per FRA regulation 49CFR part 238.103 and toxicity requirements per Boeing BSS-7239, or Bombardier specification SMP 800-C. Doors shall be designed to provide sufficient strength and rigidity to withstand a force of 200 lbs. perpendicular to the door surface applied on an area 24" x 12", with a maximum deflection of 0.3" with the area's long axis parallel to that of the door, 2" from the door edge and centered within the height of the door. Each door shall be equipped with rubber nosing, extending the full height of the door on the leading edge. When the door is closed, the nosing shall form an air tight seal with the door jamb.

7.3.3 The door closing and opening device (or door operator) must be provided in a concealed but readily accessible for maintenance.

7.3.4 The doors shall be of a service proven design and it shall be subject to Metra design review and approval. [CDRL C-7-10].

7.3.5 Body end doors shall be lockable from either side only by Metra's standard coach key (Drawing M-250).

7.3.6 An approved manually operated, rattle-free latching device shall be provided such that when in use, the device shall hold the doors in an open position

7.4 ELECTRIC LOCKER DOORS/CREW LOCKER DOOR

7.4.1 Lockable doors shall be provided for all electric lockers and crew lockers. Aesthetics of the doors shall match interior design of the car. Where practical, a recessed door pull shall be provided on the exterior face of each door. If needed electric locker doors shall be equipped with grilles at the top and bottom to allow circulation of air. Design of electric/crew locker doors shall be subject to Metra design review and approval. **[CDRL C-7-08]**

7.5 CONTROL STATION DOORS

7.5.1 On cab control cars, a door(s) shall be provided from the passenger area of the car to the control station. These door(s) shall be operable from outside the cab by a rotating handle and shall be operable from the inside by a panic crash bar, requiring no turning of a handle. The door(s) shall be lockable from the cab side with a manual slide, and on the passenger side by Metra's standard coach key. Each of the control station door(s) shall be designed with intrusion resistance that meets or is greater than that listed in Federal Aviation Administration (FAA) Advisory Circular (AC) 25.795-1A, dated 10/24/08. The Contractor shall submit the design of the control station door(s) for Metra review and approval. **[CDRL C-7-09]**

7.5.2 The door shall have a decal on the outside (facing into passenger compartment) per Metra drawing M-1968 stating “Warning – No Unauthorized Personnel Beyond This Point – Violators Will Be Prosecuted”.

7.6 TOILET ROOM DOOR

7.6.1 The door from the passageway to the toilet room shall be automatically (activation without touch) open/close sliding type. Doors shall be designed to open and close manually in the event of power loss. The Contractor shall submit the design of the toilet room door system for Metra review and approval. **[CDRL C-7-11]** Minimum clear door opening per current ADA requirements, ANSI A117.1.

7.6.2 The door pull/passage set shall be lockable on the toilet side manually, and on the other side by Metra's standard coach key.

7.7 WEATHERSTRIPPING

7.7.1 Adequate weather stripping shall be provided to provide satisfactory seals at door openings where airtight weatherproof conditions are required.

7.8 HARDWARE

7.8.1 Recessed rubber bumpers are to be used on all hinged doors to prevent rattling. The bumpers are to be mounted with screws, or by other approved means. All exterior and interior lock sets, including cases, handles, pulls and escutcheons shall be of unpainted white bronze unless otherwise specified. Hinges shall be stainless steel.

7.9 FIRE SAFETY

7.9.1 All door components shall meet the flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 21.16 of this specification.

7.10 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	**Title**
P-7-01	Door System

7.11 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-7-01	Side Loading Door Design and Configuration
C-7-02	Side Loading Timing and Announcement
C-7-03	External Door Release Design
C-7-04	Traction Interlock
C-7-05	No Motion/Zero Speed System
C-7-06	Passenger Compartment Door Panel Design (If Applicable)
C-7-07	Passenger Compartment Door Hold Open (If Applicable)
C-7-08	Electric/Crew Locker Door
C-7-09	Cab Door Panel Design
C-7-10	Inter-Car Door Design and Configuration
C-7-11	Toilet Door Design and Configuration

8 CAR BODY INTERIOR

8.1 INTERIOR FINISH

8.1.1 GENERAL

8.1.1.1 Interior renderings of all levels of the car shall be submitted with the proposal cross sectional views of the car interior (both longitudinal and transverse) shall be included. Proposer shall note plan on how small passenger baggage (computer bags, backpacks, purses) will be accommodated for in the car design, including what percentage of seated passengers will have a location that can accommodate small baggage. **[PDRL P-8-01]**

8.1.1.2 Plastic and plastic faced material shall be integrally colored in the exposed face. It shall be of low glare unless otherwise specified. Samples of all surface treatments that are exposed to Metra's passengers or operating crews shall be submitted for approval**. [CDRL C-8-01]**

8.1.1.3 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.

8.1.2 SIDE FINISH

8.1.2.1 A formed panel made of thermoform plastic material, or alternative material meeting specified flammability and smoke emission standards, as stated in Section 21.16 shall form the window frame. The design and construction of the panel shall be subject to Metra review and approval. **[CDRL C-8-02]**

8.1.2.2 The interior surface of all toilet room walls are to be lined with stainless steel or a material suitable for this environment. Wall material shall be resistant to cleaner solutions, water, salt, other corrosive agents, etc.

8.1.2.3 The interior surface of all walls of the operator's stations in cab cars shall be lined with a non-glare material. Any area not conducive to non-glare material application, including desk and upper console, shall be painted flat black.

8.1.3 PARTITIONS, LOCKERS, ETC.

8.1.3.1 The air ducts in the vicinity of the overhead heaters (if used) shall be constructed of stainless steel.

8.1.3.2 A crew locker shall be provided in a location approved by Metra. One coat hook shall be provided inside wall in the crew locker.

8.1.3.3 Cab lockers shall be lockable with a Metra standard coach key. The Contractor shall submit design specifications and drawings of each internal design of both the Engineer's side and observer's side locker for Metra approval. **[CDRL C-8-03]**

8.1.3.4 On cab control cars, a locker to house cab signal protective system and other equipment shall be installed. The lockers shall be lockable with a Metra standard coach key.

8.2 FLOORING

8.2.1 The flooring shall meet the 49CFR238 Appendix B and Boeing BSS 7239, or Bombardier SMP 800-C for toxicity, including a thirty-minute fire resistance test (testing to ASTM E119) per 49 CFR 238.103 and NFPA 130 with the car builder's structural configuration. All floor panels

shall be capable of withstanding the requirements of ASTM E119 when exposed for 30 minutes or greater on the carbody underside. Test reports must refer to 49CFR238 Appendix B testing condition and criteria, as well as the ASTM codes, and must be provided to Metra for review and approval. **[CDRL C-8-04]** Floor panels shall be as large as possible, but should only be as wide as the compartment it is in. Cab floor panels shall be able to stay if replacing adjacent floor panel and vice versa. Lavatory floor panel(s) shall not extend beyond the lavatory compartment. Floors shall be able to be replaced without cutting around lockers and compartments. Panels shall extend full width of the car (where possible) with all joints located over structural members. Floor panels shall be bonded to the floor beams to isolate them from the carbody structure. The floor shall be leveled to provide a flat surface. Height variations between panels shall be no greater than 0.030 inch. Gaps between panels shall be sealed against incoming dirt, moisture, and water using appropriate flexible sealant that allows for thermal expansion and contraction of panels. Design and details of the floor system shall be submitted to Metra for review and approval. **[CDRL C-8-05]**

8.2.2 The floor panels shall not deflect more than 1/250 of the shorter span between supports, up to a maximum of 0.170 inch, whichever is less, with a uniformly distributed AW3 load state.

8.2.3 Floor surfaces on all passenger and crew sections shall conform ASTM D2047 and ASTM C-1028 coefficient of friction shall be greater than or equal to 0.8 for both wet and dry conditions. Test reports must be provided to Metra for approval. The floor surface shall be hard and highly durable in order to last 40 years in service without major repair. Floor surface shall be easy to repair. Repaired area shall not be visibly detectable. Mechanical integrity of the floor panel shall be maintained after repair. ADA passenger locations in the car shall be designated with the proper ADA signage embedded into the floor. Signage areas shall have the same wear and slip characteristics as the main floor and be flush. Signage shall not be able to delaminate separately from main floor for the life span of the floor.

8.2.4 All interior stairway shall have uniform riser heights and tread depths in accordance to ADA guidelines. Stairways shall be designed to minimize the accumulation of water and have the same slip resistant characteristics as the main flooring. Tread nosing shall be designed with an ADA compliant profile and visual contrast. **[CDRL C-8-06** Cove moldings shall be either stainless steel or made of the same material and color as the floor surface. Coves shall have a minimum radius of 1" (25 mm) to ease cleaning, and shall be sealed to the floor surface. Low level exit path marking (LLEPM), if supplied on flooring, shall be fully integrated into and flush with the floor surface to present no tripping hazard and not delaminate separate from the floor surface. LLEPM may be either active or passive and be compliant with APTA standards PR-PS-S-004-99, latest revision. Passive LLEPM marking lines shall be High Performance Photo Luminescent material (HPPL) that complies with APTA standard PR-PS-S-002-98, latest revision. Wear resistance of the HPPL locations shall be the same as the floor covering and integrated in order to be flush with the floor surface and to prevent any separation, delamination and water infiltration. Floor surface inside the electric lockers need not conform to ADA guidelines for surface slip resistance. The Contractor shall submit floor surface specifications and samples for Metra review and approval.

8.2.5 Floor layout of passenger areas for entraining and detraining shall be designed such that water drains out of car to prevent slip surfaces to the extent possible.

8.2.6 Heated flooring, (if provided), shall be of construction with an integrated heating system. The heated flooring system shall be controlled and integrated into the vehicle's main HVAC system. The performance of the heating system shall be demonstrated through a dielectric test in representative conditions , an electrical fatigue test (no default after 200,000 on/off cycles of 30 seconds each), a high-voltage insulation test , and an impact test according to the UL 1693 standard (impact test with a 2" steel ball of 1.1 lbs dropped from a height of 79". Ground fault/

shock hazard requirements per APTA requirements. To the greatest extent possible, these panels shall be repairable without removing radiant floor heat panels from the car. An additional protection system LCDI - Leakage Current Detector Interrupter – shall be installed if needed. Design, details and test procedures of the heated floor system shall be submitted to Metra for review and approval.**[CDRL C-8-19]**

8.3 PASSENGER SEATING

8.3.1 GENERAL REQUIREMENTS

8.3.1.1 All seats shall conform to APTA Standard PR-CS-S-016-99, latest revision. Seats shall also conform to the FRA's requirements for retention of seat components, 49 CFR Part 238.

8.3.1.2 All components used in the seat and cushion assemblies shall meet the flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 as well as Section 18.16 of this specification.

8.3.1.3 An engineering design and ergonomic analysis shall be performed by the Contractor in conjunction with the seat manufacturer on the proposed seat design arrangement and installation and shall be submitted for Metra's approval. The analysis shall take into account all aspects of the seat design, including as a minimum the materials used in the seat construction, human factor related dimensions, passenger ingress and egress, cushion contours including lumbar support, seat pitch, cushion comfort, seat attachment method, and maintenance. Final approval of the detail design of the seat shall be after review of proposed samples. **[CDRL C-8-07]**

8.3.1.4 Contractor shall submit an in-depth analysis on life-cycle cost and comfort level for passenger with an average ride length of 1 hour to a maximum passenger ride of 2 hours. **[CDRL C-8-07]**

8.3.1.5 Seats shall either face each other at all emergency sash locations or have provisions to move seat to allow correct size unobstructed opening per 49 CFR Part 238.113.

8.3.1.6 All seat bottom cushion and backrest assemblies shall be secured to the frame in accordance with FRA Regulation 49 CFR Part 238.233 (as clarified by the FRA in their January 30, 2008 letter). When installed, cushion and backrest assemblies shall be secure in place insuring that they shall not cause any noise during car operation whether occupied or unoccupied. Seat cushions shall not be removable by passengers, but shall be removable by maintenance personnel within one minute with the use of nothing more than simple hand tools. Each seat cushion assembly shall be interchangeable with like assemblies. Seat cushion covering shall be transportation grade material subject to Metra approval. Seat covering material shall be able to be cleaned by at least three widely available commercial industrial cleaning agents that are known to be chemically compatible. **[CDRL C-8-08]** Seat covering physical properties shall be tested in accordance to the tests listed in Table 1. Alternate testing methods with supporting documentation to superior testing methods can be submitted for Metra review and approval in lieu of listed tests

Table 1	
Physical Property	**Test Method**
Total Weight	CFFA-700D
Thickness	CFFA-700C
Tensile Strength	CFFA-17
Tearing Strength (Trapezoid)	CFFA-16C
Coating Fabric Bond	CFFA-3A
Stretch	CFFA-15
Abrasion Resistance	CFFA-1a Wyzenbeek
Crocking	CFFA-7, dry
Blocking	CFFA-4
Cold Resistance	CFFA-6A, 5# roller
Accelerated Weathering Resistance Test	CFFA-2, A1, (SAE-J2412) B1, (ASTM G155-13) C1, (ASTM D4329)

Metra will indicate the colors to be provided after notice to proceed. Covers (both bottom cushions and backrests) shall not require the use of tacks or staples for attachment nor shall they become disengaged under normal use (including patrons placing their feet between the cushion and backrest).

8.3.2 SEAT DESIGN

8.3.2.1 All seating parts and hardware shall be corrosion resistant to but not limited to: water, commercially available cleaners, road salt, etc.

8.3.2.2 Seat assembly weight shall be minimized to the extent practical by the seat manufacturer.

8.3.2.3 Tops of seatbacks shall have a headrest for each passenger position. A diagonal slope at the aisle end shall accept a handgrip. The handgrip shall be rubber coated steel or alternate approved transit grade material suitable for the commuter car environment, subject to review and approval by Metra, and positioned such that no striking hazard to face or head of seated passengers is presented, even in the case of an emergency stop or other unusual condition. The aisle side handgrip should be attached to the seat such that the mounting hardware is recessed or hidden.

8.3.2.4

8.3.2.5 Armrests shall be provided for all seating locations and may be static or foldable. The foldable armrest(s), if supplied, shall be able to rotate in between the up and down positions and shall be flush with the seat back while in the up position. Aisle side armrests shall be static and of close loop design as to prevent injury to passenger from catching passenger bags, clothing, etc. The armrest shall be removable without requiring the disassembly of the seat in order to replace a damaged or defective armrest. The armrest shall be approved transit grade material suitable for the commuter car environment and pass APTA and 49 CFR Part238.103 requirements. Design is subject to Metra review and approval.

8.3.2.6 A cup holder shall be provided for as many seating locations as possible. The cup holder opening shall be able to accommodate a range of beverage containers readily used the food industry and travel style containers up to a diameter of 3-1/2 inches.

8.3.2.7 Seat backrest cushion assembly design shall be submitted to Metra for review and approval. The seatback cushion assembly-to-frame latching mechanism shall be easily disengaged by hand without tools. The latch/release mechanism shall be easily accessible to Metra personnel but concealed from passenger view. The latch mechanism shall be demonstrated for approval after award of the contract.

8.3.2.8 Low Level Exit Path Marking (LLEPM) shall be incorporated on the seat assembly. Marking design and high performance photo luminescent (HPPL) material shall meet all APTA requirements and must be submitted to Metra for review and approval.

8.3.3 FOLDING SEAT

8.3.3.1 Folding seats shall be provided where necessary and subject to all APTA and FRA tests. Design is subject to review and approval by Metra.

8.3.3.2 Seat construction, components, and attachments shall be of sufficient strength to withstand without permanent deformation (defined as + 0.125 inches) the testing requirements of APTA Standard PR-CS-S-016-99, latest revision or the loads listed below, whichever is more stringent **[CDRL C-8-09]**:

8.3.3.3 APTA 5.1.1 Backrest Strength: 300 lbs. per passenger uniformly distributed perpendicular to the plane of the seat back in the rearward and forward direction, three (3) inches below the top of the back or 36 inches above floor, whichever is lower

8.3.3.4 APTA 5.1.2 Grab Handle Strength: 300 lbs. on hand grip in a horizontal direction, rearward and forward.

8.3.3.5 APTA 5.1.3 Vertical Seat Strength: 450 lbs. per passenger uniformly distributed vertically downward on the front edges of the seat cushion.

8.3.3.6 APTA 5.1.4 Armrest Strength: 250 lbs. horizontal to the armrests in both directions on the armrests. 150 lbs. for folding center armrest(s) if applicable.

8.3.3.7 APTA 5.1.4 Armrest Strength: 250 lbs. vertically downward on the armrests. 150 lbs. for folding center armrest(s) if applicable.

8.3.3.8 APTA 5.1.5 – 5.1.7: As applicable with optional supplied equipment. Performed as dictated in APTA Standard PR-CS-S-016-99, latest revision

8.3.3.9 APTA 5.2 Dynamic Sled Testing: Performed as dictated in APTA Standard PR-CS-S-016-99, latest revision

8.3.3.10 APTA 5.3.2 Lateral Seat Attachment Test: Performed as dictated in APTA Standard PR-CS-S-016-99, latest revision

8.3.3.11 APTA 5.3.3 Vertical Seat Attachment Test: Performed as dictated in APTA Standard PR-CS-S-016-99, latest revision

8.3.3.12 APTA 5.3.4 Forward-Facing Seat Attachment Test: Performed as dictated in APTA Standard PR-CS-S-016-99, latest revision

8.3.3.13 APTA 6.1 Mechanisms: As applicable with optional supplied equipment. Life cycle test criteria shall be submitted to Metra for review and approval prior to APTA testing.

8.3.3.14 APTA 6.2 Cushions and Upholstery: Each unique seat assembly shall be dynamically tested, jounce and squirm as follows:

8.3.3.14.1 180 pound load on bottom cushion
8.3.3.14.2 110 pound load on back cushion
8.3.3.14.3 200,000 jounce cycles @ 100 cycles per minute
8.3.3.14.4 4,000 squirm cycles @ 4 cycles per minute

Foam should show no signs of tearing, shearing, or significant loss of height. Cushion covering shall show no signs of tearing or ripping and should remain attached to cushion pan or structure. Seat covering stitching should show no signs of unraveling or breakage.

8.3.4 Seat Equipment List

8.3.4.1 The seat shall have one (1) USB A and one (1) USB-C port each, location subject to Metra approval (reference Section 11.6.3). The USB parts shall be removable without having to disassemble the seat. **[COPL CO-8-02]**

8.4 PARCEL RACKS

8.4.1 A continuous closed type parcel rack, extending to the longest length practical, shall be provided in each side of the passenger sections (if applicable) and shall incorporate longitudinal restraints, with mounting brackets providing lateral restraints. Parcel racks shall be sized to fit a typical computer bag, back pack, small carryon luggage, etc that passengers may bring in revenue service. A parcel racks should be sized to accommodate storage for a maximum amount of seated passengers. The Contractor shall submit the parcel rack design to Metra for review and approval. **[CDRL C-8-10]**

8.5 ACCESSIBILITY PROVISIONS

8.5.1 The cars built to these specifications shall comply with regulation 49 CFR Part 38, subpart E. All provisions for passengers with disabilities must be documented, including passage and turning routes, and all clearances for mobility aids shall be submitted with proposal. **[PDRL P-8-02]** The Contractor shall also be guided by the latest issue of the following, to the extent that the following do not conflict with the above requirements, which shall govern:

8.5.1.1 Title 49, Code of Federal Regulations, Part 37 Transportation for Individuals with Disabilities.

8.5.1.2 Title 49, Code of Federal Regulations, Part 609 (Transportation for Elderly and Handicapped Persons)

8.5.1.3 ICDB Accessibility Standards Illustrated manual.

8.5.1.4 ANSI A117.1, American National Standard for buildings and facilities - providing accessibility and usability for physically handicapped people.

8.5.2 All entry and exit, passage, and turning routes to and from mobility aid positions shall conform to the requirements of the ANSI A117.1 as to clearances, turning radii and pathway impediments. All requirements for reaching, control and device activation, and other use of manual dexterity imposed by car-borne equipment shall also comply with ANSI A117.1. In all cases, the Contractor shall take into account all potential hazards related to hand, knuckle and finger clearances of persons operating mobility aids, as well as potential hazards to others created by mobility aid operation. Bulkheads and partitions in the route of mobility aids between the entryway and the mobility aids positions shall not incorporate any wings protruding into the aisle.

8.5.3 Each car shall have provisions for two (2) ADA designated locations. An approved number of retractable jump seats, or alternative design, as described in section 8.3, shall be provided in each ADA position for use by ambulatory passengers when mobility aids are not present.

8.5.4 The width of each passageway shall be dictated by the needs of the ADA lift mounting. The stanchion assembly shall be located in such a manner as to avoid potential hazards related to the hands of patrons while the mobility aid lift is in use. The mobility aid lift shall be installed such that a continuous threshold/lower track is maintained for the entire width of the side entrance door opening.

8.5.5 A mobility aid lift shall be provided on each side of each car, to permit the raising and lowering of passengers in mobility aids, or between station platform level and car level floor height. The ADA lift system and setup shall be subject to Metra review and approval. **[CDRL C-8-11]**

8.5.6 The station platform height shall be assumed by the Contractor to range from between top of rail to 8'' above top of rail. The lift shall stow in an enclosure when not in use.

8.5.7 The entire lift shall be modular in design to facilitate removal of the lift for servicing. Weather resistant enclosure(s), with provisions to drain any accumulation of moisture shall be provided to protect components. The enclosure supporting frame should be designed to allow full access of the ADA lift for maintenance.

8.5.8 The lift platform shall conform to the length and width requirements of 49 CFR Part 38 Subpart E Paragraph 38.95[b][6]. The surface of platform shall be treated with an approved skid resistant material. The lift platform shall be equipped with a barrier at both the inner and outer ends, which shall automatically rise to contain a mobility aid and prevent roll off during operation (either in powered or manual modes). When lift platform has been fully lowered, the outer barrier flap shall lower and shall serve as a transition surface between the mobility aid lift and the station platform. When the lift is fully raised, the inner barrier shall lower and aid in transition between lift and vestibule. Side rails shall be permanently fixed to the platform to prevent side roll off.

8.5.9 The platform shall be capable of safely lifting and lowering loads of up to 800 pounds (363 Kilograms) in either powered or manual modes, without lift platform deflection in excess of 3 degrees. There shall be no failure mode, in either manual or powered, loaded or unloaded operation, in which the lift platform is capable of uncontrolled free fall.

8.5.10 Handrails shall be provided on both sides of the platform for safety of the rider when the lift is in use and for the safety of other passengers when it is not. The handrails shall not contain any electrical circuitry or switches.

8.5.11 The mobility aid lifts shall be circuit breaker protected. Control of the lifts shall be local and side-specific. The lift controls shall be interlocked with the car's air brake system and locomotive control system.

8.5.12 A switch, keyed to Metra's standard coach key, shall be provided for each lift in an approved location. When in the "on" position, power is provided to the lift (enabling its controls), a magnet valve is energized to apply brakes to the individual car, a signal is provided to the controlling cab and the amber indicator lights (one next to the switch, with sun shield and the exterior pilot lights) are energized. These events will also be triggered when the key switch is in the off position and the lift is manually deployed (pulled out).

8.5.13 Two (2) sets of operating controls shall be provided for each lift. The first set of operating controls shall be mounted in the enclosure or interior of the car. The second set of operating controls shall be the same as above but mounted in an enclosure in the carbody in the vicinity of the doors (when facing the doors from the outside).

8.5.14 The enclosure shall have a weatherproof cover. A lock, keyed to Metra's standard coach key shall retain the cover in the closed position. When the cover is opened, the controls in the enclosure shall be activated, with the controls in the enclosure or interior disabled.

8.5.15 An audible signal shall be activated when the mobility aid lift is activated.

8.5.16 The logic circuitry of the mobility aid lift shall prevent a lift platform from being lowered unless it has been fully deployed. It shall be possible however to stow a lift in powered mode in any position.

8.5.17 When raising the lift under power from the lowered position the outer barrier shall automatically close and will operate normally regardless if the barrier was lowered automatically or manually. No manual correction will be required to reposition the barrier.

8.5.18 In the event of a lift failure or a power failure, it shall be possible to operate the lift to and from any position in the raise/lower cycle, whether loaded or unloaded, and to stow and deploy the lift platform by hand if it is unloaded. Operation in this manual mode shall not damage the lift or any of its components.

8.5.19 Under powered operation, a complete cycle of deploying the platform, lowering the lift platform to station platform height, raising it to floor height, and stowing the lift platform, shall take a minimum amount of time.

8.5.20 In manual mode, this operation shall take no longer than three times the maximum time allowed for the powered cycle, when operated by a person of average manual dexterity. Any operation in manual mode, including operation under load, shall require no more than average strength, with no more than the equivalent of 40 pounds (18 kilograms) lifting force required, except that the force required to initially breakaway to deploy can be up to 60 pounds (27 kilograms).

8.5.21 A pilot light (reference section 10.4.2) shall be installed on each side of the car directly below door open indicator. These shall illuminate on both sides of the car when a wheel-chair lift is energized, regardless of the actual position of the lift.

8.6 TOILET ROOM

8.6.1 The toilet room shall be in a location that is easily accessible for ADA passengers.

8.6.1.1 The spatial arrangement and equipment provided shall conform to the requirements of regulation 49 CFR Part 38 and ANSI Standard A117.1 latest revision and is subject to approval of Metra. **[CDRL C-8-12]** A hinged access door shall be provided in the toilet room for servicing of the water tank and other related equipment.

8.6.2 One (1) set of equipment, as listed below, shall be provided in the toilet room:

8.6.2.1 One (1) toilet, meeting latest U.S. Public Health standards. The flush button shall be wall mounted.

8.6.2.2 One (1) retention tank having a minimum usable capacity required for sanitation use as required for revenue service. Proposer shall determine sizing based on expected passenger usage between servicing at a Metra service yard.

8.6.2.3 The tank shall be heated and the heaters activated when ambient temperature is less than 40 degrees Fahrenheit, see section 9.6.2. The tank shall be constructed of 12 gage stainless steel and equipped with clean-outs and emptying provisions. The tank shall also have an approved sight or liquid level meter to indicate an approximately full retention tank. In addition, the tank shall be equipped with a sensor that will illuminate an LED indication in the vicinity of the toilet empty line that will indicate when the toilet retention tank is at 75% capacity. The design of the system provided shall be subject to Metra approval. **[CDRL C-8-13]**

8.6.2.4 Lines between the tank and the toilet shall be stainless steel pipe, with stainless steel fittings. Lines shall be as short as possible, pitched toward the tank and free of "traps". The tank, the lines between the tank and the toilet, plus the emptying line shall be heated to prevent freeze-up. Emptying line shall be equipped with a 4 inch "Camloc" fitting and dust cover.

8.6.2.5 One (1) approved wall mount soap dispenser with touchless activation. Soap dispenser shall be mounted near the sink.

8.6.2.6 One (1) approved 2 roll toilet paper holder.

8.6.2.7 One (1) approved electric hand dryer with touchless activation

8.6.2.8 One (1) soiled towel receptacle

8.6.2.9 One (1) approved folding type coat and hat hook.

8.6.2.10 One (1) mirror of 1/4" coated polycarbonate set in a rolled stainless steel frame. The mirror shall be at least 9" wide by 12" high.

8.6.2.11 Stainless steel, 1-1/2 in. dia. Handholds properly oriented for ADA passenger use

8.6.2.12 One (1) fold-down transfer seat designed per ADA requirements.

8.6.2.13 One optical smoke sensing type smoke alarm with battery back-up (main car battery).

8.6.2.14 One (1) approved wall mount stainless steel sink. Sink shall have touchless activation.

8.6.3 WATER SUPPLY

8.6.3.1 The supply side of the water system shall be designed for potable water conforming to FDA (Food and Drug Administration) regulations. Water shall also be provided for flushing the toilet and supplying the sink (if applicable). The water system and tank are to be cleaned before the cars are delivered in accordance with United States Public Health regulations.

8.6.3.2 The entire system, with the exception of the water tank (which is to be isolated) shall be pressurized to 150 lbs. and checked for leaks.

8.6.3.3 A single stainless steel water tank shall be furnished. Proposer shall determine sizing based on expected passenger usage between servicing at a Metra service yard. The tank shall be suitably insulated to prevent the formation of condensate on its exterior. The tank shall be vented to the roof, permitting the fill pipes to drain. Access to the tank shall be provided for maintenance. A grille, will permit circulation of heated or cooled air around the water tank. The water tank shall be designed to withstand a hydrostatic test of fifty (50) pounds per square inch.

8.6.3.4 Two (2) approved water filling nozzles shall be provided. They should be located at the toilet end of the car, one on each side. One nozzle is to be used as a fill and the other to act as an overflow drain. These shall be enclosed in a self-draining stainless steel box, covered by a spring-loaded hinged stainless steel door for sanitary protection.

8.6.3.5 A suitably-sized interconnecting network of insulated copper piping shall be furnished, using sweat type fittings except where removal of components dictates the use of compression fittings. Piping shall be joined, using silver solder. It shall be suitably clamped to prevent rattles.

8.6.3.6 A combination shut-off / drain valve with metal identification tag shall be provided adjacent to the toilet. Location of the valve is subject to Metra approval. **[CDRL C-8-14]**

8.6.3.7 All piping must be installed in such a manner as to avoid formation of air pockets or, water pockets when the system is drained.

8.7 MISCELLANEOUS INTERIOR

8.7.1 Coat hooks shall be provided for as many seating locations as possible. Style and location subject to review and approval by Metra.

8.7.2 Ticket clips shall be provided for passenger seating and for the flip seats at the mobility aid positions. The location and design of ticket clips shall be approved by Metra. **[CDRL C-8-15]**

8.7.3 Waste receptacles, a minimum of two (2), shall be installed in each car. The receptacle location and mounting is subject to the approval of Metra. **[CDRL C-8-16]**

8.7.4 Two (2) appropriate keys shall be provided per car for any other locking devices used other than pencil locks.

8.7.5 Each car shall be equipped with two (2) emergency tool kits, one on each end of the car consisting of the following: 1 ea. dry chemical type fire extinguisher; 1 ea. 18 inch ripping chisel, 1 ea. LED Flashlight, and 10-pack box of glow sticks. On B-end only, 1 ea. Hot box stick shall be included in emergency tool kit. The tools shall be mounted in a case with a clear plastic front. The clear plastic shall be etched in an "X" to facilitate access in emergency situations. The case shall be sized to accommodate the above equipment plus Metra's standard first aid kit (applied by Metra.). The chisel and flashlight kit shall be marked with "Property of Metra".

8.7.6 One announcement holder, per Metra Drawing M-166 and made of polycarbonate shall be provided on each car

8.7.7 (deleted)

8.7.8 On odd numbered cab control cars, provision shall be made for the installation of a flush mount enclosure for an automated external defibrillator. Defibrillator enclosure should primarily be constructed of stainless. Any glazing shall be mounted to allow replacement of the glazing. Appropriate signage shall identify the location of the AED unit. Details of location and installation of the defibrillator shall be submitted to Metra for review and approval. **[CDRL C-8-17]** The alarm of the defibrillator cabinet shall be designed to accommodate standard AA or AAA batteries that easily can be replaced on an annual basis.

8.7.9 The Contractor shall propose a bicycle rack system that shall be able to handle between two and five (5) bicycles in the Priority Seating Areas if those areas are not being utilized for passengers. The bicycle racks shall be capable of storing bicycles without any bicycle component interfering with passenger circulation in the main aisle way. Bike racks shall have the capability to lock the frame of a bicycle to the rack assembly using a standard U-shaped type lock. Bike racks shall be designed to accommodate bicycles with tires up to 2.5 in. wide. The Contractor shall submit the design of this system to Metra for review and approval. **[CDRL C-8-18]**

8.7.10 One (1) baby changing station shall be provided in toilet room.

8.7.11 A minimum of two (2) touchless hand sanitizer dispensing units shall be installed in each car, at least one (1) on each end of the car. Touchless hand sanitizer units shall be battery or car low voltage circuit operated and hold hand sanitizing packets with a minimum of a 700 mL packet.

8.8 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	**Title**
P-8-01	Carbody Interior
P-8-02	Accessibility (ADA) Provisions

8.9 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	**Title**
C-8-01	Interior Material Samples
C-8-02	Wall Panels
C-8-03	Cab Locker Designs (Engineer and Fireman Side)
C-8-04	Floor Fire Test
C-8-05	Flooring System
C-8-06	Anti-Skid Design
C-8-07	Seat Ergonomic Assessment
C-8-08	Cushion Covering and Material
C-8-09	Seat Dynamic and Static Testing
C-8-10	Parcel Rack Design
C-8-11	Mobility Aid Lift System
C-8-12	Toilet Room/Equipment Arrangement
C-8-13	Retention Tank Level Indication
C-8-14	Toilet Shut-Off/ Drain Valve
C-8-15	Ticket Clip Installation and Design

C-8-16	Waste Receptacle
C-8-17	Automated External Defibrillator
C-8-18	Bicycle Racks
C-8-19	Heated Floor

8.10 CONTRACT OPTIONAL PROPOSAL LIST

COPL	Title
CO-8-01	(deleted)
CO-8-02	USB Ports

9 HEATING, VENTILATION AND AIR CONDITIONING

9.1 GENERAL REQUIREMENTS

9.1.1 Each car shall be equipped with a heating, ventilation and air conditioning system to automatically provide the specified interior temperatures specified herein. These systems shall perform this function with or without the variable internal heat loads such as passengers, lighting and miscellaneous electrical apparatus, or external factors such as solar heat gain and frequency of door openings. 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. Proposer shall propose general description and requirements. The rating and design of the equipment shall be in accordance with ASHRAE Standard 37 or EN 14750-1 (passenger compartment) climate zone 3 and EN 14813-1 (operator cab) winter climate zone 3 and summer climate zone 2. The air conditioning equipment shall be tested per EN 14750-2 (passenger compartment) Test Row 1 and EN 14813-2 (operator cab) Test Row 2. **[PDRL P-9-01]**

9.1.2 The HVAC system shall maintain the car's interior temperature, including the engineer's cab (if applicable), to a specified programmable temperature range parameter in all circumstances described in EN 14750-1 (passenger compartment) and EN 14813-1 (operator cab) for winter climate zone 3 and summer climate zone 2..

9.1.3 The car temperature shall recover within 4 degrees F of the required interior vehicle temperature within three minutes maximum following a two-minute door opening of all doors on one side of the car. It shall be demonstrated that this requirement can be met during two hours of continuous door cycling of thirty seconds open and 2 minutes closed for 1 hour at the design conditions in both heating and cooling modes.

9.1.4 All system components shall be service-proven and supported by design and test data, adequate to demonstrate compliance with the specified requirements. Details of the system capacity and performance calculation, design, arrangement, installation, and operation of the HVAC system shall be submitted to Metra for review and approval. **[CDRL C-9-01]**

9.2 HEATING

9.2.1 The cars shall be electrically heated using 480 volt, 3-phase, 60 Hz A.C.

9.2.2 The system shall be thermostatically controlled with convection heaters in combination with the HVAC system.

9.2.3 The heating system shall be designed and adequately sized to maintain interior temperature as specified in EN 14750-1 (passenger compartment) and EN 14813-1 (operator cab) for winter climate zone 3 and summer climate zone 2.. Main heat shall be divided into stages or shall be a single stage operating with a modulating switching device. If multi-stage heat is chosen, the stages shall be designed to minimize the cycling of heat contactors.

9.2.4 Floor heat shall be provided either by electric heaters mounted behind heater guards, or an industry proven floor surface heating solution. If a floor surface heating solution is proposed, details of the design, installation, and arrangement of the floor surface heating solution shall be submitted to Metra for review and approval. **[CDRL C-9-02]** If conventional floor heating is utilized, the heater guards shall be of special design to prevent the surfaces coming in contact with passengers from exceeding 125 degrees F and shall be designed to maximize passenger foot space to the greatest extent possible.

9.2.5 The forced air heaters and radiant floor heaters shall be protected against over temperature.

9.2.6 Layover heat will be manually activated after the car is parked and is connected to a source of head end power. Layover heat control is to be part of the HVAC automatic controls.

9.2.7 Layover heat shall be provided by convection heaters in combination with the HVAC system and shall close the fresh air damper. Layover heat shall maintain an interior temperature of 50 degrees F ± 5 degrees F. This set layover temperature shall be made programmable through the control display in the driver's cab.

9.2.8 Each cab shall be equipped with manually controlled heaters. These heaters shall be controlled via the driver's display. The Contractor shall propose a method of heating and cooling the driver's cab by using a separate cab specific HVAC system.

9.3 VENTILATION

9.3.1 The ventilation system shall be designed to maintain a uniform temperature throughout the car. The temperature within that unit shall be within the limits of EN 14750-1 and EN 14813-1 for winter climate zone 3 and summer climate zone 2.

9.3.2 All ducts and plenum chambers shall be insulated to prevent the formation of condensate on their exterior.

9.3.3 Each system shall deliver to the vehicle interior ten percent (10%) of the total airflow of each HVAC unit as fresh air or as defined in the EN 14750-1. The HVAC system shall automatically control the fresh air intake. The fresh air openings of the HVAC system shall be designed to prevent infiltration of snow and water.

9.3.4 Flexible transition ducts of approved material shall connect the passenger supply distribution ducts to each evaporator blower

9.3.5 All flexible transition ducts shall be installed so that it is not under stress and shall be clear of surrounding obstruction when units are in operation. The ducts shall be equipped to allow it to clip on at least one end to ensure ease of replacement or HVAC unit removal. These ducts shall withstand, without damage, the minimum and maximum temperatures and the flexing experienced.

9.3.6 Air ducting shall be insulated and constructed of an approved material. All insulation shall be applied to the outside of the duct.

9.3.7 (deleted)

9.3.8 Ventilation system shall be balanced so that the carbody, with doors closed, maintains a positive pressure at any speed, with the fresh air dampers open and the evaporator blowers for both systems operating normally.

9.3.9 A disposable pleated filter element(s) MERV5 shall be provided in the return and fresh air intake(s) of each HVAC unit. As an option the contractor shall look into an enhanced HVAC filtering system.

9.3.10 An exhaust outlet for the toilet shall be provided by considering a constant negative pressure difference between toilet system and the exterior. The design and function shall be subject to Metra review and approval. **[CDRL C-9-03]**

9.4 AIR CONDITIONING

9.4.1 All subject cars in the trainset shall be equipped with air conditioning equipment comprising of a minimum of one (1) self-contained compact unit. The units shall be roof mounted or located in a location for ease of maintainability and replacement.

9.4.2 Each self-contained unit shall be removable in less than 4 hours and require minimal tooling and facilities. Each unit shall consist of one or more compressor/condenser sections and one or more evaporator sections with electric heating, and an independent control panel.

9.4.3 Each HVAC system should have enough redundancy built in, so that basic failures don't lead to a total loss of the respective HVAC system. Refrigerant for these units may be R-407C, 134A or an approved alternative refrigerant that conforms to 40 CFR Part 42. Type of refrigerant shall be subject to Metra review and approval.

9.4.4 The units shall be constructed using stainless steel or aluminum to the greatest extent possible.The hardware for mounting the units shall have enough safety factor incorporated, so that the failure in one of the bolted connections does not lead to unsafe scenarios. .

9.4.5 (deleted)

9.4.6 The mounting of the air conditioning units shall incorporate damping to cushion and limit longitudinal movement. The units shall be equipped with vibration isolator, sized to minimize transmission of vibration of the units to the car body.

9.4.7 Each package HVAC unit shall be individually removable with the use of a crane without removing any additional roof equipment.

9.4.8 The structure of the units shall permit the entire unit to be removed without damage, and appropriate lifting lugs or eyes shall be incorporated. HVAC unit shall be designed to remove condenser fan, compressor, filter dryer, expansion valves and solenoid valves without the removal of entire unit from car. The entire arrangement is subject to Metra review and approval. **[CDRL C-9-04]**

9.4.9 The power for the air conditioning system shall be derived from the car's power distribution. Power for the control of the air conditioning system shall be determined by the contractor. Low voltage DC control power may be used with the approval of Metra.

9.4.10 All motors for the evaporator, condenser and compressor shall have overload protection of all three phases, mechanically interlocked to remove all power to the devices on activation in order to prevent a single phase condition. All component and devices must operate satisfactorily within the voltage variation parameters as established by the National Electrical Code, without any effect on the longevity of the components or devices.

9.4.11 The refrigerant compressors shall be accessible hermetic (semi-hermetic) reciprocating or scroll type, sized to the proper capacity required of the HVAC system. The Contactor may propose an HVAC unit with multiple compressors working in tandem. Eliminators shall be provided in an approved manner to prevent transmission of compressor vibration to the air conditioning unit frame and suspension.

9.4.12 Condenser and evaporator coils shall be constructed of seamless copper tubing, copper headers with copper fins or aluminum and stainless steel side plates and framing. No crevices or closures shall be permitted, which would hinder cleaning. The Contractor may propose alternative coil materials and fin layouts.

9.4.13 The HVAC systems condensate should be drained directly out of the system and into the roof drainage system of each car.

9.4.14 The condenser fan shall be powered by the car's power system voltage. The fans and their motors shall be of service proven design.

9.4.15 Direct (not belt driven) driven condenser fan and evaporator blower utilizing the car's power system voltage. The fans and their motors shall be of service proven design.

9.4.16 Evaporator blower housings shall be fastened in manner that focuses on secureness and ease of replacement.

9.4.17 The units shall also have within the self-contained assembly at least the following as needed:

9.4.17.1 Filter drier
9.4.17.2 Moisture indicator
9.4.17.3 Suction and discharge shutoff valves (liquid line);
9.4.17.4 Refrigeration charging valves
9.4.17.5 Receiver tank
9.4.17.6 Solid state high and low safety pressure switches and modulation pressure switch (or sensors with a microprocessor control system)
9.4.17.7 Test gauges, liquid filled, suitable for vibration and shock of the railroad environment
9.4.17.8 A test mode to override temperature control signals

9.4.18 All refrigeration piping shall be of service proven design. The tubing shall be pre-formed where possible and shall be assembled with as few fittings as practical.

9.4.19 If roof mounted units are proposed, the bottoms of each unit shall have collection pans under the evaporator section and the condensing section. Condensate is directed directly onto the car roof and led into roof drainage system. Horizontal runs shall have a downward pitch.

9.4.20 The drain lines shall be routed to the underside of the car, located so that the condensate shall drain clear of all underfloor equipment and running rails. The number of fittings and bends shall be minimized and, where used, shall be of large radii for ease of unplugging. The drain piping shall be insulated to preclude condensation.

9.4.21 (deleted)

9.4.22 The evaporator and condenser pans, along with all surfaces of the unit shall be insulated, if needed to prevent condensation.

9.5 TEMPERATURE CONTROL

9.5.1 The heating and cooling controls shall consist of a single heating and cooling control display per driver's cab. The controls shall be arranged for automatic changeover from heating to cooling.

9.5.2 Each temperature control display shall enable authorized personnel to toggle the HVAC system between the normal "ON" operating mode, the layover mode, and an off mode. The off mode shall not disable the operation of the anti-freeze protection circuits. The target temperature for the normal operating mode shall be set to achieve an interior temperature of 72 degrees F within the limits of EN 14750-1 (Passenger compartment) and EN 14813 (Operators cab). The target temperature shall be programmable by personnel with privileges within the range of 68 degrees F to 76 degrees F, if alterations are necessary.

9.5.3 The controls shall be an electronic based, positive, non-hunting type to ensure proper operation of the air comfort sub-systems. The design and arrangement of the controls shall be subject to Metra review and approval. **[CDRL C-9-05]** The use of programmable logic controllers and/or microprocessors is preferred. The controls should be equipped with non-proprietary Portable Test Equipment (PTE) software/ports that would enable personnel with higher levels of access to adjust the temperature parameters for heating, modulated cooling and cooling, and accessing diagnostic data such as fault and download history.

9.5.4 Temperature sensors shall be located behind the return air screen in the return air duct, at the fresh air inlet (may be used for anti-freeze protection), supply air sensor at the HVAC main duct, and at minimum one in the passenger area. Evaporator coil sensors shall be used to detect the build-up of ice on the evaporator coil. All sensors shall be properly utilized by the controller to optimize temperature control and provide diagnostic data for maintenance, servicing, and testing.

9.5.5 Pressure transducers shall be provided to allow the temperature controller to monitor and indicate the suction and discharge line pressures. The temperature controller shall be capable of displaying diagnostic data or uploading diagnostic data via the PTE software program. Faults and download history shall be logged and accessible to technicians.

9.5.6 Automatic damper controls shall be furnished as part of the temperature control system.

9.5.7 An indicator and monitor display shall be furnished in to indicate the status of the heating and cooling equipment. The displays shall be located in each driver's cab . The display shall indicate which stages of heating or cooling have been called for by the settings of the climate control panels and shall indicate whether the heating or cooling being called for is functioning. The panel or panels shall also indicate fresh air temperature, supply air temperature, return air temperature, suction line pressure and discharge pressure, and any on-going faults.

9.6 ANTI-FREEZE PROTECTION

9.6.1 Anti-freeze protection shall be provided at each side entrance door and shall be of sufficient capacity to prevent the formation of ice at these locations (> 40° F. surface temperature @ -20° F.). The design of such system shall be included in door system design review and shall be subject to Metra design review and approval. **[CDRL C-7-01]**

9.6.2 (deleted)

9.6.3 Anti-freeze protection shall also be provided for the water tank, piping from the tank to the basin and toilet, the drain from the water basin in the toilet room, water filling pipes, and the water line and retention tank under the car. Design for heating of the retention tank shall either

be an immersion heater, Metra preferred, or a heating pad. Design of system shall be subject to Metra design review and approval. **[CDRL C-9-06]**

9.6.4 A water freeze dump valve shall be provided for the toilet water system. The location and the specific heating system used for the water freeze dump valve shall be subject to Metra review and approval. **[CDRL C-9-07]**

9.6.5 All heaters shall activate antifreeze circuits at ambient temperatures of 40 degrees F or below, and shall de-activate antifreeze circuits when ambient temperatures rise above 50 degrees F.

9.7 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-9-01	HVAC System

9.8 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-9-01	HVAC System – Design and Installation
C-9-02	Floor Surface Heating Solution (If Applicable)
C-9-03	Toilet Room Exhaust
C-9-04	HVAC Unit Lifting Provision
C-9-05	Temperature Control Arrangement
C-9-06	Retention Tank Heater
C-9-07	Water Freeze Dump Valve

10 LIGHTING

10.1 GENERAL REQUIREMENTS

10.1.1 This section describes interior and exterior lighting that shall be provided on both trailer type and cab car type trainsets.

10.1.2 Interior lighting shall be designed to enhance passenger comfort visually and illuminate areas evenly without glare or dark areas at critical locations. The lighting shall enhance the appeal of interior furnishings, while providing for maximum passenger and crewmember safety. All interior and exterior lighting shall conform to the latest applicable APTA, EN/IEC standards and FRA regulations. All interior and exterior lighting shall have proven service railroad operations or need to be approved by Metra.

10.1.3 Exterior lighting shall feature maximum and efficient illumination and indication to passengers and crew members.

10.1.4 Lighting shall be provided in a minimum of two modes: Normal and Emergency.

10.1.5 Lighting shall be provided using energy efficient Light Emitting Diode (LED) technology in all instances

10.1.6 All lighting components shall use efficient and environmentally sustainable components, as well as being recyclable to the greatest extent practicable.

10.1.7 For each type of car proposed, the Contractor shall provide Metra a detailed interior and exterior lighting plan for Metra to review. The plan shall include the type of lighting, lighting arrangement (including any switches, ballast, control, lamp styles), fixture type, voltage, color temperatures, illumination levels in the interior of the car at specified locations for all lighting modes, and compliance with appropriate emergency lighting and signage regulations, standards, and recommended practices. A description of power consumption and voltage levels in the various modes of operation shall be included in the proposal. The details of the design, installation, and arrangement of the lighting solution shall be submitted to Metra for review and approval. **[CDRL C-10-01]**

10.1.8 (deleted)

10.1.9 All lighting and associated lighting electronics shall be tested and conform to all applicable sections of Standard EN 50155 (including EN 50121-3-2), IEC 61373, 49 CFR 238 Appendix B, and NFPA 130. Certification to applicable APTA, applicable EN/IEC standards, and FRA criteria shall be provided by the contractor upon the request of Metra. **[CDRL C-10-02]**

10.2 INTERIOR AND PASSENGER COMPARTMENT LIGHTING

10.2.1 The coach sections shall be provided with an approved arrangement of LED fixtures. Alternate lighting technology, such as service-proven OLED lighting, may be proposed for Metra review and approval.

10.2.2 The lighting system shall: not produce objectionable glare, not deteriorate rapidly in effectiveness through the collection of dirt, permit easy cleaning and renewal of lighting elements, and be free of rattles and vibration when in service.

10.2.3 If a proposed lighting system is equipped with a lighting control circuit that will automatically dims main lighting to compensate for adequate ambient lighting in the car, the diming functionality shall be able to be cut out by Metra personal at any time to ensure nominal lighting levels. If such a system is proposed, the contractor shall ensure charging of HPPL material is maintained to meet APTA requirements. If proposed, the contractor shall list as an option. **[COPL CO-10-01]**

10.2.4 The passenger compartment lighting system proposed shall be tested to meet or exceed main light levels specified in the latest revision of APTA specification APTA PR-E-RP-012-99, Recommended Practice for Normal Lighting System Design for Passenger Cars. All material must comply with applicable flammability and smoke emission requirements of FRA Regulation 49 CFR Part 238 Appendix B and NFPA 130 as well as Section 18.16 of this specification. **[CDRL C-10-03]**

10.2.5 The material of all lenses shall be described and proposed to Metra, including any compliance certification received previously. Metra will require material test reports and certification letters for all lens materials prior to FAI.

10.2.6 The fixtures shall be mounted with non-exposed hardware and shall resist undesired opening to the maximum extent possible. Replacement of LEDs shall be accomplished readily from the exposed fixture face, with tamper resistant closing devices used. Lighting elements shall be supported by mechanical restraints to relieve mechanical loading on the power pins.

10.2.7 An “Occupied” LED light fixture, viewable from the aisle in either direction shall be provided above the toilet room door. A switch or sensor shall be provided in the door jamb to energize the light when the door is fully closed and the passage set is “locked.”

10.2.8 Electrical lockers shall be provided with LED light fixtures. The light shall be operated by a door switch located so as to turn the locker light off when the door is closed.

10.2.9 Ceiling mounted LED light fixtures shall be provided in the cab of cab control cars. Control switches shall be provided.

10.2.10 LED reading lights shall be provided in cab of cab control cars. Control switches shall be provided.

10.3 EMERGENCY LIGHTING

10.3.1 Emergency lighting shall conform to the requirements of FRA Regulation 49 CFR Part 238 as well as APTA PR-E-S-013-99, latest revision. The emergency lighting system shall be tested to meet or exceed emergency light levels specified in the latest revision (at the time of notice to proceed) of APTA PR-E-S-013-99 Standard for Emergency Lighting System Design for Passenger Cars. The emergency light system shall be designed to maintain acceptable illumination for a minimum 120 minutes. For The emergency lighting solution that is proposed, details of the design, installation, and arrangement of the emergency lighting solution shall be submitted to Metra for review and approval. Test reports shall be submitted to Metra. **[CDRL C-10-04]**

10.3.2 Emergency lights shall be located in the main seating area, in stairways (if applicable)~~,~~ in the toilet room, in the cab, in each end passageway, above all escape sash locations with additional fixtures provided in the passenger compartments as required to comply with the lighting levels specified in FRA Regulation 49 CFR Part 238 and latest revision of APTA PR-E-S-013-99 Standard for Emergency Lighting System Design for Passenger Cars.

10.4 EXTERIOR LIGHTING

10.4.1 Exterior lighting fixtures installed on the vehicle exterior, and in the interior within 2 ft. of a doorway, shall be watertight, except for interior ceiling lights. All lighting lamps and fixtures shall be suitable for rough duty service found in the railroad environment throughout North America. All exterior lighting plans and design is subject to Metra and approval. **[CDRL C-10-05]**

10.4.2 End passageways outside body end doors shall be illuminated with LED fixtures. The fixtures shall be activated with the general interior lighting along with emergency light.

10.4.3 Exterior platform lighting shall be provided at side exits that meet or exceed latest revision of APTA Standard PR-E-RP-012-99, Recommended Practice for Normal Lighting System Design for Passenger Cars. The lights used to satisfy the above requirements shall be separate spotlights, LED lighting is preferred, on the exterior of the car (as stated in 49 CFR Part 38.101(b) and 49 CFR Part 38.157(b)) and mounted in the vicinity of the vestibule side loading doors. The exact location of the light used to illuminate the exterior platform shall be subject to Metra design review and approval, included in **[CDRL C-10-05].**

10.4.4 One (1) door open and one (1) lift activated light of differing colors shall be installed on the exterior adjacent to each set of side entrance doors.

10.4.5 The fixtures shall have redundant LED lamps in each fixture, each showing to the front and to the rear. The lamps shall have sufficient brightness that a person of normal visual acuity may tell, from a distance of six hundred (600) feet on a sunny day, whether the light is on or off, even if one of the lamps in the fixture is inoperative. The fixtures shall fall within clearance limitations. The lights shall be circuit breaker protected.

10.4.6 On the control end of cab cars only, two headlights (2) either sealed beam incandescent lamps or halogen low voltage D.C. sealed PAR 56, compliant with 49 CFR Part 229.125, shall be mounted in an enclosure. If lights are proposed with LED technology, they shall not be prone to ice or snow buildup and shall be reviewed by Metra.

10.4.7 The headlamp shall be accessible for maintenance purposes, for re-lamping of the headlight. The light beams may be adjusted both vertically and horizontally. The headlight shall be protected against lamp burnout due to high battery charging voltage. A headlight dimming resistor, or dimming mechanism like half-beam, subject to Metra review and approval, shall also be provided. The wiring within the enclosure shall be of the heat-resistant type and the enclosure shall be provided with adequate ventilation holes. [**CDRL C-10-06]**

10.4.8 On the control end of cab cars only, two ditch lights (low voltage D.C. sealed beam incandescent lamps or halogen lamps compliant with 49 CFR Part 229.125) shall be installed one each side of the cab control end. If lights are proposed with LED technology, they shall not be prone to ice or snow buildup and shall be reviewed by Metra. The lights shall be aligned to cross at approximately 300 feet down the track and illuminate the roadbed approximately 800 feet down the track.

10.4.9 Lights shall operate in one of the following modes: steady, flashing, or flashing after horn or bell only. The control unit shall be incorporated into the vehicle control unit (VCU). Installation location shall be subject to approval of Metra. Methods to protect the lamp from overvoltage (such as a resistor) and methods to dim the lamp (such as with a dimming resistor) shall be included in the design.

10.4.10 The contractor shall propose an additional mode of operation. A momentary push button or Metra approved alternative device located adjacent to the headlight/ditch light switches that when depressed will momentarily turn off the ditch lights, dim the headlights, and turn off Mars light (if Mars light proposed). When the momentary push button is let go the headlights, ditch lights, and Mars light (if Mars light proposed) revert back to whatever mode of operation the headlight/ditch light switches were set to.

10.4.11 (deleted)

10.4.12 The lights shall be controllable via the display or buttons.

10.4.13 On each end of the train, two (2) red lights shall be provided which indicate the end of the train, or indicate when the train is in parking position.. The entire arrangement shall comply with FRA regulations, as stated in 49 CFR Part 221.

10.4.14 In the control section on cab cars, the cab shall be equipped with a light burnout detection panel that notifies operating crew and/or Mechanical personnel that an exterior lamp has failed. Alternatively, an indication on the display can be made. The burnout detector panel or display indication shall have provisions to monitor both headlights and both ditchlights. The Contractor shall submit the design of this system for Metra review and approval**. [CDRL C-10-07]**

10.5 LOW LOCATION EXIT PATH MARKING (LLEPM)

10.5.1 Each car shall be equipped with a passive low location and exit path marking system that complies with the requirements of APTA SS-PS-004-99 and APTA PR-PS-S-002-98, latest revision. The system shall use HPPL marking material as specified in Section 19.2.21 of this specification. The system shall be detailed in the proposal. **[PDRL P-10-02]**

10.5.2 The system chosen by the Contractor shall be arranged to provide visual guidance for evacuation of the car when overhead lighting and the emergency lighting system has failed or has been obscured. The low location exit path marking system shall clearly identify the primary path to be followed for exiting the car under emergencies. The primary exit path shall be designed to evacuate the passengers to the next car and not onto the right-of-way.

10.5.3 The Contractor shall propose the techniques and options for integration of passive HPPL elements into floor coverings, seat frames, door, exit path, stairways and bulkhead elements to achieve the APTA standard requirements. Emergency Exit Route Evacuation Maps (Signs) and shall be constructed of HPPL material per APTA requirements. The system design shall be reviewed and approved by Metra and demonstrated on the Pilot Car. **[CDRL C-10-08]**

10.5.4 If additional LLEPM options are proposed, they shall be listed as options. **[COPL CO-10-02]**

10.6 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	**Title**
	(deleted)
P-10-02	LLEPM

10.7 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	**Title**

C-10-01	Interior and Exterior Lighting Plan
C-10-02	Lighting Electronics Environmental Testing
C-10-03	Normal Mode Light Level Testing and Environmental standards
C-10-04	Emergency Lighting Details and Testing
C-10-05	Exterior Lighting Design and Functionality
C-10-06	Headlight Dimming/Protection
C-10-07	Light Burnout Detection
C-10-08	Low Location Exit Path Marking (LLEPM)

10.8 CONTRACT OPTIONAL PROPOSAL LIST

COPL	**Title**
CO-10-01	Automatic Dimming
CO-10-02	Additional LLEPM Options

11 ELECTRICAL

11.1 GENERAL REQUIREMENTS

The onboard power source shall be capable of supplying power to all loads on the trainset. The power sources may be distributed amongst the cars.

11.1.1 Complete circuit diagrams shall be submitted to Metra for approval prior to construction. Complete circuit diagrams are schematic level circuits **[CDRL C-11-01]** All wiring not explicitly referenced in other parts of this specification shall meet at a minimum the latest revision of APTA standard PR-E-RP-009-98, “Recommended Practice for Wire Used on Passenger Equipment”, or EN 50264 and EN 50306, latest revision of APTA standard PR-E-RP-002-98 “Recommend Practice for Wiring of Passenger Equipment”, or EN 50343, and latest revision of APTA standard PR-E-S-001-98 “Standard for Insulation Integrity”, or EN 50124-1. The contractor shall submit to Metra for review and approval a “Regulation of Car Wiring Works” document that will at minimum include: scope, general car wiring methods, treatment of termination, wiring number marking, treatment for wiring and connection, wire label methods, and other items as agreed upon by Metra and the contractor.

11.1.2 An electrical load study detailing the electrical loads shall be provided to Metra for reference and approval. **[CDRL C-11-02]** A basic load study and overview of the electrical systems proposed in this section shall be included in the proposal. **[PDRL P-11-01]**

11.1.3 Where applicable, software or firmware shall be developed in accordance with and meet the latest revision of IEEE standard 1558 “IEEE Standard for Software Documentation for Rail Equipment and System” or EN 50657 "Railways Applications - Rolling stock applications - Software on Board Rolling Stock". **[CDRL C-11-03]**

11.2 VOLTAGES

11.2.1 Where applicable, equipment should follow guidelines in accordance with the latest revision of IEEE standard 519 “Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems” or equivalent rules and proven designs.

11.2.2 The contractor shall propose an onboard D.C. system voltage, and in the proposal shall justify the recommendation based on documented proven reliable design and prevailing industry standards in the United States commuter rail market. The DC voltage power system design shall be subject to Metra review and approval. **[CDRL C-11-04]**

11.2.3 The power system shall be trainlined in order to distribute power for redundancy, and efficiency of design. If such a design is included in the proposal, the trainlined battery voltage shall be protected by a circuit breaker or alternative approved protection scheme. The voltage power system design shall be subject to Metra review and approval.

11.3 LOW VOLTAGE DC POWER SUPPLY

11.3.1 Backup Power Requirements

11.3.1.1 The backup power system shall be sized to carry the full DC load under emergency conditions (defined as after loss of normal power condition) for no less than two hours before the activation of load shed. At a minimum but not limited to, these loads include items such as: pilot lights, TIMS, door closing lights, TIMS destination signs, PA System, Passenger emergency intercom (s), all cab operational equipment (cabs only), PTC (cabs only), event recorder system (cabs only), cab signal system (cabs only), train radio (cabs only),

forward facing camera system (cabs only), car level monitoring system, passenger seating camera system, lighting if applicable, and additional loads as agreed upon between the contractor and Metra.

11.3.1.2 (deleted)

11.3.1.3 (deleted)

11.3.1.4 The contractor shall submit a service proven reliable design that provides the latest available technology in passenger rail and provides the longest life-cycle cost effective system. The backup power system design shall be subject to Metra review and approval.

11.3.1.5 The load shedding concept for the first 120 minutes for worst case summer and winter operating conditions in the Chicago area shall be proposed and submitted to Metra for review and approval. **[CDRL C-11-03]**

11.4 SWITCHBOARD AND CONTROL FEATURES

11.4.1 Switchboards and equipment for the control of the various electrical circuits, such as circuit breakers, etc., shall be provided in electrical cabinets.

11.4.2 All switches, circuit breakers, relays, resistors, etc., shall be identified by nameplates. All circuit breakers shall be indicated ON with toggle up and OFF with toggle down.

11.4.3 All electric lockers shall be designed with provisions to prevent, to the greatest extent possible, the ingress of snow, moisture and heavy debris. Electric lockers shall be large enough to allow ergonomical access for railroad maintenance personnel. Each circuit breaker panel shall carry apparatus arranged to be easily accessible to connections and designed to prevent an operator form coming in contact with live voltage when operating switches or circuit breakers. In addition, a reasonable amount of locker footprint shall be open for future installation of new equipment by Metra. Inside each electrical locker a reasonable amount of spare terminal points and DIN rail shall be allocated for future expansion.

11.4.4 The circuit breaker panels shall be dead front type, with removable front covers. Circuit breakers shall be arranged so that the handles move vertically or horizontally. Breaker covers are to be provided on operational sensitive controls to prevent inadvertent use of breaker. If utilized, bus bars shall be arranged to have tapped holes along their entire length and be of a design such that all phase combinations are available at each breaker site.

11.4.5 All panels shall be conveniently located, in the electrical cabinets, for ease of access by service personnel. Reduced wiring and ease of maintenance shall be of prime consideration.

11.4.6 For electrical panels, a wiring gutter shall be provided along the top, sides, and bottom, for the routing of high voltage leads to their designated circuit breakers.

11.4.7 Circuit breakers shall each be grouped with their respective voltage and be labeled according to the appropriate voltage. A master circuit breaker shall be provided for each voltage level. The circuit breaker panel shall be configured for easy removal so that maintenance and repair action are not impeded. Design of the electric lockers shall be subject to Metra review and approval. **[CDRL C-11-06]**

11.5 480 VOLT AND CONTROL TRAINLINES

11.5.1 All trainline systems described below in Sections 11.5.1-11.5.7 shall be subject to Metra design review and approval. **[CDRL C-11-07]** It may be proposed to integrate the 27-wire locomotive control trainline, door control trainline, and communications trainline systems into the digital IP based trainline system. **[COPL CO-11-01]**

11.5.2 Door Control Trainline

11.5.2.1 The cars relevant door circuits shall be trainlined for door control to accomplish proper door operation.

11.5.3 Communications Trainlines

11.5.3.1 The cars PA system shall be trainlined for all cars in a train consist.

11.5.4 (deleted)

11.5.5 Digital Trainlines

11.5.5.1 The cars shall have an IP based digital trainline. This trainline may be used for such 3rd party systems as Train Information Management Systems (TIMS), passenger Wifi, PA announcements, digital monitoring systems, and other systems as agreed to by Metra and the Contractor.

11.5.5.2 (deleted)

11.5.5.2.1 (deleted)

11.5.5.3 Ethernet cable (Digital trainline)

11.5.5.3.1 Each train shall be equipped with two GigaBit Ethernet networks in a ring topology, one for Comunications and Information system and one for Train Control and Management System. The network cables shall be compliant with IEEE Standard 802.3-1999. Between the cars the networks shall be connected with jumper cables. The jumper and receptacle shall be at a minimum an IP67 grade connector when mated. The jumper shall be provided with a retention mechanism that will prevent the jumper from falling outside the acceptable gauge envelope of the vehicle and fouling any trackside equipment. The conductor size shall be selected to ensure that this will be capable of withstanding the daily operation of the harness including the flexing that can be expected in normal vehicle operation. Each jumper cable shall be protected along the length of the cables external jacket against abrasion that may occur during installation or normal vehicle operation. The jumper cables shall be screened over the length of the cables and the screen shall be connected to the connector. The screen connection will not be continuous over the full length of the assembly to prevent providing a common earth connection between adjacent vehicles. The screen of each cable shall be capable of being connected to the vehicle body at one point only. All other connector and parts of the assembly shall be constructed to prevent multiple point earth points on the cable screen.

11.5.5.3.2 In each car, there shall be a minimum of one PoE (Power over Ethernet) equipped network switch located in a minimum of one electrical locker. The network switch shall contain a minimum number of ports to provide connectivity to the digital (Ethernet) trainline as well as on-board compatible digital systems and spare ports for provisioned digital systems. The switches chosen shall also include a bypass feature, or other Metra approved methodology, to ensure the physical connection between the 2 end-point connections on the car remains continuous even when the car is not powered. Network equipment used must comply with current industry protocol standards. The proposer shall indicate which network standard(s) are met with their proposed solution. The proposer shall commit to design to a communication network standard with proven application in passenger rail in North America. The contractor shall provide justification for choosing such standard(s). Each car shall feature network redundancy such as ring network technology in order that failure of onboard communication systems will not affect the digital trainline. The digital trainline design, network equipment and equipment placement within the electrical locker shall be subject to Metra approval. **[CDRL C-11-07]**

11.5.5.4 (deleted)

11.5.5.4.1 (deleted)

11.5.6 USB and/or 120VAC outlet charging port shall be provided for each seating position, except flip seats where not possible. The ports shall be located on the side wall just below the window, or should fixed seating be provided, the USB ports may as an option be provided on the seat back of each multiple passenger seat (except for bulkhead and back to back seats). USB ports shall also be provided adjacent to the ADA position area on the locker wall. Final position of the USB ports and design of the USB system is subject to Metra design review and approval. **[CDRL C-11-09]** USB ports shall have the following current rating:
USB-A: 0.5 amp
USB-C: 3.0 amp
They shall be a compatible with all Apple and Android mobile devices.

11.6 CONDUIT

11.6.1 Conduits shall be in accordance with the latest revision of APTA PR-E-RP-002-98 “Recommended Practice for Wiring of Passenger Equipment” or EN 50343 "Railway applications - Rolling stock - Rules for installation of cabling". An exception may apply for trainline cables which may be cleated to the underfloor structure, in such manner as to prevent wire chafing.

11.6.2 The car shall be provided with thin wall conduit within the car body. Conduit shall be securely clamped with all runs electrically grounded to make a continuous ground. Suitable approved insulation to prevent electrolysis shall be provided where dissimilar metals are in contact. All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes, except that all open-ended conduits shall be installed in such a manner as to ensure gravity drainage out the end. The conduit arrangement shall be subject to Metra review and approval.

11.7 ELECTRICAL GROUNDS

All electrical equipment, with a voltage of greater than 24 volts nominal shall be grounded to the car body. Grounding and bonding shall be done in accordance with the latest revision of APTA Standard SS-E-005-98 or EN 50153 "Railway applications - Rolling stock - Protective provisions relating to electrical hazards".

11.8 CAR LEVEL MONITORING SYSTEM

11.8.1 A monitoring system shall be included as part of the Train Control Management System. The monitoring system shall be Internet Protocol (IP) based, and a device with an Ethernet port or ad-hoc Wi-Fi capability shall be able to view real-time information when connected to the monitoring system. The monitoring system shall acquire and aggregate data from the following car subsystems (at a minimum): Door system, HVAC (including interior temperature), LVPS/Battery Charger, water and waste system, brake/wheel slide system, PA/IC/Communications (including interior audio levels), TIMS (Train Information Management System), lighting, CDVRS, passenger seating area camera systems, ADA systems, event recorder, data link, and other sub systems on the car as agreed upon between Metra and the contractor. The diagnostic system shall have spare interfaces for future systems, such as I/O and Ethernet ports. The parameters and subsets of data from each system to be stored onto the monitoring system shall be agreed upon between Metra and the contractor. The monitoring system shall store fault logs. In addition, a visual indication and status of the designated systems shall be displayed. The graphical user interface shall be clean, easy to use, and intuitive. The monitoring system shall be capable of holding seven (7) days' worth of data within the systems Rail Communications Units solid state drive (SSD).The data shall be capable of being securely transmitted to Metra storage servers through Wi-Fi when in range of wireless access points in depots and maintenance yards. The data shall be accessible via non-proprietary formats, such as .csv files. The design and infrastructure of the monitoring system shall be subject to Metra design review and approval. **[CDRL C-11-10]**

11.8.2 The contractor shall propose, as an option, a remote monitoring and diagnostic system. This system shall capture and analyze data from components and subsystems aboard the trainset.. The system accessibility shall be provided by a web based access or similar. The data that is monitored shall apply to the systems described in 11.9.1 and shall include: process data such as temperature, and pressure; counter data, such as start/stop, door opening cycles, loads cycles, and number of brake releases; Incident-based data such as emergency brake application, power unavailable, door failure to open; time and location stamps for event-based and process-based data from various sources. The monitoring system shall issue automatic alerts based on a specific event trigger and/or based on calculations of data. Archiving criteria shall be adjustable according to Metra's needs. There shall be a set of pre-defined reports, analysis and graphical tools. In addition, Metra shall be able to set up its own analysis, and reports and shall be able to edit the analytics provided without the involvement of a third party. There shall be a system of authorization profiles on the control center software. The data shall be accessible via non-proprietary formats, such as .csv files. All asset data shall be the property of Metra. **[COPL CO-11-02]**

11.9 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-11-01	Electrical System and Load Study
P-11-02	(deleted)

11.10 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-11-01	Electrical Circuit Diagram
C-11-02	Electrical Load Study
C-11-03	Load Shedding
C-11-04	Battery Box and Battery Protection
C-11-05	Battery Charger/LVPS

C-11-06	Electric Lockers Design
C-11-07	Trainline Circuits
C-11-08	Surge Protective Device
C-11-09	USB Port Position and Design
C-11-10	Car Level Monitoring System

11.11 CONTRACT OPTIONAL PROPOSAL LIST

COPL	**Title**
CO-11-01	Integrated Digital Trainline
CO-11-02	Remote Monitoring System

12 COMMUNICATION SYSTEMS

12.1 GENERAL REQUIREMENTS

12.1.1 The system shall communicate between trainsets using trainline connections described in Section 11.5. Single points of failure along the trainline(s) shall be analyzed and mitigated.

12.1.2 The system shall feature redundancy to the greatest extent possible.

12.1.3 All critical subsystems, including Public Address, Emergency Intercom, Train Radio, and portions of the Train Information Management Systems shall utilize backup power and function in emergency situations.

12.1.4 A complete train communications system shall be installed. The system shall comply with FRA Regulations 49 CFR Parts 229 and 238. The details of the design, equipment, arrangement, and installation of the complete communication package shall be submitted to Metra for review and approval during the design review process. **[CDRL C-12-01**] It shall provide passenger cars with the following functions:

12.1.4.1 One-way communication from the train crew or operator's cab to the passengers (Public Address System)

12.1.4.2 Two-way private communication between the operator's cab and the train crew (Intercommunication System Function)

12.1.4.3 Two-way communication between passengers and the train crew/operator's cab (Emergency Passenger Intercommunication System Function)

12.1.4.4 Two-way communication between the Train Information Management system servers and the Train information Management system on the train.

12.1.5 The proposer shall include the detail the functionality and the onboard equipment of the above systems in their proposal to the greatest extent practicable **[PDRL P-12-01]**

12.1.6 All Communication System electronics shall be tested and conform to all applicable sections of Standard EN 50155 (including EN 50121-3-2), IEC 61373, 49 CFR 238 Appendix B, and NFPA 130. Certification to FRA and/or AAR S-9401 criteria shall be provided by the contractor upon the request of Metra.

12.1.7 The Public Address and Train Information Management systems shall be compatible with each other. The Train Information Management System shall be 100% compatible with Metra's ACORN (Automated Communications and Onboard Reporting Network) in terms of interfaces, transmission, and receiving of messages, signals, software, databases, and data. The user interface used by Metra GPS operators to track trains, prepare messages, and transmit messages shall utilize the same interface as ACORN and be integrated within the ACORN system Metra is adopting. The system shall meet all the technical and functional Requirements of Metra's ACORN system, which will be provided by Clever Devices. The system shall demonstrate compatibility with Metra's Clever Devices ACORN communication system and shall be subject to Metra review and approval. **[CDRL C-12- 02]** To be 100% compatible with the Clever Devices ACORN system, the following components and any necessary ancillary equipment for compatibility need to be utilized in the system:

12.1.7.1 Clever Devices IVN-R, 32G GPS Part #404-2185-0001
12.1.7.2 Clever Devices Bracket, IVN4 Part #101-120-0130
12.1.7.3 Clever Devices Transit Control Head, Rail Part #103-300-0009
12.1.7.4 Clever Devices Connector Kit, Acorn Part #KIT-CONN-ACORN

12.2 PUBLIC ADDRESS / INTERCOMMUNICATION SYSTEM

12.2.1 The public address and intercommunication equipment shall meet all applicable environmental tests specified in section 21.24 as well as other applicable standards for Sound and PA Equipment including those for Temperature Range, High Humidity, Vibration Stability, and Shock Stability.

12.2.2 All circuits shall be physically isolated and protected against any circuit that can cause or induce electromagnetic interference. Circuit breakers shall be provided for circuit protection. The PA system shall comply with all applicable aspects of 49 CFR 238.121, including emergency back-up power requirements.

12.2.3 The complete system shall utilize the following components installed on each car with alternative designs, subject to Metra approval:

12.2.3.1 Conductor Control Unit (CCU), designed to provide audio input, amplification, audio output, intercom and public address (PA) functions.

12.2.3.2 An indicator light or LED shall notify a conductor that a handset has gone off-hook (or conductor's microphone has been activated) and an intercommunication link has been made. When intercom is selected, loudspeakers in cars shall be muted.

12.2.3.3 Switch arrangement shall be provided to allow selection of PA and Intercom mode. Any mode selected (PA or IC) shall remain selected until the mode is changed.

12.2.3.4 Conductor voice input (microphone) capable of at least 1,000,000 operations. Handset microphone (or alternate microphone design) design will be subject to Metra review and approval

12.2.3.5 The CCU shall be mounted in a "Coach Key" locked compartment.

12.2.3.6 The public address system in each car shall include an ambient noise controlled amplifier monitored throughout the car. The unit will allow for automatic volume control, enabling announcements to be heard over the ambient noise level within the car.

12.2.3.7 One power amplifier shall be required for each car and designed to provide audio input, amplification, audio output and regulated voltage for control units.

12.2.3.8 The power amplifier shall be capable of: Transient suppression, Power supply line isolation (DC/DC Converter), Regulated voltage supply, Compressor pre-amplifier, and Power amplifier.

12.2.3.9 The output level adjustment and shall remain consistent throughout the specified temperature range.

12.2.3.10 The power amplifier must provide protection against transient voltage. Short and open circuits shall not impose damage to the power amplifier.

12.2.3.11 With speech and sound input, the amplifier shall operate continuously with full output at rated voltages and without damage or degradation to the PA components.

12.2.3.12 There shall be a minimum of six (6) speakers in each passenger seating compartment, with a detailed coverage analysis carried out to show best placement and quantity for each car. The power pack walkway shall contain minimum of two (2) speakers, one at each end. The contractor shall conduct a detailed audio sampling and study of all passenger areas of the car, ensuring volume consistency between areas, as well as optimal sound levels. **[CDRL C-12-03]**

12.2.3.13 There shall be a minimum of four (4) speakers on the exterior on each side of the car. They shall be high performance loudspeakers.

12.2.3.14 Exterior speakers must be outdoor rated and weatherproof. The external speakers shall be installed to prevent ingress of water and dust. The loudspeakers and their assembly shall be immune to the chemicals and detergents used normally during washing, as well as any normal abrasive cleaning that may occur during washing.

12.2.3.15 The external speakers shall feature a wide dispersion angle and be able to be heard and understood by passengers on the platform area.

12.2.3.16 The volume levels of each passenger area, including the exterior speakers, shall be adjustable independently by a maintenance person.

12.2.3.17 The PA system shall feature minimal Total Harmonic Distortion over their entire operating frequency range. Total Harmonic Distortion shall not exceed 2% at the output of the Power Amplifier into rated load at full rated power over the range from 300 Hz to 3 kHz.

12.2.3.18 The audio communication systems and PA systems shall exhibit a Speech Transmission Index (STI) rating of 0.6 or above according to the latest revision of IEC-602682-16 when measured in a quiet, empty car.

12.2.3.19 (deleted)

12.2.3.20 An Emergency Passenger Intercom Unit (EPIU) shall be provided per Federal regulation, 49 CFR Part 238.121 The units shall be flush mounted with the locations subject to Metra approval. **[CDRL C-12-04]** The units shall feature the following:

12.2.3.20.1 One-touch shall activate the intercom. The emergency intercom shall be recessed and otherwise protected against accidental activation.

12.2.3.20.2 Once activated, an alert will play to notify the crew that a passenger has activated an EPIU and state the car number and location within the car from which the EPIU was activated.

12.2.3.20.3 Upon Intercom initiation, the EPIU will become hands free. The passenger will not need to hold the push button down.

12.2.3.20.4 The EPIU shall allow crew members to respond via any CCU or OCU located on any car of a train consist including the locomotive.

12.2.3.20.5 Each EPIU shall be equipped with indicators: one to indicate the EPIU is successfully connected to the train intercom, one instructing a passenger to "wait/listen" and one indicating when the passenger can talk.

12.2.3.20.6 The conversation will be ended by the train crew hanging up on the OCU or CCU panel.

12.2.3.20.7 The EPIU shall have provisions to filter out ambient noise to ensure clear communication and also to prevent ambient noise from preventing the EPIU to disconnect after the call has ceased.

12.2.3.20.8 The face of the EPIU shall be labeled "Emergency Intercom" in luminescent material per APTA Standard PR-PS-S-001-98, latest revision and shall have instructions for operation. The car number shall be permanently and legibly applied to the car immediately above each EPIU.

12.2.3.21 In addition to the above, the following equipment shall be provided in the cab of cab control cars:

12.2.3.21.1 An Operator's Control Unit (OCU) located in an approved location on the cab lower console. The OCU shall be designed to provide: audio input amplification; audio output; control of the radio, intercom and public address functions. The OCU shall have the following:

12.2.3.21.2 An indicator light or LED shall indicate that the handset has gone off-hook (or engineer's microphone has been activated) and an intercommunication link has been made. When the intercom is selected, loudspeakers in cars shall be muted.

12.2.3.21.3 A three (3) push button switch arrangement shall be provided to allow selection of PA, Radio PA and Intercom mode. Logic shall be such that the radio receiver is always on regardless of function selected. When selected the PA or IC mode shall remain selected until the mode is changed. The Radio PA switch must be depressed to enable the radio to be transmitted on the PA.

12.2.3.21.4 A handset microphone with coiled cord shall feature a push-to-talk switch capable of 1,000,000 operations. Handset microphone design (or alternate modern microphone design), will be subject to Metra review and approval.

12.2.3.21.5 A loud speaker assembly shall be provided in the cab ceiling. The assembly shall have a control to adjust the output volume of the speaker.

12.2.4 The contractor may propose a fully digital Public Address system. If proposed, the system shall utilize the digital trainline(s) described in 11.5.5 or a standalone digital PA trainline.

12.2.5 The Public Address/Intercom system shall feature radio to PA capability, with the design and details subject to Metra review and approval.

12.2.6 (deleted)

12.3 TRAIN RADIO

12.3.1 Alternatively, and at Metra's sole discretion, Metra may elect to supply the train radio to the Contractor. If such an option is chosen by Metra, the Contractor shall be responsible for all ancillary equipment and materials needed to complete the installation and successfully conduct a full functional qualification test of the train radio. The qualification test procedure shall be subject to Metra review and approval. **[CDRL C-12-05]**

12.3.2 Cab Control cars shall be equipped with a narrow band train radio. The radio shall comply with AAR Standards and with any Federal Communications Commission or other regulations.

12.3.3 The radio shall be capable of adjustment to clarify reception and alter volume.

12.3.4 The radio shall be a >100 channel radio, with an internal microphone, remote audio connector and remote control head. The radio shall take power from the locomotive battery power source or (other approved independent power source) and the circuit shall be suitably protected. Power must be filtered if appropriate.

12.3.4.1 Clean cab mounting plate to be provided.

12.3.4.2 One handset (or alternate Metra-approved microphone) with push-to-talk switch, coiled cord, and AAR connector shall be provided at the operator's station.

12.3.4.3 The handset hang-up cup (or alternate Metra-approved design) shall include a radio control reverting switch.

12.3.4.4 The minimum functions of the transit control head shall be: PTT, Channel Display, Display brightness control, Number pad, Volume up/down, Home group, AAR group, and squelch tight/normal setting

12.3.5 A standard railroad style antenna shall be supplied. The location shall be subject to Metra approval.

12.3.6 The cab radio shall feature a ruggedized housing, ruggedized display, and ruggedized keypads.

12.3.7 The cab radio shall meet AAR S-9401 Vehicle Interior Cab standards (or Metra approved equivalent) for Humidity, Vibration, Mechanical Shock, and Abrasive Environment.

12.3.8 The cab radio shall conform to all applicable AAR standards for cab radio and radio transmission, including the capability of transceiving on all AAR channels. The radio must support all current AAR designated analog FM two-way radio channels, at "narrowband" 12.5 kHz deviation. This includes the standard designated channels 007-098 and 107-198 interstitial channels. These channels should be accessible in a specific group that allows entry by keypad of independent Tx and Rx frequencies. (ex. 077 077 for simplex operation).

12.3.9 The cab radio shall be set up to transmit and receive on all channels used by Metra. These channels shall be easily selectable. The radio must also support a “Home channel” group. Group must be customer programmable by Metra Radio Shop staff. Home channels may include any frequency in the VHF 155-174 MHz range, 25 kHz and 12.5 kHz. Home channels must also support standard CTCSS/PL and DCS/DPL tone coded squelch options. Must also support Rx only channels.

12.3.10 A full functional qualification test of the train radio shall be completed. The qualification test procedure shall be subject to Metra review and approval.

12.3.11 The details of the cab radio shall be proposed to Metra for review and approval. **[CDRL C-12-05]**

12.4 BUZZER SYSTEM

12.4.1 A trainlined electric signal system shall be provided in all cars. Pushbuttons and buzzers shall be located approximately as follows:

12.4.2 One (1) low tone buzzer located in the control station of cab-control cars

12.4.3 Two (2) pushbuttons located in the passenger boarding/alighting area of all cars, one adjacent to each door control panel

12.4.4 One (1) pushbutton in a Metra approved location near the body end door opening at one end of all cars

12.5 TRAIN INFORMATION MANAGEMENT SYSTEM/ACORN

12.5.1 The Contractor shall furnish and install a Train Information Management System (on train equipment only) in accordance with 49 CFR 38.103, Public Information System. The Train information Management System shall be 100% compatible with Metra’s existing ACORN system as per section 12.1.6. The compatibility requirement shall not constrain the proposer to require wireless trainline connections. In the proposer’s proposal, a description of how the system is networked and trainlined, including if wired or wireless connections are proposed shall be included. The details of the design, equipment, arrangement, and installation of the complete train information management system shall be submitted to Metra for review and approval during the design review process. **[CDRL C-12-06].** Proposal functionality and hardware details of this system shall be provided as part of **[PDRL P-12-01].**

12.5.2 The train information system shall be fully compliant with all applicable ADA regulations and recommendations.

12.5.3 The system shall monitor train location via the Global Positioning System and use this information to provide on-train text and audio messages regarding train arrivals and delays. The system shall transmit location information (within ten (10) meters) to Metra’s existing base station servers. The system shall demonstrate compatibility with Metra’s communication system back office and GPS operation.

12.5.4 The onboard train system will be linked via cellular communication to a Metra base station server. The system shall also be Wireless Fidelity (WiFi) equipped to allow for base station communication via Wi-Fi if in range. The system shall be independent from PTC Wi-Fi.

12.5.5 Metra personnel onboard shall be able to connect for troubleshooting and maintenance purposes.

12.5.6 The onboard train system shall be capable of sending customized messages from the user application to be displayed/announced aboard individual trains in real-time.

12.5.7 There shall be a user interface to allow the programmable control on its car and the interior signs on its car. The interface shall allow for control, testing, and adjustment of the text (signs) and audio announcements. The programmable interface shall feature a numeric keypad and a ruggedized screen display or proposed alternative, subject to Metra approval. The interface shall allow a trainman to specify the following:

12.5.7.1 Specify train number
12.5.7.2 Specify operating characteristics
12.5.7.3 Specify reason for delay and
12.5.7.4 Specify manual announcements.

12.5.8 The Train Information System Network controller will be stored in a secure area accessible only by using a train maintenance key or Metra's standard coach key.

12.5.9 The terminal shall store train schedules and train numbers in a database (approximately 245 stations, 482 trains inbound to and 482 trains outbound from Chicago traveling on 12 rail lines). Actual train performance is compared to scheduled performance and is used to alert passengers when a train is behind schedule. The system allows a trainman to select a reason for the delay. The updates to the database shall be made via a portable computer. The system shall be capable of updating the database from the base station computer. In addition to this information the database would also contain the voice files for the prerecorded commuter information and the safety messages.

12.5.10 The system shall allow for live announcements sent directly from the base station server.

12.5.11 The contractor shall include infotainment subject to Metra approval. This shall include features such as: dedicated digital display areas for advertisements that can be triggered based on location, time of day, Metra line, and date range. These signs/screens shall allow for animated graphic displays, including entertainment and advertising. These areas shall not interfere with displaying important passenger information including “next station stop,” delay messages, conductor announcements, and messages sent from GPS operators. Importing and removing of advertisements shall be easily controlled by Metra. Infotainment details shall be included in the Proposal. **[PDRL P-12-02]**

12.5.12 The contractor shall propose additional infotainment options to Metra if they are available. **[COPL CO-12-01]**

12.5.13 The communication system shall be seamlessly interfaced with the PA system, and all necessary equipment to interface with the public address system shall be provided. The system shall be configurable to select whether generated audio and text messages yield precedence to conductor PA announcements. The system shall allow all cars on a train to play and display announcements simultaneously.

12.5.14 The system shall be fully compliant to all ADA codes and standards. Advanced features will be investigated and implemented where possible, with the designs and functionality being submitted as part of the Proposal Deliverable [PDRL P-12-01] for Metra review and approval.

12.5.15 Optional ADA passenger enhancements, including speech-to-text and assistive listening technology, which go beyond local, state, and federal requirements shall be proposed as options. **[COPL CO-12-02]**

12.5.16 The system will provide the following announcements automatically over the train's public address system and signage system for the selected train number:

12.5.16.1 Train destination and scheduled station stops prior to departure from the initial terminal

12.5.16.2 Train destination and scheduled station stops repeated along with emergency exit announcement after exiting the initial terminal

12.5.16.3 Emergency exit announcement prior to the arrival at the final destination

12.5.16.4 Announce an upcoming station prior to arrival

12.5.16.5 Announce the next station stop upon departure from a station (The signs shall continuously display this until the next arrival message is prompted)

12.5.16.6 Announce delay when a train is behind schedule and announce the reason for the delay if available

12.5.16.7 Announce any modifications to the normal schedule and any special announcements programmed.

12.5.17 The contractor may be responsible for the creation of the digitized audio files for the above, and the system shall allow loading of existing audio and text data and have the ability to schedule playback.

12.5.18 The system shall be designed to automatically display messages on specific cars in the train consist at specific times of the day. Example: “Quiet Car” logo is displayed on the screens of the second car and second to last car on weekday consists from 6am-9am and 4pm-6pm automatically regardless of train consist size. Provisions shall be in place to allow train crews to push a list of pre-defined messages/logos and custom messages to the Passenger Infotainment display screens of all or selected train cars of consist. Pre-defined messages/logos shall be editable to maintenance personnel. Examples of messages could be messages such as “No alcohol allowed on train – with predefined logo”, “Toilet out of service – with predefined logo”, or “a typed message – “Train will now operate express to ‘___’.”

12.5.19 Interior/Exterior Signs

12.5.19.1 The contractor shall provide LED, LCD, TFT-LCD, OLED, or AMOLED (or any combination thereof) interior signage technology which has proven service in passenger transit applications. The signage shall be multipurpose, for simultaneous display of route/destination information and infotainment.

12.5.19.2 The interior signs shall display the text messages/animations that are coordinated with the on-train audio announcements. Text displays include time and date, train number, final destination, on-time / delay information, and emergency procedures. In addition to GPS location triggering of station stops, messages shall be initiated via back office of the train information management system and the programmable interface onboard.

12.5.19.3 The interior signs shall refresh at rate indiscernible to the human eye. The interior signs shall be capable of producing smooth animations. The interior signs shall be capable of producing multicolored text and animations.

12.5.19.4 The signs shall feature a wide viewing angle, and the signs shall be readable by a maximum number of passengers in each passenger area. The sign shall be clearly readable in all ambient light conditions from total darkness to direct sunlight. The signs shall adhere to all current and applicable ADA and APTA required and recommended standards at the time of the contract award.

12.5.19.5 For messages able to be entirely displayed on the screen at once, the text shall statically display, and not scroll or disappear. The interior signs shall continuously display next station stop announcements upon departure from the previous station until the arrival at the following station.

12.5.19.6 The signs shall function nominally during input voltage fluctuation ranges seen in passenger rail operation. The signs shall feature input protection for electrical inputs outside of the normal operating range. The signs shall function nominally in the vibrations seen in a normal railroad operating environment.

12.5.19.7 The interior signs shall be capable of featuring emergency messages and would be part of the trains essential load/emergency power supply.

12.5.19.8 The signs shall be applied in locations subject to Metra approval in anti-theft enclosures. The signs shall be housed in durable enclosures. The sign shall be accessible for maintenance crews to replace the sign or adjust settings.

12.5.19.9 The signs shall be tested in accordance with other tests required for onboard equipment in this specification, such as: vibration; flame, toxicity, and low smoke; electromagnetic compatibility; temperature and humidity.

12.5.19.10 The contractor shall supply two (2) exterior information signs on each car. These signs shall provide information to the passengers on the platform, this will include end destination, car passenger load, restroom locations. ADA areas and any key journey points of interest, such as Airport or Train station.
Each end car, shall provide an additional two (2) information signs. One providing the train number, while the other providing the trains end destination.
Destination signs shall have illuminated characters on a non-illuminated background and shall use electronic segment or LED type displays. Other technology will be considered. All signs shall be discernible in bright daylight.
Access to the signs shall be from inside the car, and shall provide for easy replacement and maintenance of all components.
The side signs shall also be programmable to display public-relations messages. They shall be capable of displaying in a static mode a minimum of 14 characters 2" height to be well perceived and well-read at least from 15 feet as well as from a very short distance by the passenger waiting on the platform or approaching the train and is subject to Metra approval.
The front destination sign shall be capable of displaying a minimum of nine (9) characters maximizing the available space to spell the destination. In compliant with IEEE1477 the display shall also be capable of displaying characters 4" height and to manage spelling of the message in scrolling mode.

12.5.19.11 The design, placement, and testing requirements for the passenger information signs shall be subject to Metra approval. **[CDRL C-12-07]**

12.5.20 The system shall utilize an open architecture to provide for future expansions and upgrades. The system shall be designed to easily add new functions and upgrades from different manufacturers. All input/output modules, control and data transfer protocols shall be non-proprietary to the greatest extent possible. The system shall also be designed for

adaptation to wireless local area networks (WLAN) for the purpose of automatic file update downloads.

12.6 PASSENGER COMPARTMENT DIGITAL VIDEO RECORDING SYSTEM

12.6.1 A secure, railroad-grade Passenger Compartment DVR system shall be proposed. It shall reliably capture and securely archive video for retrieval. The system shall be composed of one central dedicated recorder; a suitable number of cameras for each passenger compartment and the passenger boarding/alighting areas and all applicable interconnections. The DVR system shall be powered from a separate circuit breaker (on the breaker panel). If a cable break point is necessary, then the break should pass through a shielded ethernet bulkhead coupler, not a terminal board. The design and arrangement of the DVR system, including camera locations shall be proposed and subject to design review and approved by Metra. **[CDRL C-12-08]**

12.6.2 Each component must be modular, interchangeable, and replaceable without affecting the rest of the DVR system. The DVR system shall have capability of automatic detection when a camera is plugged into the DVR system and automatic configuration of the camera for plug and play functionality. To the greatest extent possible, the passenger camera system hardware and software shall be non-proprietary in nature, such that Metra will not be hindered from expansion, upgrading, or replacing certain components.

12.6.3 It is required that the DVR recorder be a digital IP (Internet Protocol) based system and support digital IP cameras. The DVR recorder shall, at a minimum, be designed to meet all applicable FRA, AAR and APTA regulations in place at the time of Contract Award. The DVR recorder video channels shall be used to capture and record video from multiple connected cameras simultaneously. The DVR recorder audio channels shall be used to capture audio from multiple connected microphones simultaneously. Microphones internal to the camera are acceptable for passenger compartment video monitoring system, provided that they can be enabled or disabled through the DVR software. It is preferable that the DVR recorder shall feature video motion detection to trigger recording. If proposed, the video motion detection sensitivity shall be adjustable, customizable, and shall be capable of being enabled or disabled by Metra. The DVR shall have the capability of remote live viewing of video and remote downloading. Video data transmission through digital trainlines may be proposed.

12.6.4 The cameras shall be capable of clearly recording in all types of temperature and humidity experienced on the car, day, or nighttime conditions, with normal nighttime illumination from the main LED lights of the rail car. The cameras are required to be a high definition digital IP type camera. The cameras are required to be powered by PoE. The cameras shall be capable of recording in color with a minimum resolution of 1080p and 20 FPS. The DVR shall have user adjustable resolution and FPS settings. The settings shall be made accessible to Metra. The settings shall be adjustable for each individual camera connected to the DVR. Each camera shall have 1 adjustable lens. The camera lens focal length shall be selected during the design. Each camera shall be housed in a compact vandal resistant enclosure. The cameras shall be suitable for interior trainset installations. The camera shall be adjustable to allow for camera positioning.

12.6.5 At least one camera shall capture clear, unobstructed, and consistent views of passenger's faces to enable Metra police forces to utilize facial recognition software using a still image from the camera feed.

12.6.6 All cameras and camera system components shall be electrically isolated to not cause a ground fault on the carbody.

12.6.7 The DVR shall have a visual indicator system that indicates the system is properly functioning and recording. The visual indicator system shall alert personnel upon failure of any camera, hard drive, or other type of fault.

12.6.8 The Passenger camera system components shall be moisture, dirt, and vandal resistant. The components shall comply with all applicable environmental standards for onboard electronic equipment mentioned elsewhere in this specification.

12.6.9 The lifecycle of the DVR system shall be a minimum of 8 years. Any components with an estimated lifespan of less than 8 years shall be field-replaceable. The contractor shall provide a parts list for the field-replaceable components in the maintenance manual and/or illustrated parts catalog.

12.6.10 The DVR shall feature an interface to enable for a direct computer connection. An Ethernet interface is preferred.

12.6.11 The DVR shall contain built-in Wi-Fi hardware (if possible, the contractor shall utilize Metra's ACORN Mesh Networks) to enable access and perform downloads from the system via ad hoc or peer-to-peer Wi-Fi such that will facilitate Metra in performing DVR data dumps via Wi-Fi/Mesh at maintenance facilities and outlying points. Metra shall retain the ability to enable or disable the Wi-Fi capability features on the DVR system.

12.6.12 The video archive is required to be a minimum 10 calendar days.

12.6.13 Passenger Camera DVR Software

12.6.13.1 The contractor shall enable security measures to prohibit unauthorized DVR downloads, including, at a minimum, password protection configurable by Metra.

12.6.13.2 The DVR system shall include computer software that allows for downloading and onboard viewing of video directly from the DVR recorder without removing the hard drive.

12.6.13.3 The software shall allow the user to specify specific dates and times in order to control the length of the video clips downloaded.

12.6.13.4 When downloading a video/audio clip, the user shall have the ability to select or deselect which video and audio channels are to be downloaded.

12.6.13.5 The software shall have the capability to export all video and audio channels on the trainset into 1 file with all video and audio channels synchronized.

12.6.13.6 Each audio/video clip shall contain at minimum a time stamp with date, time, name of DVR system (car number), and associated video channel names that are overlaid onto the image and synchronized with video and audio.

12.6.13.7 The computer software used to view the CCTV images, both live and downloaded, will be user friendly and self-intuitive, requiring a minimum amount of selections by the end user. Camera selection can be made for single cameras, cars or whole units when viewing live, if there are more images than can fit on the screen, the images shall scroll in an systematic fashion. When viewing downloaded images, a selection of at least 4 separate camera images will be able to be displayed simultaneously. The software interface design shall be subject to Metra approval.

12.6.13.8 The DVR system shall include computer software allowing for video downloads for a hard drive removed from the DVR recorder that is connected to a laptop or desktop computer, by means of a docking station or special adaptor cables. The software interface design shall be subject to Metra approval.

12.6.13.9 The ability for Metra personnel to install and configure all supplied software without contractor assistance or interaction shall be required.

12.6.13.10 Future DVR software and DVR firmware updates to any computer software shall be provided free of charge to Metra for the duration of the contract.

12.6.13.11 The Contractor shall supply Metra with all computer software archived on electronic media. The software shall be archived along with the DVR documentation.

12.6.13.12 The operating system requirements for all computer software supplied to Metra by the Contractor shall be compatible with currently supported Windows 10 Operating Systems.

12.6.13.13 Any software supplied shall have the ability to be configurable to meet the requirements outlined in this section. Metra shall have the ability to reconfigure the software as needs change and shall not be locked into the requirements as defined in this section.

12.6.13.14 If 360° or fisheye cameras are included, the software shall have a pre-configured set of four views automatically de-warped (or four raw feed views) when downloading footage. The software shall feature automatic (when configured) de-warping of the video footage. These views shall each appear as normal single camera footage and shall not exhibit any distortion or cropping. The capability, ease, and desirability of the aforementioned will be evaluated during the technical evaluation. The de-warping and/or view customization of any 360° camera and camera software shall be subject to Metra review and approval as part of **[CDRL C-12-08]**.

12.6.13.15 Video footage shall be able to be exported with the contractor's software into commonly used or non-proprietary video formals, such as .avi.

12.7 PASSENGER WI-FI PROVISIONS

12.7.1 The proposer may proposer passenger Wi-Fi as an option. **[COPL CO-12-04]** If the proposal does not include passenger Wi-Fi, provisions for passenger Wi-Fi shall be built into the car.

12.7.2 Provisions for a future Wi-Fi installation shall be made to include: spare power wires to where the future router may be provisioned, create a designated area where a hole can be drilled/used for the Wi-Fi exterior antenna. This area would ease the installation process when/if Metra decides to install the Wi-Fi system and in some way have existing safeguards to prevent water intrusion if a hole in the roof is utilized. The design and arrangement of this provision shall be subject to design review and approved by Metra. **[CDRL C-12-09]**

12.8 AUTOMATED PASSENGER COUNTING

12.8.1 The Contractor shall provide an Automated Passenger Counting (APC) system. The design, placement, and functionality shall be submitted to Metra for approval during the design review process. **[CDRL C-12-10]**

12.8.2 The APC shall have the ability to integrate with Metra's Computer Aided Dispatch and Automatic Vehicle Location (CAD/AVL) system.

12.8.3 The APC system shall have the ability to count every passenger of size and shape, boarding and alighting a train at each station.

12.8.4 The APC system shall have the ability to record passenger count data in a manner that allows for reporting as required by the National Transit Database (NTD) Certification Checklist.

12.8.5 The APC system shall accurately count passenger loads during high volume peak times for boarding and alighting.

12.8.6 The APC system shall be able to count passenger loads across the entrances and exits in each car, including end-doors.

12.8.7 The APC system shall have the ability to accurately count regardless of the size of the passenger from small child to large adult without requiring a passenger to carry an identifying ticket or other object to board or alight the train.

12.8.8 The APC system shall be able to reasonably distinguish an individual human passenger from non-human objects such as luggage, briefcases, service animals, strollers, walkers and bicycles.

12.8.9 The APC system shall have the ability to account for passengers boarding and alighting only, and not count after the doors have closed.

12.8.10 The APC system shall have the ability to associate APC datum with its date and time, accurate to at least the minute.

12.8.11 The APC system shall have the ability to associate APC datum with its geolocation.

12.8.12 The APC system shall have the ability to associate APC datum with entities such as train, station, and route.

12.8.13 The APC system shall have the ability to report total ridership count for entities such as train, station, and route.

12.8.14 The APC system shall provide APC data in a non-proprietary (open data) format. This data shall automatically be offloaded to the trainset's data storage unit or be automatically offloaded to Metra's database when in Wi-Fi range at Metra's facilities/yards.

12.8.15 The APC system shall have the ability to identify when an APC system aboard a train is not functioning normally.

12.8.16 The APC system accuracy shall be greater than 95%, based on a minimum of 1000 boarding and 1000 alighting events, accounting for different ridership and lighting conditions, and to be representative of Metra's operating conditions. The 95% accuracy level shall be reached on raw data without any post processing of the data and without use of any adjustments factor.

12.8.17 The APC system shall retain its normal accuracy in all lighting conditions and regardless of the speed of passengers.

12.8.18 The APC shall require no manual correction after installation and initial activation, regardless of its application and the season it is operating in.

12.8.19 The APC units shall have certification of counting accuracy.

12.8.20 The APC system shall require little to no calibration after it is installed. If calibration is required after a certain amount of years, this calibration procedure shall be as effortless as possible.

12.8.21 The APC system shall be modular with simple architecture and minimal wiring required.

12.8.22 The APC system shall feature clear and easy diagnostic indicators, such as LEDs or via quick and simple PTE or diagnostic interfaces.

12.8.23 The APC system shall integrate seamlessly into Metra's existing ACORN reporting tool and user interface. The software shall require no additional license fee and shall be used by an unlimited number of Metra users.

12.8.24 The APC shall be protected against and function in conditions seen in its operating environment, including: rain, snow, humidity, high and low temperature, condensation, dust, and vibration.

12.9 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-12-01	Functionality and the Onboard Equipment of Complete Communication System
P-12-02	Infotainment Proposal

12.10 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-12-01	Design, Arrangement, Installation of Communication Package
C-12-02	Compatibility with Metra's existing ACORN communication system
C-12-03	Audio Sampling and Study of all Passenger Areas
C-12-04	Emergency Passenger Intercom Unit
C-12-05	Cab Radio
C-12-06	Train Information Management System
C-12-07	Passenger Information Signs
C-12-08	Passenger Compartment DVR System
C-12-09	Passenger Wi-Fi Provisions
C-12-10	Automated Passenger Counting

12.11 CONTRACT OPTIONAL PROPOSAL LIST

COPL	Title
CO-12-01	(deleted)
CO-12-02	(deleted)
CO-12-03	(deleted)
CO-12-04	(deleted)

13 BRAKE SYSTEM

13.1 GENERAL REQUIREMENTS

13.1.1 The blended brake system shall be capable of providing the total service braking effort and maintaining normal revenue operation without degradation of service. The brake system shall integrate and blend the braking efforts of the dynamic brake and the friction brake system to produce the required or demanded braking effort. The emergency brake shall be of fail-safe design and allow direct venting of the brake pipe. Brake pipe pressure is to be 90 psi. The brake equipment shall be provided on a per truck basis. The brake system shall include interface capability for Electronically Controlled Pneumatic (ECP) brake system with appropriate functionality with cab signals, overspeed protection, vigilance/alerter control and the event recorder. The ECP system and its interface with these ancillary devices shall have no single point failures. The ECP control logic and hardware platform shall be compatible with AAR standards. Trainsets shall be equipped with hard conduit ready to accept ECP wire trainline as defined by AAR Standards. Conduit shall be terminated with protective caps adjacent to the brake pipe train line hose connection. The brake system shall follow common AAR standards, EN standards (EN 16185 and EN 15595) are also applicable. The blended brake system is subject to Metra design review and approval. [CDRL C-13-01]

13.1.2 (deleted)

13.1.3 The Contractor shall submit to the Customer a detailed brake system, brake distribution, control, and blending description, including all interfaces, for review and approval.
The air brake equipment shall be arranged in the car so that there is sufficient clearance to remove the valve portions of the equipment. It shall be rack mounted. Details on the reliability and maintenance of the system shall be included. [CDRL C-13-01].

13.1.4 A Failure Mode Effects and Criticality Analysis (FMECA) shall be conducted by the Contractor. The specific systems, including software and interfaces for the FMECA shall be approved by the Metra during design review.

13.1.5 The contractor shall submit as part of the proposal, a general description of the air system, including specifics of the air brake system and air supply unit. **[PDRL P-13-01]**

13.1.6 Service brake applications shall be initiated from the master controller and shall be regulated by the control handle position. An Alerter system shall be provided. The Alerter system shall monitor the Operator's action. The Alerter shall comply with CFR 49 part 229.140 Alerters. If the Alerter is not reset as required, a penalty brake application shall be triggered. The Contractor shall submit, for the Authority's approval, complete data on the Alerter design, operation, and functionality. **[CDRL C-13-02]**

13.1.7 Service brake applications shall be initiated from the master controller and shall be regulated by the control handle position. An Alerter system shall be provided. The Alerter system shall monitor the Operator's action. The Alerter shall require periodic reset by the Operator as defined below. If the Alerter is not reset, flashing lights and increasing levels of audible alarm on the system alarm panel shall be initiated. The Alerter shall comply with CFR 49 part 229.140 Alerters. If the Alerter is not reset as required, a penalty brake application shall be triggered. The Contractor shall submit, for the Authority's approval, complete data on the Alerter design, operation, and functionality [CDRL C-13-02].

13.1.8 An Emergency Mushroom Push Button is to be provided per Cab. This Push Button shall vent the Brake Pipe and apply an Emergency Brake. The Push Button should be colored red.

13.1.9 (deleted)

13.2 AIR END CONNECTIONS

13.2.1 On trainset lead ends, brake pipe hose shall be of sufficient length to be compatible with all Metra equipment, AAR approved and dated. These hoses when coupled to a Metra coach or locomotive must negotiate the applicable curves described in Section 3 without hoses parting or distorting.

13.2.2 MU hoses shall be provided at both ends on both sides of the coupler and marked accordingly. The MU lines shall consist of:

13.2.2.1 Independent brake application and release line.
13.2.2.2 Main reservoir equalizing line
13.2.2.3 Actuating line.

13.2.3 Brake pipe angle cocks shall be ball-type.

13.2.4 The builder's standard dummy couplings shall be provided for the front and rear brake pipe hoses. All dummy couplings shall be vented.

13.3 AIR COMPRESSOR

13.3.1 A minimum of two (2) air compressor shall be provided. The air compressor system shall have enough reserves so that one air compressor can supply the required air delivery rate for the whole pneumatic system. The air consumption estimation and the duty cycle of the compressor shall be subject to Metra for review and approval. **[CDRL C-13-03]**

13.3.2 Air quality must comply with APTA standard PR-M-S-011-99, latest revision.

13.3.3 Main reservoir pressure shall be maintained at 125-150 psi operating range.

13.3.4 Alarm for air compressor low oil shall be provided (unless an oil-less compressor is provided).

13.3.5 The after cooler shall be equipped with a separate automatic drain dump valve and shall be designed to avoid condensate traps and dump valve shall be heated as required to avoid freezing.

13.3.6 If electric motor-driven, the compressor shall be able to operate when the locomotive is on wayside power.

13.4 GAUGES AND FITTINGS

13.4.1 At a minimum the following gauges should be available:
- Brake cylinder and park brake cylinder pressure (white hand), black dial
- Brake pipe (red hand) and main reservoir pressure (white hand), black dial

13.4.1.1 (deleted)
13.4.1.2 (deleted)
13.4.1.3 (deleted)

13.4.2 Salem test fittings shall be provided at all gauges plus at the air compressor control switch.

13.4.3 (deleted).

13.4.4 The above indications can be included in the Builder's integrated electronic display (if provided) in lieu of the above.

13.5 MAIN RESERVOIR

13.5.1 The main reservoir and air dryer system shall be subject to Metra design review and approval. **[CDRL C-13-04]**

13.5.2 A minimum of 400 l of main reservoir volume shall be provided on the trainset. Reservoirs shall comply with the requirements of 49 CFR 229.31. Reservoirs shall have an accessible drain hole at the bottom of each reservoir to facilitate draining of condensate.

13.5.3 The brake system of each truck shall have a separate R-Reservoir with a minimum volume of 80l.

13.5.4 Reservoirs shall be equipped with drain valves. Drain valves shall be located at the lowest point of the reservoir.

13.5.5 An aftercooler shall be provided in the air compressor system.

13.5.6 The air filter/dryer system shall meet the requirements as specified in APTA Standard APTA PR-M-S-011-99. A heater shall be included.

13.5.7 A safety valve set for a maximum of 160 psi shall be provided before the outlet of the compressor.

13.5.8 All check valves in the reservoir system shall be flange mounted.

13.6 AIR PIPING

13.6.1 Air piping shall be according to ASTM A-53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 316L or the equivalent 1.4404. Pipe Connection shall be according to ISO 8434 Metallic tube connections for fluid power and general use.. Contractor's standard piping and tubing shall be approved by Metra. **[CDRL C-13-05]**

13.7 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	**Title**
P-13-01	Air Brake and Air Supply System

13.8 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	**Title**
C-13-01	Air Brake System
C-13-02	Deadman Pedal
C-13-03	Air Compressor
C-13-04	Main Reservoir and Air Dryer

C-13-05	Air Piping

14 WARNING DEVICES

14.1 BELL

14.1.1 A bell (electric or pneumatic) shall be provided. The bell shall be mounted in a position to minimize snow and ice intrusion while still maintaining audible requirements. The location and design of the bell and bell controls shall be subject to Metra review and approval. **[CDRL C-14-01]**

14.1.2 Each driver's cab shall be equipped with two manual bell control buttons, reachable by the engineer and at the observer side.

14.1.2.1 Controls shall be arranged so that the bell may be operated manually in an active cab at any time.

14.1.2.2 The same apparatus panel to activate the bell shall be the same apparatus panel to deactivate it.

14.2 HORN

14.2.1 Horn sound levels must satisfy the requirements of FRA regulations 49 CFR 229.129. A minimum sound level of 96 dB(A) and a maximum sound level of 110 dB(A) at 100 feet forward of the locomotive in its direction of travel.

14.2.2 A low profile three-chime horn shall be provided. The horn(s) shall be located in a Metra approved location. The location and design of the horn and horn controls shall be subject to Metra review and approval. **[CDRL C-14-02]**

14.2.3. A horn heating system shall be provided. At a minimum, the center chime must be heated. The heating system for the horn assembly shall be subject to Metra review and approval.

14.2.3 The horn shall be activated by two (2) controls, one located on the engineer's console and the other on the observer's desk.

14.2.4 Horn assemblies with internal heating feature to prevent failure from ice or snow accumulations shall be provided.

14.3 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-14-01	Bell
C-14-02	Horn

15 TRUCKS

15.1 GENERAL REQUIREMENTS

15.1.1 Details of the design, arrangement, installation, and testing of the truck components and assembly shall be submitted to Metra for review and approval. **[CDRL C-15-01]** Truck system proposal shall include a basic general arrangement drawing, service history, and basic description of system function. **[PDRL P-15-01]**

15.1.2 Only trucks manufactured by a supplier with successful experience in railway passenger truck design and manufacture shall be acceptable. Final assembly needs not be done at an AAR certified shop however, manufacture of wheels and axles and their mounting shall be performed at AAR certified facilities. Trucks and components shall be based on a service proven design, which has operated in similar service in the United States. A technical evolution of the truck frame design is accepted under consideration of all track classes according to 49 CFR 213.9 and the requirements according to the standards EN 13749, EN 15085, EN 15827 and applicable CFR requirements. The Contractor shall submit the service history of the truck, noting any deviation for this application to Metra for review and approval, prior to selection of truck. **[CDRL C-15-02]**

15.1.3 The trucks shall provide a safe and secure support and guidance system, transmitting accelerating and braking forces to the car-body, and must provide comfortable riding quality at all speeds up to 100 miles per hour on track appropriately certified by FRA. The design, arrangement and equipment of the trucks shall be such as to prevent "hunting" or "nosing" at all speeds, and to minimize rocking of truck frame at critical speeds. **[CDRL C-15-05]**

15.1.4 The design safety concept shall be according to the standards EN 13749, EN 15085, EN 15827 and applicable CFR requirements. In the design of all truck parts, all forces and combinations of forces, including braking forces, must be taken into account. Multiplication of forces due to accelerations and shocks, and non-uniform distribution of vertical loading due to track irregularities and super elevation, must be considered according to best practice. The design center bearing load for both trucks shall be determined from the heaviest end of the trainset, using AW3 load, plus train supplies, less truck weight. To this dead weight must be added all dynamic loads and multiplying factors.

15.2 TRUCK FRAME

15.2.1 Truck frames shall be stress relieved, one piece cast, low alloy nickel structure, normalized and tempered, or welded steel fabrication of adequate cross sectional area at all locations. Junction of cross members to side members must be proportioned and shaped to eliminate stress points. Truck frame shall have as much strength and capability of resisting twisting and uneven distribution of loading as possible.

15.2.2 The truck frame shall be analyzed for static and dynamic loads and will be tested for static stresses and fatigue stresses. On-track testing of the truck frame and equalizer beam may also be required per the truck validation plan.

15.2.3 Design shall allow removal of wheelsets with traction motors or wheelsets with axle riding gear boxes using drop tables.

15.2.4 Axle-drive, end of-axle wheel-truing access provision, to allow wheel truing while the wheel set is attached to the car.

15.2.5 The truck frame shall provide a minimum life of 40 years based on proper performance of scheduled maintenance.

15.3 BRAKE RIGGING AND HANDBRAKE

15.3.1 Brake system shall be the builder's standard and service proven design to include tread or disc brakes, or a combination thereof.

15.3.1.1 Pneumatic application will apply brakes at all wheels
15.3.1.2 A suitable combination (as required) of disc or tread brakes shall be installed.
15.3.1.3 Self-aligning and adjusting brake rigging to correct clearances resulting from wear of brake pads, brake discs and wheel surface shall be provided.
15.3.1.4 Composition brake shoes/pads shall be used. Alternatively organic or sinter pads may be used.

15.3.2 Performance of a parking brake mechanism shall ensure that the vehicle can be safely parked at a 3% grade holding capacity, assuming the manufacturer's suggested friction coefficient for the brake pad. The hand brake shall be electrically operated, with indicator lamps near the brake unit and also in the cab. The design and placement of the handbrake and handbrake controls shall be subject to Metra design review and approval. **[CDRL C-15-03]**

15.4 TRUCK BOLSTER

15.4.1 Truck Bolster shall be a welded or cast steel structure. The junction of cross members to side members must be proportioned and shaped to eliminate stress points.

15.4.2 The bolster shall include an integral central bearing between the bolster and truck frame. Two piece locking pin shall be utilized between the truck frame and bolster. Vertical and Horizontal wear liner shall be a polymer material with previous service history and excellent maintenance performance.
If no vertical and horizontal wear liner are used the vertical and lateral suspension is given by air spring system. The lateral suspension is limited by progressive lateral rubber bumper in parallel to the air springs. The rotation is given by the air springs and pivot center bearing between frame and bolster.

15.4.3 The first truck bolster shall be tested as described in Section 22.2.8.2. On-track testing of the bolster may also be required per the truck validation plan.

15.5 SIDE BEARINGS

15.5.1 Truck frame shall have side bearing pads located between the truck frame and bolster that are provided with a replaceable steel liner. An air gap is specified between the bolster and steel liner to limit lean in extreme conditions and does not contact during normal service. Side bearing pads provide a safety or hard stop for extreme cases of car-body lean. Alternatively, the lateral suspension is limited by progressive lateral rubber bumper in parallel to air springs.

15.6 WHEELS/AXLES/GEARS

15.6.1 Gear ratio shall provide for operation up to 90 mph minimum and the gear seat on axle shall be tapered.

15.6.2 Axles shall be supplied to the latest revision of AAR Specification M-101, grade "F" material or EN 13261. End-of-axle access shall be provided for wheel truing operations.

15.6.3 New wheels shall be 870 mm, 33” or 36” diameter, wrought steel, multiple wear, heat-treated, curved plate design conforming to AAR specification M-107/M208, latest revision for Class B wheels. Wheels should have sufficient material to allow multiple wheel truing operations. Mill scale shall be removed from the entire wheel so that inspection can be made before application. The wheel profile shall be a narrow flange APTA 220 wheel profile as specified in APTA PR-M-S-015-06 latest revision, based on AAR-1B (AAR S-669), 1:20 taper, modified for 5.5 inch wheel width. Wheels shall be balanced to the design requirements in accordance with the procedures specified in recognized industry standards

15.6.4 Before assembling wheel and axle sets, the pairs of wheels must be matched as to tape size according to EN 13260, or AAR Wheel and Axle Manual, and all operations of boring wheels, assembly, and pressing same on axle, and press tonnages obtained, must be in accordance with recommendations in EN 13260, or AAR Wheel and Axle Manual.

15.6.5 Wheels must be statically balanced to the requirements from EN 13262, or at minimum to with 1.3 Lbs at outside rim diameter and the amount of imbalance to be marked or stenciled on the back of rim face at point of maximum imbalance. The contractor shall follow APTA PR-M-S-019-17 latest revision for the back-to-back wheel measurement.

15.6.6 Radial, plane and parallelism for the mounted wheels shall be per AAR requirements. In the absence of such requirements the following shall apply: Radial - .008", Plane - .015", Parallelism - 0.150".

15.6.7 Bearing press charts shall be provided with each mounting wheelset report in addition to the reporting requirements specified in the AAR Wheel and Axle Manual. Alternatively, the reporting requirements from EN 13260 can be used.

15.7 JOURNAL BEARINGS

15.7.1 Roller bearing races, fingers, seal rings, cones, spacers and other parts placed on axles must be properly assembled or pressed in place, in accordance with bearing manufacturer's and AAR recommendations. Alternatively, service proven tapered bearing units (TBUs) from approved suppliers can be used.

15.7.2 Journal bearings shall have not less than a ninety percent (90%) probability of an expected life of at least the equivalent of 1 million miles (1.62 million km) acc. ISO 281. The Contractor shall confirm the size by an approved analysis, in conformance with AAR size, weight, and speed relationship or appropriate EN standards.

15.8 SUSPENSION SYSTEM

15.8.1 The suspension system shall be consistent with the overall performance requirements of the trainset. The Contractor shall demonstrate through test results or simulations that the interfaces and integration of the system has been fully and successfully accomplished and that its dynamic performance under all operating conditions and speeds is in accordance with the requirements of this Specification and the intended services. If simulation is to be used for the strength assessment, the Contractor shall demonstrate the correlation between the numerical strength assessment and the results of the laboratory testing according to EN 13749.

15.8.2 At a minimum, each truck shall be provided with two shock absorbers to control the vertical motion of the truck bolster

15.8.3 Wheel Load Equalization

15.8.3.1 The suspension system shall meet Class R load equalization requirements per latest revision of APTA Standard SS-M-014-06.

15.8.4 Static Lean Response

15.8.4.1 The trainset and suspension system shall meet static lean requirements as follows:

15.8.4.1.1 For maximum cant deficiency a worst-case wheel load no less than 60% of the static wheel load (see 49CFR Section 213.57 and 49CFR Section 213.329).

15.8.4.1.2 (deleted)

15.8.5 Track Dynamic Forces

15.8.5.1 Track dynamic (P2) forces shall not exceed 82,000 lbs for a 0.5 degree dip angle and all speeds up to the operating speed limit. The calculation is to consider nominally stiff concrete tie track and to use the British Rail Equation (as defined in British Railways Board Group Standard GM/TT0088 Issue 1, Rev. A).

15.8.5.1.1 The specific equation to be used is as follows:

$$P_2 = P_0 + 2\alpha v\sqrt{\frac{m_u}{m_u + m_t}}\left(1 - \frac{\pi c_t}{4\sqrt{k_t(m_u + m_t)}}\right)\sqrt{k_t m_u}$$

Where:

P_0 Static wheel load in pounds
α Dip angle in radians
v Vehicle speed in inches/ second
m_u Unsprung mass per wheel in lbf/in/ sec2
m_t Track mass per wheel in lbf/in/ sec2
c_t Track damping per wheel in lbf/in/sec
k_t Track stiffness per wheel in lbf/ in
Track parameter values are as follows:
α 0.0085 Total dip angle in radians based on '/2 degree on both sides of the dip
m_t 1.1335 Track mass per wheel in lbf/ in/ sec2 for nominally stiff concrete tie track
c_t 671 Track damping per wheel in lbf/in/ sec for nominal track conditions (from literature)
k_t 392,900 Track stiffness per wheel in lbf/in for nominally stiff concrete tie track (corresponds to track modulus of 5,100 lb/in/in, assuming a track deflection of 0.084 inches under a 33,000 pound wheel load)

15.8.5.1.2 Calculation of P_2 forces using builder proposed alternative values in the British Rail Equation and resulting change in the value of P_2 forces may be considered by the Customer upon approval of justification for such changes by the Customer and that such calculations are also approved by the owner of the right-of-way or his designated representative.

15.8.6 Dynamic Response on FRA Class 1 through Class 5 Track

15.8.6.1 Track-worthiness of the suspension system shall be verified through test results or simulations following the requirements of EN 14363.

15.8.6.1.1 (deleted)
15.8.6.1.2 (deleted)
15.8.6.1.3 (deleted)
15.8.6.1.4 (deleted)
15.8.6.1.5 (deleted)
15.8.6.1.6 (deleted)

15.8.6.2 Test or analysis is to consider speeds up to 90 mph (where appropriate). Limit values are to be based on criteria defined in EN 14363.

15.9 TRUCK-TO-CAR ATTACHMENT MECHANISM

15.9.1 The truck design shall follow EN 13749. The arrangement shall provide for lifting of trucks when the car body is lifted without disengagement of the mechanism.

15.9.2 Entire mechanism shall be in accordance with FRA Regulation 49 CFR Part 238 and APTA Standard PR-CS-S-034-99, latest revision, Section 5.6. Alternatively, a solution in accordance with 49 CFR 238,201(b) and EN 13749 may be proposed.

15.10 TRUCK GROUNDS

15.10.1 A Metra approved flexible ground strap system shall be provided between the car-body and each truck frame. The design and placement of truck ground strap shall be subject to Metra review and approval. **[CDRL C-15-04]**

15.10.2 Minimum Clearance of Truck Parts according to CFR49 229.71 above top of Rail (worst case): 2-1/2" apart from wheel mounted or adjacent equipment like wheel mounted brake discs, brake pad holder or brake pads.

15.11 AAR S920 COMPLIANCE

15.11.1 The Contactor shall comply with AAR S920 (AAR CID) for wheels. Scanned Data shall be provided with each car history book electronically.

15.12 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	Title
P-15-01	Truck System

15.13 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-15-01	Truck Design Review
C-15-02	Service History of Truck
C-15-03	Handbrake
C-15-04	Truck Ground
C-15-05	Ride Quality Simulation or Test Report

16 CAB CONTROL STATION

16.1 GENERAL REQUIREMENTS

16.1.1 An operating station shall be located on the lead end of all cab control cars. It shall have an Engineer's position on the right side (when looking out the windshield) and an observer's position on the left side.

16.1.2 The control station shall conform to the FRA and AAR standards for cab arrangements, to the greatest extent possible, considering the requirements of this specification.

16.1.3 The Engineer's operating controls shall be arranged in and on a desk-top console to the front of the engineer's seat and immediately below the windshield. All switches, circuit breakers and alike shall be arranged to permit a one man operation from the engineer's position. Details of the design of the cab, arrangement of the cab, and the locomotive controls, to include a mock-up of the cab, shall be submitted to Metra for review and approval. **[CDRL C-16-01]**

16.2 CAB SEATS

16.2.1 The control cab accommodate an Engineer and two seated Observers.. The seats shall comply with the requirements of APTA Standard PR-CS-S-011-99, latest revision and FRA Regulations 49 CFR Part 238.103 and 49 CFR Part 229.119. The cab seat design and layout shall be subject to Metra review and approval. **[CDRL C-16-02]**

16.3 AIR BRAKE EQUIPMENT

16.3.1 The air brake system shall have a penalty system linked to PTC, alerter function and overspeed.

16.3.2 Recovery from an emergency brake application shall only be possible after standstill. There shall be no delay on recovery from a penalty application except for a triggered emergency brake application via the penalty system..

16.3.3 Equipment to be provided as follows:

16.3.3.1 One (1) desk top electronic brake valve
16.3.3.2 One (1) dual gauge for MRE and Brake Pipe
16.3.3.3 One (1) dual gauge for brake cylinder and park brake cylinder pressure
16.3.3.4 (deleted)
16.3.3.5 One (1) emergency brake push button accessible for the operator and observer
16.3.3.6 One (1) alerter foot panel
16.3.3.7 (deleted)
16.3.3.8 Emergency brake shall trigger a traction cut-off.

16.3.4 (deleted)

16.3.5 (deleted)

16.3.6 "Deadman" feature shall be provided with appropriate sealable cutout switch.

16.4 CONTROL EQUIPMENT

16.4.1 A master Electro-Mechanical controller shall be provided in the control station to permit forward or reverse control of the train.

16.4.2 Power Knock/Out (PKO) will occur in response to emergency or penalty brake application. Automatic unloading and return to idle speed of engine or unloading of locomotive traction power without affecting engine speed, as appropriate to head end power supply requirements, will occur in the event that emergency brake application is made, or a service application is instituted through the safety control, overspeed, train stop or speed control systems. The propulsion system will receive the PKO signal from the brake system and immediately remove traction power. Also, a light shall be provided to indicate when the "PC" switch is open. Visual indication of the Power Knock/Out shall be displayed on the TOD (Train Operator Display)

16.4.3 Equipment to be provided as follows:

16.4.3.1 One (1) cab makeup switch.
16.4.3.2 One (1) attendant call switch (pushbutton or spring return switch);
16.4.3.3 One (1) Power Trainline Control (TLC) Reset

16.5 SPEED INDICATOR/ALERTER/EVENT RECORDER

16.5.1 A speed indicator shall be provided. The indicator shall be mounted in the lower console in the general line of sight, while facing forward.

16.5.2 The vehicle control unit (VCU) and the monitoring control unit (MCU) shall include multiple overspeed (underspeed) settings.
1. General Overspeed shall be set for 82 MPH and underspeed set for 3 MPH.
2. Overspeed PTC Cut Out 40mph, if there is not ATC (Overspeed 79mph) installed or block signal (Overspeed 59mph) system in place..

16.5.3 An event recorder shall be installed to record operating parameters of the car to interface with the PTC event recorder. The event recorder shall be fully compliant with 49 CFR Part 229.135.

16.5.4 The following parameters, at a minimum, shall be measured:

CHANNEL	TYPE	DESCRIPTION
1	Digital	BCP < 15 PSI
2	Digital	Manual Reset
3	Digital	Equalizing Reservoir
4	Digital	Not used
5	Digital	Bell
6	Digital	Horn
7	Digital	Self Test
8	Digital	Override Switch
9	Digital	Radio

10	Digital	Gen. Field
11	Digital	Throttle Sol. A
12	Digital	Throttle Sol. B
13	Digital	Throttle Sol. C
14	Digital	Throttle Sol. D
15	Digital	Forward
16	Digital	Reverse
17	Digital	Not used
18	Digital	Lift Deployed Override
19	Digital	Alerter Penalty
20	Digital	Osc. Headlight
21	Digital	Lift Deployed Signal
22	Digital	Door Closed Light
23	Digital	Train Control Penalty
24	Digital	Cab Signal Green
25	Digital	Cab Signal Yel/Grn
26	Digital	Cab Signal Yellow
27	Digital	Cab Signal Red/Yel
28	Digital	Not used
29	Digital	Not used
30	Digital	Not used
31	Digital	Not used
32	Digital	Not used
1	Analog	Brake Cylinder Pres.
2	Analog	Brake Pipe Pressure
3	Analog	Headlight Voltage
4	Analog	Ditch light on
5	Analog	Ditch light Flash
6	Analog	Ditch light Flash Auto
7	Analog	Not used
8	Analog	Not used
1	Frequency	Speed
2	Frequency	Not Used
3	Frequency	Not Used
4	Frequency	Not Used

16.5.5 An alerter system shall be provided which monitors the action of the operator and is recorded to the event recorder. If the alerter is not reset, a visual and an audible warning shall be made on the systems alarm panel (flashing visual light and increasing level of audible alarm). After the initial allowance time of 20 seconds upon system activation, the reset time shall inversely relate to speed. The alerter penalty application shall be capable of reset with a "running release". The details of the alerter system shall be submitted to Metra for review and approval. **[CDRL C-16-03]**

16.5.6 The conditions for resetting the alerter shall be submitted to Metra for review and approval and consider the following actions. [CDRL C-16-03]:

16.5.6.1 Master Controller Movement
16.5.6.2 Horn Use
16.5.6.3 Change in Direction of Travel
16.5.6.4 (deleted)
16.5.6.5 (deleted)
16.5.6.6 Alerter Reset Button
16.5.6.7 Bell Use

16.5.6.8 Change of State of the Headlight
16.5.6.9 Radio Use

16.5.7 A dedicated cutout function, with seal, shall be provided in a visually accessible location to cutout the alerter function in case of failure.

16.5.8 Alerter reset intervals shall be speed dependent; as vehicle speed increases, the alerter must be acknowledged more frequently. Per 49 CFR Part 229.140, alerter warning timing cycle interval shall be within 10 seconds of the calculated setting utilizing the formula (timing cycle specified in seconds = 2400 ÷ track speed specified in miles per hour). At speeds below 20 mph, the interval shall be between 110 seconds and 130 seconds.

16.5.9 The reset timing shall be as follows:

SPEED (MPH)	TIME (SEC.)
0.5-1.9	120
2.0	120
10	120
20	120
30	80
40	60
50	48
60	40
70	35
80	30

16.5.10 The following ditch light operating modes are controlled by solid state relays which are activated either by PTC, the train control system, or horn/bell activation:

16.5.10.1 Continuous
16.5.10.2 Flashing
16.5.10.3 Flashing after horn/bell.

16.6 CAB SIGNAL SYSTEM

16.6.1 (deleted)

16.6.1.1 (deleted)

16.6.1.2 (deleted)

16.6.1.3 (deleted)

16.6.2 (deleted)

16.6.3 (deleted)

16.6.4 (deleted)

16.6.5 (deleted)

16.6.6 (deleted)

16.6.7 (deleted)

16.7 POSITIVE TRAIN CONTROL

16.7.1 The Contractor shall propose to integrate and install the Wabtec I-ETMS Positive Train Control System kit. The PTC system components shall be reviewed and agreed between Metra, Wabtec and Stadler. The PTC components shall be drop shipped by Metra within four weeks of start of final assembly. The Contractor shall be responsible for all ancillary equipment and materials needed to complete the installation of the PTC system. Contractor will be responsible for the successful completion of the on-board diagnostic testing prior to delivery to Metra. The Contractor shall work with Metra to determine the best locations for PTC equipment and submit a final design for review and approval by Metra. **[CDRL C-16-05]**

16.8 CAB DIGITAL VIDEO RECORDING SYSTEM

16.8.1 The Contractor shall propose a new CDVRS system. The Contractor will provide its Cab Digital Video Recording System kit, with LDVR, microphones and cameras. The contractor shall comply with all applicable FRA requirements in effect at the time the proposals are submitted. In addition, the contractor will be required to meet or exceed language contained in 49 CFR 229.136. The Contractor shall be responsible for all ancillary equipment and materials needed to complete the installation of the CDVRS. Contractor shall be responsible for the successful completion of the on-board diagnostic testing prior to delivery to Metra. The Contractor shall work with Metra to determine the best locations for CDVRS equipment and submit a final design for review and approval by Metra. **[CDRL C-16-06]**

16.8.2 The CDVRS shall be composed of one central recorder, two (2) forward facing cameras, two (2) platform-facing cameras, one (1) cab-camera to cover operator control panels and one (1) cab-camera facing towards the operator (total six (6) cameras per cab), two exterior mounted microphones, one cab mounted microphone, solid state drive storage memory, crash hardened memory and all applicable interconnections. The CDVRS system shall be powered from a separate low voltage circuit breaker (on the breaker panel). A terminal board panel will be applied in a dry location near the central recorder for all CDVRS (power and signal) connections to be made. Hardware is to exhibit the smallest area footprint inside the cab cars and use the least mounted hardware as possible. The inputs and outputs of the DVR are to exhibit railroad grade connections. The design and arrangement of the CDVRS shall be approved by Metra prior to build of the first cab car.

16.8.3 The DVR recorder shall be a digital Internet Protocol (IP) based system and support digital IP cameras. The recorder shall have no less than 8 IP video channel inputs. The recorder shall have no less than 3 audio channel inputs. The DVR recorder video channels shall be used to capture and record video from multiple connected cameras simultaneously. The recorder audio channels shall be used to capture and record bell sounds, horn sounds, and have the ability to record cab compartment audio from multiple connected microphones simultaneously. The DVR recorder shall be capable of simultaneous playback, remote access, and recording. A removable hard drive shall be incorporated into the DVR recorder unit. The removable drive shall have security measures to allow only authorized personnel to remove the drive. The DVR recorder shall have a minimum of 1TB solid state storage capacity and the capacity to record at least 12-hour continuous recording capability per 49 U.S.C 20168(b)(1) and the recordings must beaccessible for review during an accident or incident investigation per 49 U.S.C 20168(b)(3). The hard drive capacity shall be sized to archive not less than 10 calendar days of video. The DVR recorder shall have Wi-Fi capabilities for ease of downloading in the case of accident or incidents when the DVR cannot be safely accessed in the rolling stock. The DVR recorder shall have crash and fire protections for any in-cab image recordings that are stored in the cab car operating compartment per 49 U.S.C 20168(b)(2). Frame rates and resolutions shall be customizable for each camera and be made accessible by Metra. The recorder shall feature

video motion detection. Video motion detection sensitivity shall be adjustable, customizable, and shall be capable of being enabled or disabled by Metra. The DVR system shall have the ability to utilize GPS data for location data and time synchronization. The DVR shall interface, access and download existing event recorder data. The recorder shall have a power input for all voltage ranges experienced by its power connection to the trainset and shall feature overvoltage and transient protection. The DVR recorder shall be capable of normal recording operations during momentary power losses, defined as 1 second or less, without: sustaining data loss, causing the DVR to reset due to momentary power loss, recording failure due to momentary power loss, or the DVR recorder entering a fault state requiring maintenance due to momentary power loss. The DVR recorder shall have a "self-test" and visual indicator system that indicates the system is properly functioning and recording. The visual indicator system shall alert personnel upon failure of any camera, hard drive, or other type of fault.

16.8.4 The two (2) forward facing cameras shall be capable of clearly recording railroad signal aspects in all types of weather, day, or nighttime conditions. The forward facing cameras shall be used to record the right of way, incidents, and railroad signal aspects of wayside signals. The cameras shall be aimed parallel to the centerline of tangent track within the gauge. The railroad signal aspects (colors) shall be clearly discernible during video playback. The cameras shall be a high definition digital IP type camera. The camera shall be powered by Power over Ethernet (PoE). The forward facing camera shall feature a dual lens, one for wide view, and one for narrow view. The focal length of the wide lens shall be 6mm. The focal length of the narrow lens shall be 16mm. Alternative focal lengths may be considered. The camera shall be mounted inside the cab, in a Metra-approved enclosure. The camera shall be adjustable to allow for camera positioning.

16.8.5 The platform cameras shall be a high definition digital IP type camera. The camera shall be powered by PoE. The focal length shall be determined during the design review. The camera shall be mounted outside the cab near the wind deflector on the observer's side in a high position close to the roof in order to get an optimal view of the vehicles side, boarding platform area and door indicator lamps. The camera will be able to resist all weather conditions in a weather-proof enclosure and include an automatic heating operation between a configurable temperature range. Additional car body cameras along the vehicle may be considered.

16.8.6 Two cameras shall be "inward facing" and used to record the cabin compartment of a cab car. Each inward facing camera shall be adjustable to allow for camera positioning. Each inward facing camera shall be a high definition digital IP type camera. Each inward facing camera shall be powered by PoE). The inward facing cameras shall be capable of recording black and white, as well as color. The settings shall be made accessible and adjustable to Metra. Each inward facing camera shall have 1 lens. Each inward facing camera shall have an adjustable lens. The camera lens focal length shall be set at 2.5mm or Metra-approved alternative. Each inward facing camera shall be housed in a compact vandal resistant enclosure. The inward facing cameras shall be suitable for indoor and outdoor installations. The inward facing cameras shall be capable of recording in any weather, day, or nighttime conditions. Each inward facing camera shall include an Infrared illumination (IR) feature for night vision video capture capability which can be enabled or disabled by Metra.

16.8.7 The dedicated microphones will have a "quick-disconnect" threaded, environmental-rated circular connector. The contractor will use the appropriate mating connector as well as non-metallic flexible ½" conduit, ½" NPT connectors and UNEF circular connector adaptor for the final two (2) feet of conduit connection to each microphone. Each dedicated microphone shall be rated for exterior outdoor use. One dedicated microphone will be mounted within three (3) feet of the bell. A new rigid metal ½" conduit will be run from the recorder location to the location of the microphone. The second dedicated microphone will be mounted on the roof within three (3) feet of the air-horn. A new rigid metal ½" conduit will run from the recorder location to the

location of the microphone. The roof microphone and associated conduit will not interfere with any removable roof panels. A third microphone will be mounted in the cab and shall be capable of recording cab compartment audio. This microphone shall be capable of being enabled or disabled by Metra.

16.8.8 In addition to the solid state hard drive storage media, a separate crash hardened memory module shall be priced for use with the DVR system. The crash hardened memory module may be internal or external. The crash hardened memory shall be sized to archive 12 hours of video. The DVR shall be already configured to accept crash hardened memory with "plug and play" functionality. The crash hardened memory module shall be a field replaceable component by Metra personnel without requiring the assistance of the contractor. The crash hardened memory module shall be upgradeable in the future to higher capacities.

16.8.9 Crash hardened memory module supplied shall be DOT certified to FRA 49 CFR Part 229.

16.8.10 The solid state hard drive shall be mechanically and functionally uniform and interchangeable across all cab compartment DVR systems defined in this specification. The hard drive shall be upgradeable in the future to higher capacities.

16.8.11 The crash hardened memory module shall be mechanically and functionally uniform and interchangeable across all cab compartment DVR systems defined in this specification.

16.8.12 On the video playback, The DVR system shall display a time and date stamp on all downloaded data. The time shall be synchronized with the time clock used by the event recorder. On the playback software, the system shall display event recorder data concurrent with video downloads. A minimum number of 4 event recorder channels shall be recorded: speed (SPD), Brake Pipe Pressure (BPP), Brake Cylinder Pressure (BCP), and Throttle (THR). The DVR system shall include computer software that allows for downloading and onboard viewing of video directly from the DVR recorder without removing the hard drive. The software shall allow the user to specify specific dates and times in order to control the length of the video clips downloaded. When downloading a video/audio clip, the user shall have the ability to select or deselect which video and audio channels are to be downloaded. The software shall have the capability to export all video and audio channels (including dedicated audio channels) into 1 file with all video and audio channels synchronized. Each audio/video clip shall contain at minimum a time stamp with date, time, name of DVR system, and associated video channel names that are overlaid onto the image and synchronized with video and audio. Upon starting the software, the main screen shall automatically (and without user interaction) display in real time live video viewports of all the cameras simultaneously. The viewports of all the video channels shall be visible simultaneously and without obstructions to the user on the main screen. The user shall not be required to make any clicks, minimize or maximize windows to cycle through to view video camera channels. The DVR system shall include computer software allowing for video downloads for a hard drive removed from the DVR recorder that is connected to a laptop or desktop computer. All computer software supplied to Metra by the Contractor shall include an unlimited use license agreement for unlimited installations and use. The ability for Metra personnel to install and configure all supplied software without contractor assistance or interaction shall be required. The software interface design shall be subject to Metra approval as part of **[CDRL C-16-06]**.

16.9 CONTROL CONSOLE AND CONTROL ARRANGEMENT

16.9.1 A desk top console and a console above the windshield shall be provided. The consoles shall be of non-reflective material. The console shall be readily removable to permit access to mounted components, wiring and piping. The console shall not loosen during normal

operations, move, or creep. No recesses, crevices or joints, which shall permit the incursion or accumulation of dirt, dust, or liquids, shall be permitted.

16.9.2 It is desired that the console surface shall be of one-piece construction. As an alternative, the console may have separately removable inserts to contain and enclose the various controls and indications.

16.9.3 The console shall not interfere with the Engineer's vision in any direction, nor with replacement of or maintenance to the windshield or other appurtenances. It shall provide a clear view of all indications and ease of reach and manipulation of all controls and switches.

16.9.4 Controls:

16.9.4.1 Master Controller, with single throttle handle with traction and brake function
16.9.4.2 Direction lever with the positions "Forward", "Neutral" and "Reverse"
16.9.4.3 Park brake push button and indicator lamps, which show the park brake status
16.9.4.4 Sand operating push button
16.9.4.5 Bell operating button
16.9.4.6 Horn Operating switch
16.9.4.7 Alerter reset button
16.9.4.8 Low beam/high beam push button combined with headlight/ditch light control on the TOD
16.9.4.9 Ditch light selector on the TOD
16.9.4.10 (deleted)
16.9.4.11 PA/IC control panel
16.9.4.12 Cab signal cutout switch
16.9.4.13 ADA Lift over-ride isolating switch or push button
16.9.4.14 Desk light switch
16.9.4.15 Radio Control Head
16.9.4.16 Attendant Call Switch
16.9.4.17 (deleted)Engine RUN/STOP Switch
16.9.4.18 Gage Light shall be controllable on the TOD
16.9.4.19 Gage Light shall be adjustable on the TOD
16.9.4.20 Power mode on the TOD
16.9.4.21 Cab activation key switch
16.9.4.22 Defroster control on the TOD
16.9.4.23 (deleted)
16.9.4.24 (deleted)
16.9.4.25 Rear Warning Light Control on TOD
16.9.4.26 Door Mode Indicator Button
16.9.4.27 (deleted)
16.9.4.28 Video System Control on PIS Panel
16.9.4.29 (deleted)
16.9.4.30 (deleted)
16.9.4.31 (deleted)
16.9.4.32 Train Radio Circuit Breaker
16.9.4.33 Video System Circuit Breaker
16.9.4.34 Train Control reset button on TOD
16.9.4.35 Train Control acknowledge button on TOD

16.9.5 Indicators:

16.9.5.1 Speed indicator
16.9.5.2 Air Gages

16.9.5.3 Ground fault indication on TOD
16.9.5.4 PCS Open indication on TOD
16.9.5.5 Wheel Slip light
16.9.5.6 Door Closed light
16.9.5.7 Lift Deployed light
16.9.5.8 Lift Override Switch Activation shall be Displayed on the TOD
16.9.5.9 PTC Display
16.9.5.10 The alerter push button shall visually indicate the alerter status combined with an acoustic tone.
16.9.5.11 Battery Charge Status Tri-Color (G-Y-R) Light on the TOD;

16.9.5.12 Indicator light test function on the TOD

16.10 BUZZERS

16.10.1 An approved high tone buzzer shall be furnished in the control console. The trigger for the buzzer shall be part of the final design for review and approval by Metra.

16.10.1.1 (deleted)
16.10.1.2 (deleted)
16.10.1.3 (deleted)
16.10.1.4 (deleted)
16.10.1.5 (deleted)
16.10.1.6 (deleted)

16.10.2 An override circuit shall be provided to allow the engineer to silence a continuous warning.

16.11 MISCELLANEOUS CAB EQUIPMENT

16.11.1 Equipment to be provided as follows:

16.11.2 Sun visors shall be provided for the windshield and the side windows. It shall be mounted above the windshield or side window. The visor shall provide coverage for the 5th and 95th percentile fields of view based on the ergonomic study.

16.11.3 An electro-static chest type cooler for bottled water shall be mounted in the control station within reach of the engineer's position. Water cooler shall be equipped with a drain to the outside of the car.

16.11.4 Two (2) single cup holders shall be provided, one the operator's side and one on the observer's side.

16.11.5 Two (2) sun visors (one over each sliding sash) shall be provided.

16.11.6 A sliding table with an integrated spring-clip holder shall be provided close to the left observer seat. The operators writing pad shall be equipped with a spring clip.

16.11.7 One (1) stainless steel enclosure with keyed lock for the storage of reverser handles.

16.11.8 A total of two (2) cab card holders shall be provided in the cab. A 9 inch x 12 inch card holder, and a 3-slot holder shall be applied in an approved location on the operator's side cab door.

16.11.9 A waste container, capable of holding a plastic liner, shall be provided in the cab behind the operator.

16.11.10 One (1) paper towel holder shall be provided in the cab.

16.11.11 One dry chemical type fire extinguisher shall be applied in an approved location in the cab.

16.11.12 One Emergency Response Book Holder per Metra Drawing M-524 shall be provided on the back wall of the cab.

16.12 WINDSHIELD WIPERS

16.12.1 One (1) operated windshield wiper system (motor and arm assembly) shall be located at each window in front of the control station. An electric windshield wiper system is the Metra preferred option. The windshield wiper system proposed shall be subject to Metra review and approval. **[CDRL C-16-09]** If pneumatic, noise from the motor's exhaust shall be reduced in an approved manner. The wipers shall operate satisfactorily at speeds up to 100 mph in a thirty-five (35) mph opposing head wind. The wipers shall have a parallel motion covering the full width of the glass and utilizing the largest blade that can be accommodated. Each wiper assembly should contain a lever that allows manual operation of wiper by operator in cab in the event of electric failure.

16.12.2 A windshield wiper control switch shall be provided. The wiper operating mechanisms shall be easily accessible, and the controls located in the operating compartment. The mechanism shall provide for variable speed and for a "park" position. The park position shall be approved by Metra. The wiper shall return to the park position each time the wiper system is turned off regardless of the position of the wiper blade.

16.13 REAR VIEW MIRRORS

16.13.1 A rear view mirror shall be provided at the front of the sliding sash cab windows on each side of the cab control car.

16.14 PILOT

16.14.1 At the lead end of cab control cars, a body mounted, high profile, snow plow type pilot of Metra approved design, shall be provided. **[CDRL C-16-10]** The pilot shall be securely attached to the car structure and shall be adjustable for height. The design of the pilot shall accommodate and afford maximum protection for the cab signal receivers and TRAINLINE junction boxes.

16.15 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-16-01	Cab Control – Design and Arrangement of Cab Car
C-16-02	Cab Seating
C-16-03	Alerter Operation
C-16-04	(deleted)
C-16-05	Wabtec IETMS System
C-16-06	Cab Digital Video Recording System
C-16-07	(deleted)
C-16-08	(deleted)

C-16-09	Windshield Wiper System
C-16-10	Pilot Design

17 PROPULSION

17.1 TRACTION MOTORS

17.1.1 The AC traction motors shall be the builder's current production, proven motor, with roller support bearings (if applicable). Adequate traction motor cooling air shall be provided for repetitive high-load start, quick stop operation. The traction motor design shall be submitted to the Contracting Authority for review and acceptance. **[CDRL C-17-01]** AC type traction motors shall be designed for North American Passenger Service. A proposal shall be submitted for the prime traction system. **[PDRL P-17-01]**

17.1.1.1 If the traction motor is axle hung, sealed-grease lubricated insulated bearings, tapered roller or equivalent shall be incorporated.

17.1.1.2 Class H or better insulation with vacuum/ pressure impregnation of all coils, armature, field or stator.

17.1.1.3 Fitted with disconnect cable leads.

17.1.1.4 Properly baffled to prevent blowing of sand and debris from rails, and to prevent motors from inhaling non-filtered cooling air, rain or snow.

17.1.1.5 The traction motor testing shall be performed in accordance to IEC 60349-2 prior to use in first vehicle.

17.1.1.6 Motors shall be cooled with clean air supply (if required) using inertial air filters or filter grids as approved by the Customer.

17.2 DYNAMIC BRAKES

17.2.1 Single-handle blended brake control shall be provided and controlled by the automatic brake handle position. The trainset shall be equipped with the builder's dynamic brakes, which shall be automatically blended with the friction braking when the dynamic brakes separately are not capable of applying the requested braking efforts. The dynamic brake system design shall be submitted to The Contracting Authority for review and acceptance. **[CDRL C-17-02]**

17.2.2 The service brake will be applied in priority using the dynamic brakes and friction brake will be added if necessary to reach the specified service brake rate.

17.2.3 Normal blended braking shall be "dynamic priority" where friction braking is used to supplement dynamically braking to produce the braking effort called for. Emergency braking shall be "friction priority", where a small fixed amount of dynamic braking shall be used only to supplement the braking effort called for.

17.2.4 To the extent that either the train or locomotive auxiliaries are demanding power, dynamic braking energy recovered and used to supply those power demands is a desirable feature. If the total energy exceeds the auxiliary power and HEP demands, the surplus energy may be stored in a supplemental energy storage device (if proposed) such as a supercapacitor bank or is dissipated as heat by the dynamic brake grid resistors.

17.2.5 (deleted)

17.2.6 (deleted)

17.2.7 (deleted)

17.2.8 (deleted)

17.2.9 Blended brake shall be nullified at speeds below 4-5 mph. The trainsete shall not transfer into blended or dynamic brake when it is at a standstill.

17.2.10 Wheel slide detection and correction shall be employed in conjunction with dynamic and pneumatic brake.

17.3 BATTERY PRIME MOVER

17.3.1 The batteries shall be of a reliable, if possible rail service proven design, with adequate power to meet or exceed established performance standards on the Metra system as described elsewhere in this Specification. Prior applications, other than rail service, may be considered but are subject to approval by The Contracting Authority's Mechanical Department. Battery design shall be optimized to allow for the lowest possible life-cycle costs and ease of maintenance. A proposal shall be submitted for the prime mover system. **[PDRL P-17-02]** Details of the design of the prime mover shall be submitted to The Contracting Authority for design review and approval. **[CDRL C-17-03]**

17.3.2 PROPULSION BATTERY **[CDRL C-17-04]**

17.3.2.1 A Li-Ion Battery propulsion battery shall be provided. Useable energy will vary based on duty cycle.

17.3.2.2 Maximum Battery discharge power shall exceed power to meet current Metra schedule

17.3.2.3 Battery and support structure to be designed for shock and vibration per IEC 61373 on branch level per IEC 62689

17.3.2.4 Battery assembly shall be protected by a hood structure with access for inspection, if not protected by the car body structure. The battery shall be protected in case of crash conditions.

17.3.2.5 Carbody or roof battery assembly shall be removable by crane or forklift.

17.3.2.6 (deleted)

17.3.2.7 General (typical) battery duty cycle assumed to be 6 days/week operation, 6 charge/discharge cycles per day (single trips on the Rock Island district blue island branch line). The auxiliary consumption considering an average loading AW1 and an external temperature of 15°C.

17.3.3 PROPULSION BATTERY CONTROL **[CDRL C-17-05]**

17.3.3.1 A Battery Management System (BMS) shall be included for each battery pack.

17.3.3.2 A master BMS shall be responsible for interfacing with Locomotive Control System.

17.3.3.3 Battery Voltage, Current and Temperature Monitoring shall be provided

17.3.3.4 When charging or discharging, protect the traction battery in the event of over/under voltage, over temperature, and over current.

17.3.3.5 Diagnostic data shall be made available from the BMS to be used for monitoring of the battery from the vehicle control and visualized on the operator's display. The battery state of charge will also be visible on the outside of the trainset.

17.3.4 PROPULSION BATTERY CHARGING **[CDRL C-17-06]**

17.3.4.1 Battery charging may be performed by an overhead DC power source (FAST CHARGE) to connect by way of pantograph

17.3.4.2 Typical Battery charge duration dependent on charge power available.

17.3.4.3 Wayside 480VAC power connections shall power an onboard battery charger to charge the traction battery and other auxiliary devices if applicable.

17.3.5 DC FAST CHARGE PANTOGRAPH **[CDRL C-17-07]**

17.3.5.1 A dedicated charging station that compliments the trainset design shall be proposed to recharge the batteries as quickly and safely as possible to quickly return the trainset into service.

17.3.5.2 DC Fast Charging via DC Catenary source.

17.3.5.3 Electric or air operated pantograph operation to be provided.

17.3.6 Proposer shall determine a trainset battery charging performance to be such to minimize down time between revenue service runs.

17.3.7 BATTERY THERMAL CONDITIONING **[CDRL C-17-08]**

17.3.7.1 A thermal conditioning unit shall be provided for e ach battery subassembly

17.3.7.2 Coolant shall be prevented from freezing in the specified temperature range

17.3.7.3 The cooling system is linked to the Battery Management System (BMS) with sensors to monitor coolant temperature and pressure. Alternatively, the link may be done by SW only and managed by the vehicle control. There may be no direct cables, or sensors between the BMS/Battery and the BTMS (battery thermal management system) responsible for the cooling function of the traction battery.

17.3.7.4 Coolant drain and refilling apparatus shall be located on the PowerPack.

17.4 PROPOSAL DELIVERABLES REQUIREMENT LIST

PDRL	**Title**
P-17-01	Traction System
P-17-02	Prime Mover System

17.5 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	**Title**

C-17-01	Traction System
C-17-02	Dynamic Brake System
C-17-03	Prime Mover System
C-17-04	Propulsion Battery
C-17-05	Propulsion Battery Control
C-17-06	Propulsion Battery Charging
C-17-07	DC Fast Charge Pantograph
C-17-08	Battery Thermal Conditioning

18 AUXILIARY POWER SYSTEM

18.1 GENERAL REQUIREMENTS

18.1.1 A proposal shall be submitted for the auxiliary power system or equivalent to power the passenger compartment areas. **[PDRL P-18-01]**

18.1.2 Design details, software documentation and electrical schematics for the auxiliary power system shall be submitted to The Contracting Authority for design review and approval. **[CDRL C-18-01]**

18.1.3 The control system shall incorporate fault monitoring, diagnostics and control of the inverter. An external communication port for the purpose of programming and diagnostic communication shall be provided. No 480 VAC empty receptacle shall be energized.

18.1.4 Controls shall be provided in the cab. The below indicators and/or controls may be replaced with indications on the builder's integrated electronic display (if provided). Design of the Auxiliary System Power controls shall be submitted to The Contracting Authority for design review and approval. **[CDRL C-18-02]** The following features shall be included:

18.1.4.1 The start, stop and emergency shut-off procedures and sequences shall be described.

18.1.4.2 Status indicator lamps or display.

18.1.4.3 (deleted)

18.1.4.4 If applicable, a selector switch or control for consist configuration relative to desired energized receptacles. (Coupled to B-end, etc.)

18.1.5 Displays or meters indicating frequency, voltage and amperage of the 3x480V power supply.

18.1.6 Auxiliary Power Supply ground fault detection system to identify an electrical ground in the train power circuit. A ground occurring in the circuit shall result in an indicator light as notification of the condition. An audible alarm is not required. A ground occurring in one phase of the train power trainline circuit shall lead to the disconnection of the corresponding load.

18.1.7 A wayside layover interlock is required to prevent connecting to wayside power while the trainset is actively powering the train or vice versa. The control system shall be designed to prevent application of power to trainlines if the trainlines are already energized from another source of 3-phase power, such as another locomotive or shore power.

18.1.8 An Inverter Backup Mode feature is desirable to allow for system reconfiguration from the propulsion to provide Train Power in the event of an Auxiliary Power System inverter failure. In such cases, appropriate controls for this transfer and corresponding fault indicators shall be provided.

18.1.9 The aux system can be activated/deactivated manually via the display from the drivers cab for the whole trainset from an active cab.

18.2 PROPOSAL DELIVERABLES REQUIREMENT LIST

P-18-01	Auxiliary Power System

18.3 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-18-01	Auxiliary Power System
C-18-02	Auxiliary Power Controls

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.

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

23 PRODUCT SUPPORT

All manuals, drawings, photographs, and training material ("Material") shall include an irrevocable license to reproduce such Material for Metra's internal purposes. Metra has rights to use above documentation in the proposal package for overhaul, parts procurement without notifying OEM.

Manuals, Drawings, etc. shall be uploaded to a mutually agreed upon sharepoint.

23.1 DRAWINGS AND REPRODUCTIONS

23.1.1 Before the first trainset is delivered, the Contractor shall furnish a complete and correct electronic editable files of the following drawings

- 23.1.1.1 Electrical Schematics & Conduit Diagrams
- 23.1.1.2 Air Piping Diagram
- 23.1.1.3 Trainset General Arrangement
- 23.1.1.4 Clearnce Diagram
- 23.1.1.5 Wire Running List
- 23.1.1.6 (deleted)

23.1.2 The released editable as-built version of the drawing set according to the mutually signed NDA shall be provided thirty (30) days after the conditional acceptance of the last car in the digital formats (.pdf) and (.dwg). The bills of materials shall be provided in the digital formats (.pdf) and (.xlsx). **[CDRL C-23-01]**

23.1.3 (deleted)

23.2 PHOTOGRAPHS

23.2.1 Electronic version (jpg) of the following color photographs shall be provided for one trainset **[CDRL C-23-02]**:

- 23.2.1.1 Side elevation of the trainset
- 23.2.1.1 Combination front and side (three-quarter) view of the trainset
- 23.2.1.2 Head-on view of each end
- 23.2.1.3 Car seating, taken from three (3) different angles
- 23.2.1.4 Stairways
- 23.2.1.5 Both trucks in the ready to run condition, but not applied to car
- 23.2.1.6 Mobility aid lift, completely lowered and completely raised
- 23.2.1.7 Ten (10) miscellaneous photographs illustrating the construction of the cars
- 23.2.1.8 Communication and door control station
- 23.2.1.9 ADA positions
- 23.2.1.10 Interior of all lockers and control panels
- 23.2.1.11 Passenger boarding/alighting area
- 23.2.1.12 Undercar equipment
- 23.2.1.13 Major underframe connections (bolster at side and center sill, etc.)
- 23.2.1.14 Underframe, inverted, before addition of superstructure
- 23.2.1.15 Roof, before equipment is installed
- 23.2.1.16 Details of side panels
- 23.2.1.17 Details of all communications equipment
- 23.2.1.18 Details of the conductor panel and door system (door leaves, door drive).

23.3 DRAWING LISTS AND BILLS OF MATERIALS

23.3.1 (deleted)

23.3.2 (deleted)

23.4 SPARE PARTS CATALOGS AND MAINTENANCE MANUALS

23.4.1 The Contractor shall deliver, in searchable, electronic form drafts of the Maintenance manual to Metra prior to the shipment of the first production car. As-built updates, including car affectivity shall be provided through the life of the contract.

23.4.2 The Contractor shall deliver to Metra the final, editable electronic version of each manual within thirty (30) days after conditional acceptance of the last trainset. **[CDRL C-23-04] [CDRL C-23-05]**

23.4.3 All manuals shall be divided into the following sections:

X.X. Maintenance Preparation Work
X.X. Preventive Tasks
X.X.X. A - Higher Level Elements / Systems
X.X.X. B - Vehicle Body
X.X.X. C - Vehicle Outfittings
X.X.X. D - Interior
X.X.X. E - Running Gear
X.X.X. F - Power / Drive System
X.X.X. G - Control Systems
X.X.X. H - Auxiliary Equipment
X.X.X. J - Monitoring and Safety Equipment
X.X.X. K - External Lighting Equipment
X.X.X. L - HVAC
X.X.X. M - Ancillary Equipment
X.X.X. N - Doors
X.X.X. P - Information System
X.X.X. Q - Pneumatic System
X.X.X. R - Brake System
X.X.X. S - Coupler & Draft Gear
X.X.X. T - Carries Systems
X.X.X. U - Electrical Wiring
X.X. Corrective Tasks

23.4.3.1 (deleted)
23.4.3.2 (deleted)
23.4.3.3 (deleted)
23.4.3.4 (deleted)
23.4.3.5 (deleted)
23.4.3.6 (deleted)
23.4.3.7 (deleted)
23.4.3.8 (deleted)
23.4.3.9 (deleted)
23.4.3.10 (deleted)
23.4.3.11 (deleted)
23.4.3.12 (deleted)
23.4.3.13 (deleted)
23.4.3.14 (deleted)
23.4.3.15 (deleted)

23.4.4 Each section shall have a table of contents.

23.4.5 The contractor shall provide within the Stadler maintenance manual the reference to the manufacture maintenance manual. The manufacture name and part number for drop replacement parts shall be within these sub maintenance manuals.

23.4.6 In all manuals, Contractor developed and vendor supplied information shall be integrated into a unified presentation for each system addressed. For clarity of presentation the same data may be presented twice but shall use the same views and diagrams with the same reference numbers in each manual.

23.4.7 The Maintenance Manual together with the sub suppliers maintenance manuals shall address components to the lowest level identified in the parts catalog. The manuals shall contain a detailed analysis of each component so that maintenance personnel can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace and overhaul the equipment. Where interfaces occur, a cross reference shall be made to the appropriate location.

23.4.8 The contractor's manual shall be divided into the following sections and address the following topics:

23.4.8.1 **Introduction** - This shall include the purpose of the manual, special tools, technical guidance including torque requirement, sealing requirement etc., and equipment and safety precautions.

23.4.8.2 **Theory of Operation** - This shall include the general theory and the specifics of this system and the relationship of assemblies, subassemblies and components with an explanation and analysis of their functions to the smallest replaceable components.

23.4.8.3 **Operating Procedures** - This shall include the location and functional descriptions of all controls, monitors and indicators.

23.4.8.4 **Troubleshooting** - This shall include a list, in tabular format, of symptoms, causes of malfunction or improper operation, and probable remedies to the smallest line replaceable component or printed circuit board level. Logic/flow charts may be used to assist troubleshooting but must reflect the most efficient and effective logic and not be simply tracing of schematics.

23.4.8.5 **Corrective Maintenance** - This shall include step-by-step removal, replacement, and adjustment procedures to the smallest line replaceable component or printed circuit board level. Detailed procedures shall be provided to adjust any unit that has been replaced.

23.4.8.6 **Preventive Maintenance** - This shall include a list, in tabular format, of all lubrication requirements, types of lubricants, frequency of application, inspection requirements and limits, component replacement and repair schedule, required adjustments, limits and tolerances, optimum test point readings, calibration charts and procedures in performing the preventive maintenance.

23.4.8.7 **Corrective Repair (Shop)** - This shall include detailed troubleshooting procedures for subassemblies as well as complete assemblies, step-by-step removal, overhaul, replacement and adjustment procedures to the smallest replaceable component. Detailed test and adjustment procedures shall be provided for all subassemblies and for the complete assemblies/units. As part of the overhaul procedure, details for rebuilding, reclaiming or replacing all wearing or moving parts with comprehensive information on the limits and tolerances sufficient to determine the best approach to follow must be included.

23.4.8.8 **Appendix** - This shall include a list of reference drawings, interface drawings, circuit diagrams, symbols, cross references and revisions.

23.4.9 The maintenance manuals shall enumerate and describe every part to the lowest level of replaceable component. They shall include component name, symbol, function, rating, tolerance, manufacturer name and address, manufacturer's part number, commercial equivalents and quantity per assembly or sub-assembly. The manuals shall contain exploded-view diagrams illustrating and indexing every removable/replaceable part.

23.4.10 Each diagram shall be accompanied by a page listing every item indexed in the associated diagram and providing complete ordering data for every item. Diagrams and exploded views shall be provided to identify the appropriate location of parts within a sub-assembly and of the sub-assembly within the next larger assembly.

23.5 OPERATING INSTRUCTION BOOK

23.5.1 The Contractor shall furnish fifty (50) copies of instruction books, of a convenient size for handling and carrying, for train crew information on the operation of the cars. The book shall provide general information for the train crew duties, including troubleshooting information in case of breakdown or failure, and safety aspects related to train crew duties.

23.5.2 Diagrams and photographs shall be used where applicable.

23.5.3 All copies of the book covering the Metra cars shall be delivered sixty (60) calendar days before delivery of the first production car to Metra. The text of the operating instruction book shall be submitted to Metra for approval prior to printing. **[CDRL C-23-06]** In addition, an electronic version (format to be agreed upon) of this book shall be provided.

23.6 RECORD OF CONSTRUCTION/CAR HISTORY BOOKS

23.6.1 Trainset Contractor shall furnish in electronic form (Original pdf Files) to Metra a complete record of construction for each car consisting of the following information **[CDRL C-23-07]:**

23.6.1.1 All serial numbers on (and not limited to) trucks and related components (bolsters, equalizer beams etc.) and all heat numbers of truck forgings and castings; axles, wheels, traction motors; batteries and charging components; bearings, journal boxes, brake components, cab components and related components, HVAC systems and related components, Positive Train Control (PTC) equipment and related components, Cab signal and related components, display units, battery chargers and power supplies, Communications systems and related components, ADA systems and related components, pressurized components, toilet systems and related components yolk and coupler, and any other serialized parts, In addition, all software and firmware part numbers and revisions shall be provided.

23.6.1.2 Serial numbers, software and firmware part numbers and revisions shall be provided with each car history. In addition, an electronic version of a master list of serial numbers per vehicle shall be provide to Metra in Microsoft Excel format that can be uploaded.

23.6.1.3 Wheel and axle mounting reports

23.6.1.4 Contractor's standard test sheets

23.6.1.5 Two copies of "Certificate of Reservoir Construction" specifying minimum tensile strength of the material used, thickness of the shell and heads, outside dimensions and serial number

23.6.1.6 Written reports, tests, and approved contract changes made by the Contractor during car construction.

23.6.1.7 Specification sheets as required by FRA shall be completed and delivered to Metra no later than delivery date of each car.

23.7 AS BUILT SPECIFICATION

23.7.1 Car Contractor shall furnish an electronic version of an as built specification showing all details of car, all components used and naming supplier and model of all equipment on cars. These books shall be furnished to Metra no later than 30 calendar days after delivery of final car. If any changes were made during construction, the as built specification shall detail the changes, and indicate to which cars changes were made or different equipment was applied during construction. **[CDRL C-23-08]**

23.8 FIELD SERVICE

23.8.1 The Contractor shall provide for field support facilities and personnel during the periods of performance testing, warranty, and retrofit programs (if any). The details and plans for field service shall be submitted to Metra for review and approval**. [CDRL C-23-09]** Where manufacturers' systems require specialist support, the Contractor shall arrange with the manufacturer for qualified personnel. Metra may require the Contractor to replace any field service personnel whom Metra deems in its discretion to be unsatisfactory.

23.8.2 Metra will accommodate field support personnel with a minimum of two parking spots at one of its main shops/yards, either Burlington Northern Santa Fe 14th St. Coach Yard or Rock Island Distrct 47th St. yard. The specific location for field personnel will be decided at a later date depending on Metra's needs and distribution of the newly purchased cars. The Contractor will be required to provide its own office space (trailer or other temporary office space, not to exceed 60 foot length by 12 foot wide by 12 foot height and office supplies (desks, chairs, computers, etc.). The field support office, including all furnishings, shall be covered under the Contractor's Risk Insurance. The Contractor shall be responsible for its own security of the office space and space provided for material storage. Material storage space will also be provided for the contractor. Metra will provide a minimum of one hundred and fifty (150) square feet of space for the Contractor to store material. Metra will provide utilities (electrical) for the office and material storage space.

23.9 TEST EQUIPMENT

23.9.1 The Contractor shall supply, sixty (60) calendar days prior to delivery of the first production trainset, two (2) sets of Specialty Tools, and any test and diagnostic equipment necessary to support and maintain the cars and their sub-systems. The contractor shall propose the type and quantity of Test and Diagnostic Equipment the contractor deems necessary and most cost-effective for their proposal. A Specialty Tool shall be considered any tool, gage, die, etc. called out for inspection, repair, maintenance or overhaul of the vehicles that is not readily, commercially available. Special Tools shall not include fixed shop equipment. Fixed shop equipment shall be defined as cranes, drop tables, car jacks, and maintenance pits. Test equipment will troubleshoot down to electronic board level (qualify boards for functionality). **[CDRL C-23-10]**

23.10 TRAINING

23.10.1 General

23.10.1.1 The Builder must provide a modular training program. Training programs will be provided for the specified number of Metra's designated Instructors, Supervisors, Operating, Maintenance, and Engineering personnel, and be of a quality and depth sufficient to permit such personnel to train others in the operation and maintenance of the cars and to safely and satisfactorily operate, service, and maintain the cars and all their ancillary equipment. The training shall be based on Metra's "Train the Trainer" philosophy to allow future training programs to benefit fully from the training materials provided. Safety and FRA inspection compliance are of the utmost importance.

23.10.1.2 The Contractor must provide modular training materials using Word-based and Power Point-based templates and style (active voice, present tense). The Contractor must be familiar with Information Mapping methods and techniques. This will allow for comprehensive training with respect to all aspects of operation and maintenance of the new equipment.

23.10.1.3 If the Builder intends to use a subcontractor for training, the Builder should identify the subcontractor. If a subcontractor is used, Metra's issuance of the Notice to Proceed is conditioned upon Metra's receipt of an executed copy of the Builder's contract with the trainer identified. The Builder should also specifically designate by name the project manager who will oversee the entire training process, oversee the training subcontractor, and who will interface directly with Metra's Director of Training & Development.

23.10.1.4 The ultimate objective of all training materials is that the trainees will be able to safely, accurately, completely, and successfully perform their assigned job tasks. Assigned job tasks include operations, maintenance, and repairs. Safety and FRA inspection compliance are critical to the success of the project. The training must include thorough explanations, operating, and maintenance instruction for any and all new technology. Metra requires that the training define with sufficient detail, accuracy, and completeness the operating and maintenance practices, procedures, and requirements associated with the supplied rolling stock.

23.10.1.5 Specifically, the Contractor must develop materials and deliver training that includes:

- Comprehensive conceptual information
- Functional descriptions
- System descriptions
- Component descriptions
- Installation and removal instructions
- Scheduled maintenance instructions
- Running maintenance instructions
- Comprehensive diagnostics and testing information
- Explicitly defined terminology for new technologies
- Comprehensive information for all new technologies, including system interfaces

23.10.1.6 Developing and delivering training requires that the Contractor:

- Obtain broad and deep knowledge of Metra equipment and supporting components
- Understand Metra's operations and operational goals

- Obtain a thorough understanding of all regulations that govern Metra operations

23.10.1.7 The training shall be conducted in two phases. The first phase shall commence prior to the first production unit being available for revenue service. The second phase shall commence sixty (60) calendar days after the conditional acceptance of the last car of the initial order, in order to provide adequate training of Metra's designated personnel to allow them to become proficient with the equipment. Phase one consists of vehicle orientation, operation and running repair. Phase two consists of vehicle heavy repair procedures and requirements.

23.10.1.8 Training shall include instructor led classroom and hands-on instruction through the use of actual equipment, mock-ups, models, manuals, diagrams, and parts catalogs.

23.10.1.9 The Builder shall assume the attendees have no knowledge of the features of the new trainsets, and using results of the assessment, shall design the training program to bring the level of student knowledge to one fully adequate for the stated objectives. The Builder's approach to this effort shall be based on the assumption that the builder's own interests, immediate and future, are best served by a high quality program.

23.10.1.10 All courses of instruction shall be presented in the English language.

23.10.1.11 Prior to the initiation of each classroom instruction, instructors to be utilized by the Builder shall attend an orientation at a Metra-designated location to become familiar with Metra's safety regulations and facilities, and to be advised of student qualifications and expectations.

23.10.1.12 A complete training plan including manuals and other training materials to be used by the Builder during training shall be delivered to Metra sixty (60) calendar days before initial training is conducted. The manuals shall be accurate, complete, of professional quality, and shall have been approved by Metra. Drawings shall be the most recent version reviewed and approved by Metra.

23.10.1.13 In addition to the above requirements, the Builder shall submit as part of the proposal, in detail a projected training plan clearly linking each individual activity and deliverable to the car production schedule, providing clear project management documents (Gantt charts, etc.), which link the various time lines. Note: the clarity of the information and level of detail will be important factors in this evaluation.

23.10.1.14 The program shall be conducted in a class room provided by Metra, at or near Metra's facilities in the Chicago, Illinois metropolitan area and shall include hands-on instruction (including practical exercises on actual equipment). The Builder shall provide an adequate supply of high quality, professionally prepared material on paper and such other training aids as may be necessary to impart the essential information to the people involved and leave them with authoritative and up-to-date reference material. The program shall include pre and post tests and hands-on practical exercises to determine the proficiency of the students in meeting the course objectives.

23.10.1.15 The training shall provide in-depth instruction covering all subjects and systems and their location, removal, replacement, and interfaces with other systems and parts of the car.

23.10.1.16 The Builder shall, within ninety (90) calendar days after the Notice to Proceed, submit an Overall Training Program Outline with clearly defined Terminal Learning Objectives and a schedule for Metra's approval that identifies milestones for submitting the course outlines, lesson plans, instructor and student guides, audiovisual and other training aids,

simulators, written and practical skills evaluations, and conducting classes. The training outline shall identify each module of instruction and the general topics to be taught and indicate the order in which modules will be presented. **[CDRL C-23-11]**

23.10.1.17 Training materials including manuals, audio/visual aids, reference documents, computer hardware and software, models, check lists, and related items shall be as described in Section 23.10.9.

23.10.1.18 Prior to training materials being developed for a given module, the Builder shall submit a set of clearly defined Objectives for each class.

23.10.1.19 All training materials such as training aids and lesson plans shall become the property of Metra at the completion of the training program. The Builder shall be responsible for the condition of these materials for the duration of the training program and shall replace all damaged materials unless the damage results from Metra's negligence. Lesson plans shall be updated as required during the course of instruction. Metra shall be given full copyrights to reproduce and modify training materials for Metra's use.

23.10.2 Instructor Qualifications

23.10.2.1 Prior to the development of any training materials, all contracting instructors must attend an orientation at a Metra-designated location. The objective of the orientation is to familiarize the contracting instructors with Metra's safety regulations and facilities. At the orientation, Metra will also advise the instructors about student qualifications and expectations. The orientation will be a one-day session. In the event that more than one session is necessary, Metra will host multiple sessions in order to accommodate all instructors.

23.10.2.2 All of the instructors provided by the Builder shall be fully capable of delivering in-depth technical information that can be understood by participants. A detailed resume for each instructor shall be provided to Metra for approval sixty (60) calendar days prior to commencement of scheduled course instruction. **[CDRL C-23-12]** Metra reserves the right to disqualify any of the builder's instructors for reasonable cause at any time.

23.10.2.3 Metra will recognize the instructor as qualified when the individual:

- Can communicate, in English, in a manner that allows the participants to understand
- Has been trained in adult teaching principles and methods and has had experience in conducting technical training courses
- Has an in-depth knowledge of the system under discussion, how it interfaces with other systems or subsystems, the procedures for isolating faults, if applicable, and troubleshooting, and is able to communicate that information to students in an effective manner.
- Is able to design practical written tests, according to the approved course objectives, to determine the extent to which students understand and can apply the information that has been taught.

23.10.2.4 As part of the proposal, the Builder should define and explain the specific person(s) for each subcontractor who will be designated as the contact to implement that portion of the training.

23.10.3 Training Schedules, Class Size, and Program Plan

23.10.3.1 The Contractor must, within ninety (90) calendar days of receiving the Notice to Proceed, submit an overall initial Training Program Plan that contains a detailed outline and a project schedule for Metra's approval. The program plan must contain:

23.10.3.1.1 All assigned project team members including:
23.10.3.1.2 The tasks to which they are assigned
23.10.3.1.3 Company name
23.10.3.1.4 Location
23.10.3.1.5 Contact information
23.10.3.1.6 Project Objectives.
23.10.3.1.7 Detailed project phases, tasks, and deliverables (scope).
23.10.3.1.8 A detailed schedule of delivery dates, specifying milestones such as draft delivery dates, edited materials delivery dates, and final delivery dates.
23.10.3.1.9 The course modules and corresponding lessons.
23.10.3.1.10 The types of deliverables for each course module (CBT, hard copy materials, etc.)
23.10.3.1.11 Project team hierarchy, sign-off authority, and delivery process.
23.10.3.1.12 Communication and reporting plan.
23.10.3.1.13 Change management plan.

23.10.3.2 The training must provide in-depth instruction, covering all equipment and components and their relevancy to the operation, maintenance/troubleshooting, and repairs. Training requirements include familiarity with new equipment systems, location, removal, and replacement. It is critical that all materials and instruction focus on the new passenger car components.

23.10.3.3 (deleted)

23.10.3.4 The Contractor must submit all training materials for review to the Metra project team. The Metra project team requires fifteen (15) working Days (as defined in Exhibit 1-A) to review, edit, and return the training materials. The Contractor must have the ability to produce and submit materials according to a predetermined training plan and schedule.

23.10.3.5 Once the Contractor receives the edits from Metra, they must resubmit the edited version within twenty (20) working days for approval.

23.10.3.6 During materials development, the Contractor must work closely with Metra's project team to ensure the Contractor is meeting Metra's and project standards.

23.10.3.7 All final versions must be ready for delivery thirty (30) working days prior to the date scheduled training date.

23.10.3.8 All training materials will become the property of Metra at the completion of the development and training program validation. Metra will retain all materials utilized in the training program and will use these for future internal training.

23.10.3.9 The Contractor must be responsible for the condition of all training materials and equipment for the duration of the training program and must replace all damaged materials unless the damage results from Metra's negligence. The Contractor must update all materials, training aidsas necessary during development and course validation. Metra must have full copyrights to reproduce and modify training materials for future use at Metra.

23.10.3.10 Course duration (hours of instruction) and class size (number of trainees) will be clearly defined for each topic, depending upon the craft and topic involved. In addition, the proposal must clearly estimate the number of hours for development per hour of classroom instruction, for each module.

23.10.3.11 All ancillary equipment should be proposed to maximize the training objectives.

23.10.3.12 Operator field instruction of at least 4 hours is acceptable as an estimate; with more specific estimates of duration to be determined in the project plan.

23.10.3.13 (deleted)

23.10.3.14 Metra will determine the class size. In general, class sizes will be from five (5) to ten (10) people.

23.10.3.15 Metra acknowledges the variances (experience and technical skills) in the workforce. The Contractor must work with the Metra project team to determine the appropriate number of classes. The amount of considered classes shall be in correspondence with chapter 23.10.3.22.

23.10.3.16 After Metra accepts the lessons, and objectives for each module, the Contractor must deliver a pilot class to verify content and presentation.

23.10.3.17 Requests for revisions will be made by the Metra project team. The project team can determine the correctness and accuracy of the content. They can also judge the quality of the content based on their extensive design and development experience.

23.10.3.18 The Contractor must supervise all classes and must comply with all of Metra's labor agreements, safety rules, other work rules, and policies. The Contractor must conduct classes during Metra's normal daytime hours of operation, Monday through Friday. The classes cannot be more than 8 hours per day, with total course duration to be mutually agreed upon by the Contractor and Metra.

23.10.3.19 Metra is planning for a two-phase training approach. Phase I is described as the Introductory Phase, and will include:

23.10.3.19.1 Overview and conceptual information about the equipment.
23.10.3.19.2 Operation of the equipment.
23.10.3.19.3 Daily inspections.

23.10.3.20 Phase II is described as the Qualification phase, and will include:

23.10.3.20.1 Maintenance.
23.10.3.20.2 Troubleshooting.
23.10.3.20.3 Repair.

23.10.3.21 (deleted)

23.10.3.21.1 (deleted)
23.10.3.21.2 (deleted)

23.10.3.22 As part of this contract, Metra requires that the Contractor provide training on specific topics for employee specializing in specific crafts. This table contains the topics, the craft, and the amount of instructors that must be trained in each topic.

Topic	Trainees per class	Days per Class	Amount of Classes	Total Trainees
Vehicle Knowledge - Driver Training for Typetest Driver	4	1	12	48
Vehicle Knowledge - Extended Driver Training & Troubleshooting for Train Driver	4	3	12	48
Vehicle Knowledge for Maintenance - Basic	8	1	6	48
Vehicle Knowledge for Maintenance - Extended	8	2	6	48
Re-Railing	10	1	5	50
General Maintenance	8	1	6	48
Fire Protection System	8	1	6	48
Brake System	8	1	6	48
Trucks / Truck Exchange	8	1	6	48
Air Supply Unit & Pneumatics	8	1	6	48
Driving Data	8	1	6	48

Topic	Trainees per class	Days per Class	Amount of Classes	Total Trainees
PIS	8	1	6	48
Front Coupler	8	1	6	48
Camera Supervision	8	1	6	48
HVAC	8	2	6	48
TCMS & TCMS Troubleshooting	8	2	6	48
ADA Equipment	8	1	6	48
ADA Operations	8	1	6	48
Traction Converter	8	1	6	48
Traction Battery	8	1	6	48
Door System	8	1	6	48
Train Radio	8	1	6	48
Documentation Management System	8	0.5	6	48

23.10.3.23 (deleted)

23.10.3.24 Training must include instructor-led classroom, and hands-on instruction using actual equipment, models, manuals, diagrams, and parts catalogs. All equipment must be located and the training conducted at Metra's Rock Island District 47th Street yard. At the conclusion of the training as set forth herein, all actual equipment, models, and other training materials are to become Metra's property. The property is necessary for Metra to train new employees in the future.

23.10.3.25 Metra can require training aids (mock-ups) from the Contractor, as an option separate to the base order. The Contractor shall price this option out based on a mutally agreed mock-up setup as part of the IDR phase. These are the following equipments but not limited to:

ADA System A fully functional, ADA compliant lift, enabling both operational and maintenance training; and therefore, including related equipment, such as but not limited to exterior control panel, electrical pump enclosure, lift cassette and enclosure, manual pump operation apparatus.
HVAC System Builder must provide, for purposes of HVAC training, an air comfort system (a/c unit) which will include but is not limited to a maintenance rack, including a frame, unit and control panel. This mock-up should be developed to allow training on the new system, maintenance training, troubleshooting and any appropriate OSHA certification issues as they relate to the new system.
(deleted)
Air Brake System An operational braking system mounted on a training rack must be provided for the related training exercises.
Door System
Communication Systems (PA and TIMS) A communications mock-up demonstrating TIMS (Train Information Management System) primarily for operating crew orientation and practical exercises. This mock-up should be designed to allow crew members to learn and practice proper modulation when making announcements. Ancillary equipment should allow evaluation of performance through audible output and may also include (for the purpose of practice) visual metering or other devices showing an acceptable range.
(deleted)
Cab MockUp A cab mock-up with all controls with all dimensions and detail appropriate to train and orient operators and other trainees on newly located controls/devices. METRA recommends to collaborate with the vendor Corys to establish the cab mockup simulator.

Toilet System The Builder must provide a functional mock-up of the toilet system. This mock-up must include but is not limited to the following sub-assemblies or items: actual toilet; air filter regulator; waste retention tank; freeze dump valve; etc. The mock-up must employ some type of water tank allowing sufficient water so that demonstrations can be conducted for the appropriate mechanical personnel.

23.10.3.26 All courses must include a combination of classroom and hands-on instruction. For most course topics, Metra expects 40%-60% of the classroom time to be allocated to hands-on activities. In-class exercises, written exams, and practical skills evaluations must be designed and developed for each course in order to determine the extent to which students have learned and can apply the information identified in the course. Metra requires the Contractor to make recommendations for test frequency and methods.

23.10.3.27 Classroom instruction for preventative maintenance courses must include not only the details and functioning of parts under discussion, but the essentials of their routine or periodic care, including lubrication schedules and materials. When methods of access, removal, dismantling, or application are not evident, the instruction must cover these matters.

23.10.3.28 The Builder shall make recommendations for test frequency, tolerance limits, and methods for testing, including instruments required, when applicable. The Builder shall assist Metra personnel in developing suitable preventative maintenance, daily and periodic inspection forms, and shall instruct Metra employees how these inspections are performed.

23.10.3.29 The Contractor must give special attention in the instructions, to matters relating to current and proposed safety and FRA inspection requirements and must provide detailed checklists to assure compliance.

23.10.3.30 It is important that the Contractor recommend, develop, and provide the most appropriate training aids and equipment in response to the Metra workforce needs and the passenger equipment subsystems being proposed.

23.10.3.31 After Metra accepts the Terminal and Enabling Learning Objectives for each module, the builder shall deliver a Module Executive Overview to verify module concept. In addition, for each module, a presentation will be made to selected members of the Labor/Management Committee involving the pertinent labor and management representatives affected by the subject matter or topic.

23.10.3.32 The Builder shall supervise all classes and shall comply with all of Metra's labor agreements, safety rules and other work rules. Classes will generally be conducted during Metra's normal daytime hours of operation, Monday through Friday, and no more than 8 hours per day with total course duration to be mutually agreed upon by the Builder and Metra.

23.10.3.33 Metra shall provide classrooms including all necessary training equipment.

23.10.3.34 (deleted)

23.10.4 Operator and Inspector Training

23.10.4.1 The operations training program shall include, but not be limited to, the following: specifications; controls and indicators; systems (brakes, train control, instrumentation, audible & visual signaling and communications); operations (i.e., actual operation of the car in maintenance yards and on the main tracks); troubleshooting procedures, and recovery operations (recovery from the situation, as in resolving the problem discovered when troubleshooting, i.e., fixing the problem).

23.10.4.2 Metra can require an operational simulator from the Contractor, as an option separate to the base order. The Contractor shall price this option out based on a mutally agreed operational simulator setup as part of the IDR phase.
If this option is chosen engineers will be trained in a fully operational cab simulator. A Metra supervisor or qualified instructor must accompany all Contractor instructors to ensure that the training complies with all Metra's safety and operational policies.

23.10.4.3 Operational instructions must follow a logical progression involving the details of the

23.10.4.4 Cars, the manipulation of all controls, and actual operation of the Car components and systems. Actual operation must be conducted under Metra's operating rules and must be performed by Metra's qualified employees under the direction of the Contractor's representative. Operating instruction must include trouble indications, their proper reporting, and corrective measures available to the engineers and operators.

23.10.4.5 All proposal respondents must take note of the provisions of 49 CFR § 238.109 in its entirety, and in particular § 238.109(b)(12), 'Training, Qualification, and Designation Program.' As part of this program, the railroad should, at a minimum: "Add new equipment to the qualification and training program prior to its introduction into service."

23.10.4.6 If proposal respondents propose an alternative to fully functional passenger equipment, given the training objectives and the federal requirements of CFR § 238.109; proposal respondents should stipulate the alternative very clearly.

23.10.4.7 Phase I – Overview and Operations Training

23.10.4.8 Phase I training must address topics and content capable of being effectively delivered prior to the availability of the first production unit. Examples of Phase I topics might be, but are not limited to:

- New equipment orientation (similarities, differences, safety)
- New equipment operation training (normal and emergency operations)
- New equipment maintenance training (craft specific classes on items such as an introduction to Daily Inspections).

23.10.5 Maintenance Training

23.10.5.1 Metra's instructors (see chapter 23.10.3.22) shall be exposed to the depth of detail that is necessary for the performance of all preventive (scheduled) and corrective (unscheduled) maintenance operations for all aspects of the cars.

23.10.5.2 (deleted)

23.10.5.3 Metra may, however, defer the classroom delivery of heavy maintenance training to a selected population on a date to be determined which is closer to Metra's performance of that work.

23.10.5.4 (deleted)

23.10.5.5 (deleted)

23.10.5.6 (deleted)

23.10.5.7 (deleted)

23.10.5.8 (deleted)

23.10.5.9 (deleted)

23.10.5.10 (deleted)

23.10.5.11 (deleted)

23.10.5.12 Wherever possible, maintenance course modules and content shall be divided into two classifications: Electrical and Electronic Systems, and Mechanical Systems. To allow student participation during the demonstration and performance of maintenance functions, each course shall be separated into one of these classifications. It is understood that certain new systems may combine these disciplines, and there may be exceptions to this requirement.

23.10.5.13 **Phase II - Maintenance Training**

23.10.5.13.1 Training must be broad enough and deep enough to allow for the simulation of 'real life' activities that maintenance workers typically experience. This activity includes preventative, periodic (such as Air Brake System component rebuilds), and corrective maintenance operations for all new components on the passenger equipment. The procedures must also include the changes to existing systems as the result of changes in equipment and/or components. Students must have the opportunity to perform the more complex maintenance functions on the equipment and in the shop. The training must also include troubleshooting systems. Troubleshooting training must include artificially induced defects so the trainees will have the opportunity to repair them.

23.10.5.13.2 Metra requires that the proposal respondents include actual component training aids as part of their training modules. When components are not possible, photograph and 'exploded' graphics are necessary to the program.

23.10.5.14 **Phase III – Heavy Maintenance Training**

23.10.5.14.1 (deleted)

23.10.5.14.2 (deleted)

23.10.6 Engineering and Supervisory

23.10.6.1 An overview course shall be provided familiarizing instructors for generalists (see chapter 23.10.3.22 for amount of trainees) with the new equipment. The course shall cover, in executive overview fashion, all subjects to be covered in all other training courses and shall be provided prior to those courses being conducted.

23.10.6.2 Class size will be according to chapter 23.10.3.22. .

23.10.7 Parts Catalog Seminar

23.10.7.1 The Builder shall also include, as a part of its overall training program, a parts catalog seminar (or course of instruction) covering car and car component familiarization for material planners and operations support personnel (20 Materials Management personnel and from one hundred (100) to one hundred twenty (120) Mechanical personnel). This course of instruction shall be comprised of a number of classes with each class given to not more than ten (10) people per class. These classes shall be held during Metra's normal daytime hours of operation at a location in the Chicago, Illinois, metropolitan area designated by Metra. The course given to each class shall be of a total duration approved by Metra and shall include both classroom and field car and component familiarization. An outline of this course of instruction shall be included in the Training Program Outline.

23.10.8 Field Instruction and Warranty Field Instruction

23.10.8.1 In addition to the formal training described above, initial field instruction must be provided by the builder during the warranty period for selected Metra personnel (approximately 16 trainees, 2x classes with 8 trainees per class). This instruction must be hands-on instruction, using the standards described above, with the intent of producing Journeyman level mastery of the troubleshooting and repair tasks encountered. This activity shall be in addition to normal builder warranty efforts.

23.10.8.2 Field instruction involving use of the cars, including both maintenance and operation, shall be presented by qualified and approved instructors (in accordance with Section 20.10.2) having thorough experience in maintenance, service, or operation as the case may require.

23.10.8.3 Instructors must be capable of communicating their knowledge to others and must have their subjects properly organized prior to commencement of the class. Instruction in operation shall follow a logical progression involving the details of the cars, the manipulation of all controls, and actual operation. Actual operation shall be conducted under Metra's operating rules and shall be performed by Metra's qualified employees under the direction of the Builder's representative.

23.10.8.4 Operating instruction shall include trouble indications, their proper reporting, and corrective measures available to the operator.

23.10.8.5 (deleted)

23.10.9 Training Material Standards

23.10.9.1 The following are standards for training materials that should be followed to assure compatibility with Metra's current methods of editing, production, duplication, storage, distribution, and delivery capabilities:

Minimum computer hardware configuration:
IBM compatible, Pentium III CPU, Intel Processor, 2 GHz processor or equivalent, 500 GB or greater hard drive

Software:
MS Windows 10 operating system
MS Office Suite (2019 or better)

MS Project

Graphics Format:
I GB video memory capacity, type DDR3

Digital Storage and Distribution:
USB 2.0 or better

Tools for developing written materials must be:

- Microsoft Windows Office-based products, including:
- Word
- PowerPoint
- Excel
- Visio
- Publisher
- Picasa (for graphics)
- Adobe Acrobat

Tools for developing CBTs:

- Captivate

Tools for developing web-based materials:

- Captivate
- Dreamweaver

23.10.9.2 (deleted)

23.11 CYBERSECURITY

23.11.1 Summary

23.11.1.1 The contractor shall provide cybersecurity requirements for all hardware, software, and firmware (hereinafter referred to as the "products" for purposes of this section) under this Contract, whether resident within a microprocessor-controlled system, provided as part of test or interface equipment, provided for the purpose of post-download data analysis and processing, or incorporated within training technology and manuals, and Portable Test Equipment (PTE) as defined in the Technical Specification.

23.11.1.2 These requirements apply to all systems that include processors or other programmable components such as Programmable Logic Devices (PLDs) and Field-Programmable Gate Arrays (FPGA). Contractor is required to flow these requirements down to all subcontractors and require that these subcontractors flow these requirements down to all of their subcontractors and sub-suppliers, regardless of the tier. Thus, where the word "Contractor" is used, it includes all subcontractors and sub-suppliers, at every tier. If the Contractor fails to flow these requirements down to all subcontractors herein and fails to remedy such non-compliance upon notice from the Contracting Officer, the Authority may exercise all available legal, contractual and administrative remedies for such non-compliance, up to and including a default termination in accordance with the Termination for Default article in the Contract.

23.11.1.3 This applies not only to Contractors as defined in the above paragraph, but to manufacturers of all hardware, software, and firmware installed in the trainset or delivered as a part of the trainset procurement. Further, if the results of any penetration testing, vulnerability assessment or other examination or audit of the Contractor's cybersecurity protections

yields any results that the Authority deems to require further examination and/or audit, the Authority may share the results of such testing with Federal, state or local authorities for the purpose of protecting national security interests, the safety and security of the riding public, or personal and real property.

23.11.1.4 The Contractor shall support the Authority in all tasks necessary to implement best practices developed under section 2(c)(15) of the National Institute of Standards and Technology Act (15 U.S.C. 272(c)(15) as applicable to the current procurement. The Contractor shall also support the implementation of standards and best practices for rail fixed guideway public transportation systems developed under the authority of the Secretary of Homeland Security. This support shall include all necessary input, technology, and systems as identified by the latest NIST Framework for Improving Critical Infrastructure Cybersecurity to appropriately Identify, Protect, Detect, Respond, and Recover from cybersecurity threats related to Contractor supplied products. Additional specific requirements for this procurement are identified below.

23.11.2 Detailed Analysis

23.11.2.1 Cybersecurity Risk Assessment

23.11.2.1.1 The Contractor shall provide an analysis of the potential effects of various possible security attacks on network transmissions and the operation and effectiveness of the measures taken to ensure the security and safety of the networks. The security analysis shall be guided by the latest NIST Framework for Improving Critical Infrastructure Cybersecurity as well as TS-50701:2023, IEC 62443-3-2:2020, IEC 62443-4-1:2018, IEC 62443-4-2:2019, IEC 62443-3-3:2013 and relevant APTA whitepapers. This document shall be submitted for Authority review and approval prior to the first design review and updated and submitted for review annually throughout the duration of the design, production, and warranty periods.

23.11.2.2 Country of Origin

23.11.2.2.1 The Contractor shall identify the country (or countries) of origin of major components to be provided under this Contract, or any subcontracts, at any tier.

23.11.2.2.2 The Contractor shall identify the countries where the development, manufacturing, maintenance, and service for the product are provided or will be provided.

23.11.2.2.3 The Contractor must submit a list of the proposed products for Major Components identifying the country of origin (“List” hereinafter) to the Authority for approval.

23.11.2.2.4 The Contractor shall notify the Authority of any changes to the List no less than 90 days prior to the date that the change will be implemented. The Contractor shall maintain the list throughout the effective term of the contract.

23.11.2.3 Cybersecurity Practices

23.11.2.3.1 The Contractor shall adhere to the specified cybersecurity practices detailed below. In the event that the Contractor knows that it cannot comply with a requirement at the time of its proposal, it shall specify in sufficient detail the justification for non-compliance and its proposed alternative method for meeting the requirement. The Contractor has the affirmative duty to seek and identify any and all information that would result in actual or potential non-compliance during the course of Contract performance. The Contractor shall immediately notify the Authority so that corrective action can be taken.

23.11.2.4 Software and Services

23.11.2.4.1 The Contractor shall remove and/or disable, through software, physical disconnection, or engineered barriers, all services and/or ports in the product not required for routine operations, emergency operations, maintenance, troubleshooting, or repair. This will include communication ports and physical input/output ports (e.g., USB ports, video ports, UART ports, serial ports, software terminal ports). The Contractor shall provide documentation of disabled ports, connectors, and interfaces for each device to the Authority.

23.11.2.4.2 The Contractor shall provide summary documentation of the product's security features and security-focused instructions on maintenance, support, and reconfiguration of the product's default settings.

23.11.2.4.3 The Contractor shall disclose the existence of all known methods for bypassing computer authentication contained in the product, often referred to as "backdoors," and provide written documentation that all such backdoors have been permanently deleted from the product.

23.11.2.5 Access Control

23.11.2.5.1 The Contractor shall restrict physical access to system components to all but authorized personnel.

23.11.2.5.2 The Contractor shall configure each component of the product to operate using the principle of "least privilege." This includes operating system permissions, file access, device access, device / user accounts, and communications / data transfer.

23.11.2.5.3 The Contractor shall provide user accounts with configurable access and permissions associated with one or more defined user role(s).

23.11.2.5.4 The Contractor shall utilize access control lists and provide a system administration mechanism for changing users' roles (e.g., group) or associations.

23.11.2.5.5 The Contractor shall configure the product such that when a session or inter-process communication is initiated from a less privileged application, access will be limited to and enforced at the more privileged side.

23.11.2.5.6 The Contractor shall provide a method for protecting against unauthorized privilege escalation.

23.11.2.5.7 The Contractor shall document options for defining access and security permissions, user accounts, and applications with associated roles. The Contractor shall configure these options, as specified by the Authority.

23.11.2.5.8 The Contractor shall recommend methods for the (Client) to prevent unauthorized changes to the Basic Input/Output System (BIOS) and other firmware. If it is not technically feasible to protect the BIOS to reduce the risk of unauthorized changes, the Contractor shall document this and provide mitigation recommendations.

23.11.2.5.9 The Contractor shall verify and provide documentation for the product, attesting that unauthorized logging devices are not installed on the provided service laptops (e.g., key loggers, cameras, and microphones).

23.11.2.5.10 (deleted)

23.11.2.6 Authentication/Password Policy and Management

23.11.2.6.1 The Contractor shall document the levels, methods, and capabilities for authentication and authorization of passwords. The Contractor shall deliver a product that adheres to standard authentication protocols.

23.11.2.6.2 The Contractor shall protect all passwords, including, but not limited to the following methods: Contractor shall not store passwords in clear text and Contractor shall not hardcode passwords into software or scripts.

23.11.2.7 Logging and Auditing

23.11.2.7.1 The Contractor shall provide logging capabilities for all products where supported and applicable. As specified by the Authority, the product shall cover the following events, at a minimum (as appropriate to their function):

23.11.2.7.1.1 (deleted)

23.11.2.7.1.2 Successful and unsuccessful authentication and access attempts

23.11.2.7.1.3 (deleted)

23.11.2.7.1.4 Privileged uses.

23.11.2.7.1.5 The Contractor shall time-stamp log files.

23.11.2.7.1.6 The Contractor shall provide security protection of log files.

23.11.2.7.1.7 The Contractor shall implement for Authority use an approach for automatic collection and storage of generated log files.

23.11.2.7.1.8 The Contractor shall provide a list of all log management activities that the product is capable of generating and the format of those logs. This list shall identify which of those logs are enabled by default.

23.11.2.7.2 Communication Restrictions

23.11.2.7.2.1 The Contractor shall provide detailed information on all communications (e.g., protocols and full interface control documents) required between the Authority's wayside systems and on-board train network security zones whether inbound or outbound and identify each.

23.11.2.7.2.2 The Contractor shall provide a method to restrict communications traffic between different network security zones. The Contractor shall provide documentation on any method or equipment used to restrict communications traffic.

23.11.2.7.2.3 The Contractor shall provide the Authority with access, including administrative access on as-needed basis, to the network components of the product where applicable.

23.11.2.7.2.4 The Contractor shall document all remote access entry pathways.

23.11.2.7.2.5 The Contractor shall document the IP address and routing scheme for Authority review and approval where needed for communication between the train and wayside systems.

23.11.2.7.2.6 The Contractor shall document the network components and their configurations (e.g. electrical schematics, network configuration concept and addresses)

23.11.2.7.2.7 The Contractor shall certify that the network configuration management interface is secure.

23.11.2.7.2.8 The use of encryption, public/private keypairs, and hardware keys is encouraged as a mitigation. These technologies shall be implemented as required as a result of the Contractor's comprehensive cybersecurity risk assessment.

23.11.2.7.2.9 The Contractor shall establish appropriate isolation of safety and security critical system functions from other functions.

23.11.3 Certification

23.11.3.1 Independent Assessment of Software and Firmware Quality

23.11.3.2 The Contractor shall procure an independent third-party assessment of all software and firmware used in safety-critical or related applications which are rated into the categories SIL-2, SIL-3 and SIL-4 according to EN 50657:2017. provided as part of this project. Software and firmware which are not safety-critical or related and therefore rated into the category Basic Integrity according to EN 50657:2017, but whose unmitigated risk identified as a part of the cybersecurity risk assessment retain unacceptable or undesirable residual risk shall also be put through an independent third-party assessment, procured by the Contractor, as an additional method of reducing the residual risk.

23.11.3.3 The assessment shall be performed by a qualified, independent organization approved by the Authority.

23.11.3.4 The Contractor shall ensure that the software suppliers shall check software and firmware to ensure that critical application security weaknesses (including OWASP's Top 10 and SANS' Top 25 Most Dangerous Software Errors) are addressed.

23.11.3.5 The Contractor shall ensure that the software supplier performs testing to identify potential cybersecurity weaknesses and vulnerabilities according to the standards mentioned in

section 23.11.2.1.1. This testing shall include, but is not limited to, fuzz testing, static testing, and dynamic testing.

23.11.3.6 The Contractor shall ensure that the assessment reports of any software supplier or any independent software and firmware quality assurance assessment are sent directly from the third-party provider to the Authority and the Contractor.

23.11.3.7 The Contractor shall provide a response to the third-party's assessment including plans to correct identified vulnerabilities. The Contractor's response and corrective action plan shall be sent to the Authority for approval.

23.11.3.8 This independent assessment of software and firmware which are rated into the categories SIL-2, SIL-3 and SIL-4 according to EN 50657:2017, shall be provided to the Authority for each software release.

23.11.4 Independent Rail Car Penetration Test

23.11.4.1 To demonstrate compliance with specified functional and cybersecurity requirements relating to this Contract, the Contractor shall procure an independent third-party penetration test/vulnerability assessment according to the standards mentioned in section 23.11.2.1.1.

23.11.4.2 This penetration test/vulnerability assessment shall be performed by a qualified, independent organization approved by the Authority.

23.11.4.3 The penetration test/vulnerability assessment shall cover all software and firmware packages, which are part of the trainset software configuration included in this procurement, as described in the other sections of the Technical Specifications.

23.11.4.4 The Contractor shall ensure that the results of any independent penetration test/vulnerability assessment are sent directly from the third-party provider to the Authority and the Contractor.

23.11.4.5 The Contractor shall provide the Authority with a response to the third-party assessment, including a Corrective Action Plan to correct identified vulnerabilities subject to the Authority's approval.

23.11.4.6 This independent penetration test/vulnerability assessment of software and firmware, which are rated into the categories SIL-2, SIL-3 and SIL-4 according to EN 50657:2017, shall be provided to the Authority for each software release.

23.12 CONTRACT DELIVERABLES REQUIREMENT LIST

CDRL	Title
C-23-01	As-Built Drawings, Drawing Lists and Bills of Material
C-23-02	Photographs
C-23-03	(deleted)
C-23-04	Maintenance Manuals
C-23-05	Parts Manuals
C-23-06	Operator Instruction Book
C-23-07	Car History Books
C-23-08	As-Built Specification
C-23-09	Field Service

C-23-10	Test Equipment
C-23-11	Training Program
C-23-12	Instructor Qualification Submittal

24 PROPOSAL DELIVERABLES REQUIREMENTS LIST

PDRL	Title
P-3-01	Car Width
P-3-02	Car Height
P-3-03	Seating Capacity
P-3-04	Passenger Flow
P-3-05	(deleted)
P-4-01	Exterior General Arrangement and Rendering
P-7-01	Door System
P-8-01	Carbody Interior
P-8-02	Accessibility (ADA) Provisions
P-9-01	HVAC System
P-10-01	Lighting Plan and Description
P-10-02	LLEPM
P-11-01	Electrical System and Load Study
P-11-02	(deleted)
P-12-01	Functionality and the Onboard Equipment of Complete Communication System
P-12-02	Infotainment Proposal
P-13-01	Air Brake and Air Supply System
P-13-02	Braking Performance Calculation
P-15-01	Truck System
P-15-02	(deleted)
P-17-01	Traction System
P-17-02	Prime Mover System
P-18-01	Auxiliary Power System
P-20-01	Audible Noise Proposal

25 CONTRACT DELIVERABLES REQUIREMENTS LIST

CDRL	Title
C-1-01	Drawing Submittals
C-1-02	Car-Body Stress Analysis
C-1-03	Contractor's Quality Assurance Manual and Procedures
C-1-04	Contractor's Organizational Chart with Personnel Assigned to Metra's Contract
C-1-05	Contractor's Management's Declaration of their Commitment to Quality and the Implementation of the Contractually Required MQP and FTA QMS Guidelines
C-1-06	Contractor's Project Quality Plan and Procedures
C-1-07	Contractor's Ratio of Inspection to Production Personnel
C-1-08	Contractor's Software Quality Assurance Plan
C-1-09	Contractor's Supplier and Subcontractor Qualification, Quality Compliance, and Management Plan and Procedures
C-1-10	Contractor's List of all supplier and subcontractors, their qualifications, and quality certifications (ANSI-ASQ ISO)
C-1-11	Contractor's First Article Inspection (FAI) Plan and Procedures
C-1-12	Contractor's MRB Plan and Procedures
C-1-13	Corrective and Preventative Plan and Procedures
C-1-14	Reliability Program Plan
C-1-15	Reliability Prediction Analysis
C-1-16	Failure Modes, Effects and Criticality Analysis
C-1-17	Reliability Demonstration Report
C-1-18	Maintainability Analysis
C-1-19	Maintainability Demonstration
C-1-20	System Safety Program Plan
C-1-21	Preliminary Hazard Analysis
C-1-22	Hazard Tracking Log
C-1-23	Fault Tree Analysis
C-3-01	Clearance Diagram
C-3-02	Car Weight
C-4-01	(deleted)
C-4-02	Car-Body Strength Test Document
C-4-03	Emergency Roof Access
C-4-04	End Structure Design
C-4-05	Cross Bearer and Underframe Design
C-4-06	Jacking Pad Location
C-4-07	Insulation Samples.
C-4-08	Thermal Analysis
C-4-09	HVAC Duct and Piping Insulation Installation
C-4-10	Diaphragm/Gangway Design and Installation
C-4-11	Ingress Emergency Window Layout
C-4-12	Egress Emergency Window Layout and Design
C-5-01	Exterior Safety Appliance and Handhold Design and Installation
C-5-02	Safety Gate Design
C-5-03	Interior Safety Appliance and Handhold Design and Installation
C-6-01	Coupler System Design
C-7-01	Side Loading Door Design and Configuration
C-7-02	Side Loading Timing and Announcement
C-7-03	External Door Release Design
C-7-04	Traction Interlock

C-7-05	No Motion/Zero Speed System
C-7-06	Passenger Compartment Door Panel Design (If Applicable)
C-7-07	Passenger Compartment Door Hold Open (If Applicable)
C-7-08	Electric/Crew Locker Door
C-7-09	Cab Door Panel Design
C-7-10	Inter-Car Door Design and Configuration
C-7-11	Toilet Door Design and Configuration
C-8-01	Interior Material Samples
C-8-02	Wall Panels
C-8-03	Cab Locker Designs (Engineer and Fireman Side)
C-8-04	Floor Fire Test
C-8-05	Flooring System
C-8-06	Anti-Skid Design
C-8-07	Seat Ergonomic Assessment
C-8-08	Cushion Covering and Material
C-8-09	Seat Dynamic and Static Testing
C-8-10	Parcel Rack Design
C-8-11	Mobility Aid Lift System
C-8-12	Toilet Room/Equipment Arrangement
C-8-13	Retention Tank Level Indication
C-8-14	Toilet Shut-Off/ Drain Valve
C-8-15	Ticket Clip Installation and Design
C-8-16	Waste Receptacle
C-8-17	Automated External Defibrillator
C-8-18	Bicycle Racks
C-8-19	Heated Floor
C-9-01	HVAC System – Design and Installation
C-9-02	Floor Surface Heating Solution (If Applicable)
C-9-03	Toilet Room Exhaust
C-9-04	HVAC Unit Lifting Provision
C-9-05	Temperature Control Arrangement
C-9-06	Retention Tank Heater
C-9-07	Water Freeze Dump Valve
C-10-01	Interior and Exterior Lighting Plan
C-10-02	Lighting Electronics Environmental Testing
C-10-03	Normal Mode Light Level Testing and Environmental standards
C-10-04	Emergency Lighting Details and Testing
C-10-05	Exterior Lighting Design and Functionality
C-10-06	Headlight Dimming/Protection
C-10-07	Light Burnout Detection
C-10-08	Low Location Exit Path Marking (LLEPM)
C-11-01	Electrical Circuit Diagram
C-11-02	Electrical Load Study
C-11-03	Load Shedding
C-11-04	Battery Box and Battery Protection
C-11-05	Battery Charger/LVPS
C-11-06	Electric Lockers Design
C-11-07	Trainline Circuits
C-11-08	Surge Protective Device
C-11-09	USB Port Position and Design
C-11-10	Car Level Monitoring System

C-12-01	Design, Arrangement, Installation of Communication Package
C-12-02	Compatibility with Metra's existing ACORN communication system
C-12-03	Audio Sampling and Study of all Passenger Areas
C-12-04	Emergency Passenger Intercom Unit
C-12-05	Cab Radio
C-12-06	Train Information Management System
C-12-07	Passenger Information Signs
C-12-08	Passenger Compartment DVR System
C-12-09	Passenger Wi-Fi Provisions
C-12-10	Automated Passenger Counting
C-13-01	Brake System Description
C-13-02	Deadman Pedal
C-13-02	Wheel Slide System Protection Design (If Applicable)
C-13-03	Tread Brake Unit Design and Installation
C-13-03	Air Compressor
C-13-04	Reservoir Design and Installation
C-13-05	Air Piping
C-13-05	Handbrake Force Calculation
C-13-06	Disc Brake Design and Installation
C-14-01	Bell
C-14-02	Horn
C-15-01	Truck Design Review
C-15-02	Service History of Truck
C-15-03	Handbrake
C-15-03	Sensor Arrangement and Wiring (If Applicable)
C-15-04	Truck Ground Strap
C-15-05	Ride Quality Test Report or Simulation
C-16-01	Cab Control – Design and Arrangement of Cab Car
C-16-02	Cab Seating
C-16-03	Alerter Operation
C-16-04	(deleted)
C-16-05	PTC Installation
C-16-06	Cab Digital Video Recording System
C-16-07	(deleted)
C-16-08	(deleted)
C-16-09	Windshield Wiper System
C-16-10	Pilot Design
C-17-01	Traction System
C-17-02	Dynamic Brake System
C-17-03	Prime Mover System
C-17-04	Propulsion Battery
C-17-05	Propulsion Battery Control
C-17-06	Propulsion Battery Charging
C-17-07	DC Fast Charge Pantograph
C-17-08	Battery Thermal Conditioning
C-18-01	Auxiliary Power System
C-18-02	Auxiliary Power Controls
C-19-01	Signage Plan
C-20-01	Noise Level Test Procedure
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	Corrosion Protection Concept
C-21-29	Surface Preparation for Bonding or Painting
C-21-30	Cable List for high-temperature Applications
C-22-01	Master Test Plan
C-22-02	Test Procedures
C-22-03	Electromagnetic Compatibility Control Plan
C-23-01	As-Built Drawings, Drawing Lists and Bills of Material
C-23-02	Photographs
C-23-03	(deleted)
C-23-04	Maintenance Manuals
C-23-05	Parts Manuals
C-23-06	Operator Instruction Book
C-23-07	Car History Books
C-23-08	As-Built Specification
C-23-09	Field Service
C-23-10	Test Equipment
C-23-11	Training Program
C-23-12	Instructor Qualification Submittal