Design Manual (DMAN)

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Version 1.0

REVIEW AND APPROVAL RECORD

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1. INTRODUCTION

Metra is the largest commuter railroad in the nation based on miles of track. The agency provides service to and from downtown Chicago with 242 stations over 11 routes totaling nearly 500 route miles and approximately 1,200 miles of track. In 2019, Metra operated nearly 700 weekday trains, providing nearly 290,000 passenger trips each weekday. The service area encompasses a region of more than 3,700 square miles and six counties in northeastern Illinois: Cook, DuPage, Will, Lake, Kane, and McHenry. Metra owns and operates four rail lines (Rock Island, Metra Electric, Milwaukee District North, and Milwaukee District West). Three lines are operated by Metra employees over freight railroad-owned track through trackage rights or lease agreements (Heritage Corridor, North Central Service and Southwest Service). Four additional lines are operated directly by freight railroads through purchase-of-service agreements (BNSF, Union Pacific North, Union Pacific Northwest, and Union Pacific West).

1.1 USE OF THE DESIGN MANUAL

This manual, the Design Manual (DMAN), was developed to provide guidance on the administration, management, and execution of Metra design projects by the Metra design consultant(s) and supporting technical consultants. The DMAN outlines the process to promote uniform and consistent project design practices across all projects managed within Metra’s Capital Delivery Department. Metra's capital program includes projects that involve design, construction, procurement, and installation of materials providing for the operation of a safe, reliable, and convenient commuter railroad system.

The DMAN consists of 19 chapters:

- Chapter 1: Introduction
- Chapter 2: Project Life Cycle – Design
- Chapter 3: Designer Roles, Responsibilities, and Tools
- Chapter 4: Track Geometry
- Chapter 5: Clearances
- Chapter 6: Civil and Drainage
- Chapter 7: Bridges and Structures
- Chapter 8: Stations and Parking (under development for DMAN Version 2; currently covered by the Station and Parking Design Guidelines)
- Chapter 9: Signals (under development for DMAN Version 2)
- Chapter 10: Communications

- Chapter 11: Traction Power
- Chapter 12: Overhead Contact System (OCS)
- Chapter 13: Stray Current and Corrosion Control
- Chapter 14: Mechanical, Electrical, and Plumbing
- Chapter 15: Shops and Yards
- Chapter 16: Crew Facilities (under development for DMAN Version 2)
- Chapter 17: Vehicles
- Chapter 18: System Safety and Security (under development for DMAN Version 2)
- Chapter 19: Cybersecurity (under development for DMAN Version 2)

Unless otherwise noted, the criteria in this document are compulsory, variance from the criteria is only permitted if approved through the design exceptions process (Section 2.3.7). Every effort has been made to eliminate conflicting criteria within the manual. If a conflict is identified, the design consultant shall discuss the conflict with the Metra Project Manager (PM) to determine which criteria will apply.

Designs submitted to Metra shall comply with all applicable federal, state, and local laws and regulations. If any design criteria contained in this manual is found to conflict with an applicable regulation, then the regulation shall govern, and the consultant shall document the conflict with the Metra PM.

For topics not covered in this manual, the design consultant shall consider industry best practices when providing its design, with particular consideration given to practices in use on peer commuter railroads.

The design consultant shall communicate regularly with the Metra PM and other key stakeholders throughout the design process and make all reasonable efforts to obtain timely resolution of questions or issues impacting design. It is vital that disciplines within a project do not operate in a silo, engagement between disciplines should begin as early as possible in the design process. This is true even for disciplines that are not explicitly included in a design. For example, the design consultant may have a contract for a station platform design that includes only architectural, civil, and structural disciplines, but the design consultant should still engage with Metra Signals early in the design process to ensure that any potential impacts to the signaling system are appropriately addressed.

1.2 APPLICABILITY AND HOST RAILROAD INTERACTIONS

This manual shall guide the design process for the four Metra-owned rail lines (Rock Island, Metra Electric, Milwaukee District North, and Milwaukee District West).

Three lines are operated by Metra employees over freight railroad-owned track through trackage rights or lease agreements (Heritage Corridor, North Central Service and Southwest Service). Four additional lines are operated directly by freight railroads through purchase-of-service agreements (BNSF, Union Pacific North, Union Pacific Northwest, and Union Pacific West). Each of these railroads have their own engineering standards that must be accounted for in design. The Metra PM will work with the design consultant to determine which host railroad criteria apply for a project.

1.3 REFERENCES

References to applicable standards, codes, and regulations are provided at the beginning of each chapter.

This manual is part of Metra's project delivery documentation and shall be used in concert with other Metra documents to facilitate successful projects. Together, these documents describe Metra's standards for the safe, timely, and cost-efficient delivery of projects that serve the needs of passengers, employees, and partner communities.

2. PROJECT LIFE CYCLE – DESIGN

The contents of this manual apply predominantly to the Project Development and Design phase in Metra's project phasing scheme (Figure 2-1). The project design process is discussed in this chapter.

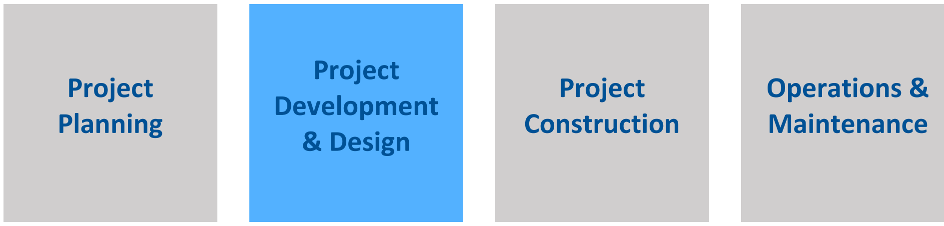


Figure 2-1. Metra Project Phasing

This manual also discusses aspects of project planning and project construction as they relate to design. It is important for the designer to have an understanding of the project from beginning to end to ensure that the delivered design meets Metra's needs.

Metra stand-alone improvements developed through the Project Charter process involve a high degree of planning and agency input in the development of the project charter, definition of costs, scope, schedule, and identification of stakeholder impacts and permit requirements. A design services contract for a defined Metra scope of work will include the design, management, and subconsultant services required to deliver a set of construction documents to Metra for bid and construction. Work that may be defined as part of these contracts can include, but is not limited to, improvements to:

- Site grading, parking, and accessibility
- Stations and track
- Shops and yards
- Structures
- Site drainage, excavation, landscaping, and erosion control
- Rail, pedestrian, vehicular and bicycle traffic control
- Americans with Disabilities Act (ADA) improvements
- Signal improvements
- Site and transit signage and lighting

2.1 DESIGN PHASES

Design phases are defined by project deliverables and milestones. Plans, specifications, and estimates (PSE) and other submittals are required to be developed by the designer at each milestone. In parallel to plan preparation, other processes such as agreements, permits, proposed utility relocations, and stakeholder coordination will occur, with the support of both the designer and the Metra PM.

Typical Metra milestones are shown in Figure 2-2. Section 3.5 defines typical deliverables for each design phase. Some disciplines may use different terminology and/or design levels during the design process. Projects, depending on scope and schedule, may use some or all of these design milestones. The designer shall discuss contract-specific requirements with the Metra PM during the contract development process.

Design consultant contracts are generally structured with provisions requiring the designer to provide services through the project advertisement and construction phases. Whether some or all of these services are required will be dictated by the scope of the improvements and will, necessarily, be part of the discussion between the PM and the consultant when formulating the design services contract.

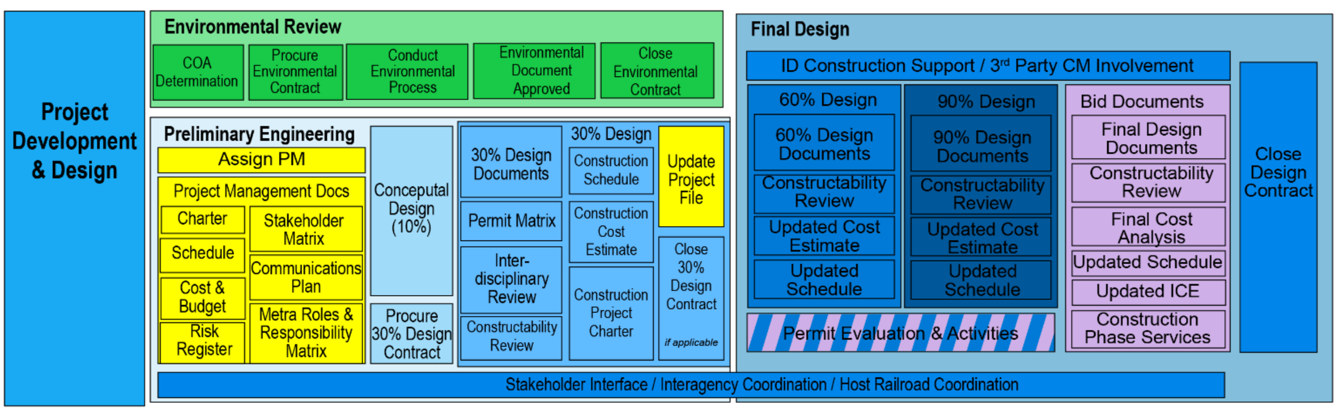


Figure 2-2. Metra Design Project Development

2.1.1 DESIGN CONTRACT PROCUREMENT

The first step of the design phase is procurement of the designer. Metra solicits for Letters of Interest and Qualification (LIQ) for design projects on the Purchasing and Procurement website. Prospective projects will have a listed Bid ID, a title, a description, a due date for applications, and a downloadable attachment describing the project and submittal requirements. Selection criteria will be described in the solicitation package. Metra employs a qualification-based selection process. No cost information is required as part of the applicant's submittal.

After selection, the prospective consultant will enter into a discussion with the Detailed scope of services and associated effort

- Key staff including subconsultants
- Diversity requirements
- Design schedule

The scope of services discussion and resultant proposal will include all of the design services discussed in the LIQ solicitation as well as any others as determined by the PM. The design consultant will be expected to provide detailed levels of effort for each defined task, generally defined as hours per task and/or hours per sheet. Personnel associated with each task will be identified. Key staff, generally defined as discipline leads, will also be identified. The level of subconsultant effort will be defined. Subconsultant submittals must also include staffing and effort.

Project schedule and submittal requirements, such as milestone submittals, will be defined in the proposal. Specific technical requirements will be provided by Metra and must be reflected in the proposal. Metra will also provide information concerning invoicing, contract supplements, and project closeout requirements.

Contract execution will take place upon approval by Metra Procurement for all contract details reflecting scope, cost, subconsultant participation, diversity requirements, and contract schedule.

In addition to stand-alone contracts where the scope is defined by a project charter, Metra may also award design services contracts for discipline-specific tasks including:

- Architectural
- Geotechnical
- Survey
- Environmental/wetland

These types of contracts can be formulated to include predetermined improvement locations with a defined scope of services or can be structured as LIQ blanket contracts where the consultant will be given work-order tasks by Metra on an as-needed basis. An “upon request” contract will generally be administered as follows:

- The PM will provide a task order request and associated scope to the consultant.
- The consultant will develop a proposal including schedule and budget for performing the work described in the task order.
- Upon Metra's concurrence with the proposal, a task order authorization will be provided to the consultant.

For more information, refer to Metra's Procurement Manual.

2.1.2 PRELIMINARY ENGINEERING

The preliminary engineering phase generally consists of a 10 percent conceptual design and a 30 percent preliminary design. Metra will generally require design reviews of each deliverable; specific required design reviews will be defined in the contract scope for each project (see Section 3.6.7).

Metra may include 10 percent design in a design contract or may perform all or part of the 10 percent design in-house. The purpose of the 10 percent conceptual design is to identify various feasible schemes and to decide on one or more concepts for further consideration, ultimately resulting in the selection of a preferred alternative. A list of typical 10 percent design deliverables is provided in Section 3.5.1.

The preferred alternative resulting from 10 percent design will then proceed into 30 percent design. 30 percent design establishes a proof of concept that is constructible given the project constraints. The 30 percent design:

- Defines major design elements
- Defines right of way (ROW) needs with enough detail to allow the purchase of ROW, if necessary
- Defines a feasible project schedule
- Provides an estimate of probable construction costs
- Determines agency permitting requirements and project approvals

A list of typical 30 percent design deliverables is provided in Section 3.5.2.

By the completion of the preliminary engineering phase, the environmental review process, including National Environmental Policy Act (NEPA), should be complete and the findings incorporated into the 30 percent design deliverable.

The project generally cannot proceed to the final design phase until all environmental concerns have been addressed.

2.1.3 FINAL DESIGN AND PERMITTING

The final design phase generally consists of a 60 percent design, a 90 percent design, and delivery of bid documents (Figure 2-3). It also encompasses permitting activities as needed. Metra will generally require design reviews of each deliverable; specific required design reviews will be defined in the contract scope for each project (see Section 3.6.7).

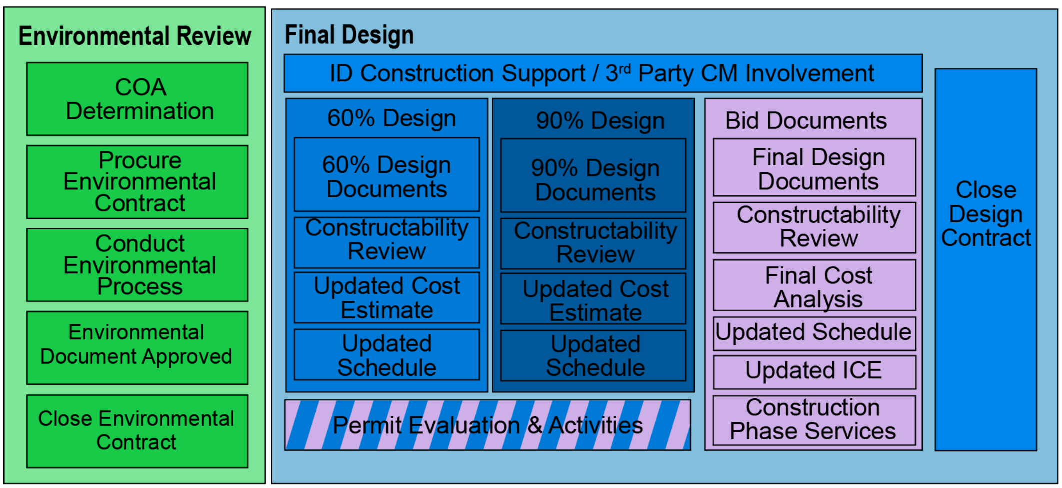


Figure 2-3. Metra Final Design Development

The objective of 60 percent design is to confirm that the proposed improvements can be constructed, and that the submitted plans and specifications will meet the objectives of the project without significant design changes. Plans, Special Provisions, a list of pay items, and quantity and cost estimates are developed following the approval of the 30 percent design. A list of typical 60 percent design deliverables is provided in Section 3.5.3.

The objectives of 90 percent design are to incorporate comments from the 60 percent design and refine and detail the size and character of the entire project to include final architectural and engineering systems, materials, and finishes. The documents delivered at the conclusion of 90 percent design should consist of a biddable set of design documents for review. A list of typical 90 percent design deliverables is provided in Section 3.5.4.

Following review of the 90 percent design deliverables (PSE) set, the designer shall incorporate all outstanding comments into a 100 percent design deliverable and/or the final bidding documents. The designer is responsible for providing Metra with all documentation required to facilitate the bidding process as described in Section 3.5.5. Design development concludes at this point, though the designer will still be responsible for supporting project implementation per its contract.

The designer will also support Metra in the preparation of permit sets and other documents required to secure permits. The permitting process generally begins no later than the start of final design and continues through the procurement and implementation (construction) phases. The designer is responsible for providing this support.

2.1.4 CONSTRUCTION PROCUREMENT

As part of the Metra procurement process, bid documents will be made available to prospective construction services providers for review and bid submittal. Contractors may request clarifications, note discrepancies, or suggest modifications. Any inquiry related to issues involving design standards and details will be directed to the designer for response. If, after analysis, it is determined that the inquiry warrants a modification to the contract documents, the PM will direct the designer to prepare an addendum. Addenda may involve plan, specification, and/or quantity modifications. The designer is required to prepare addenda as a plan change following all Metra document control processes for plan drawings, specifications, and quantity calculations. Addenda must be rigorously documented so that all proposed changes are incorporated properly, and contractors are clearly provided with only the latest drawing and document versions. The Metra procurement process involves strict deadlines for contractor questions and submittals and provides for a specific date and time for bid opening. The designer must be aware of these deadlines as they apply to the distribution of any addendum.

2.1.5 PROJECT IMPLEMENTATION

Project implementation is the phase following opening of bids and extends through the construction phase of the project. Typical deliverables for this phase are discussed in Section 3.5.6. If specified in its design services contract, the designer may also be required to respond to requests for information (RFI) that are generated during the construction phase, and/or review shop drawings. The designer will evaluate and respond to these requests through the PM.

2.2 PROJECT GUIDANCE AND MANUALS

Metra has developed a range of documents to guide the design process and the execution of the design contract. In addition to this manual, the designer should refer to applicable documentation on the Metra Engineering website. Some manuals are written to cover other aspects of the project lifecycle but may have impacts on design.

Metra provides the following agenda templates for required project meetings on the Metra Engineering website:

- Design Kick-Off Meeting Agenda Template
- Design Kick-Off Meeting Agenda and Directions
- Design Progress Meeting Agenda
- Design Progress Meeting Agenda and Directions
- Design Check-In Meeting Agenda
- Design Check-In Meeting Agenda and Directions

2.3 DESIGN MANAGEMENT PROCESSES

Metra has defined a set of design management processes whose purpose is to facilitate efficient delivery of design with minimal need for changes after design is complete. These processes, along with the tools presented in Section 3.6, will be used by the designer throughout the execution of its contract.

2.3.1 SAFETY AND SECURITY

The designer will ensure that all activities in the design contract comply with Federal Railroad Administration (FRA) regulatory requirements for safety and security, including standards, specifications, regulations, design handbooks, safety design checklists, and other sources of design guidance. Deviations from standards will be addressed by means of a design waiver and submitted to the PM for approval (see Section 2.3.7).

The designer will coordinate with the PM to obtain a temporary right-of-entry permit and flagging services for project activities within Metra or host railroad ROW. The designer will coordinate with the PM on all field reconnaissance, data collection, site assessment, and other necessary tasks, including property owner notifications. Design consultant project staff accessing Metra ROW will have federally mandated training, including annual Metra-certified Roadway Worker Protection (RWP) training consistent with Title 49 Code of Federal Regulation (CFR) Part 214. Design team field personnel must be equipped with personal protective equipment (PPE) in compliance with federal regulations and Metra requirements. The designer will copy the PM on all coordination and correspondence with the host railroad.

2.3.2 PROJECT SCOPE

The designer's performance and all deliverables will be measured against the project scope as approved by Metra at the conclusion of the design contract procurement process. The designer's scope of work can only be changed through the contract amendment process, with the approval of Metra.

2.3.3 PROJECT START-UP DELIVERABLES

Within 14 days of receiving Notice to Proceed (NTP), the designer shall submit a detailed design project plan that addresses the design work scope, deliverables, risks, assumptions, milestones, schedules, budget, and team working practices required to meet the intent of the design contract.

As part of this submittal, the designer will include a milestone delivery schedule and a detailed design schedule that will contain all the activities, tasks, events, meetings, reviews, and deliverables for the duration of the project. The initial submittal must be approved in writing by the PM. Any subsequent revisions to the schedule will require the approval of the PM.

The PM may require the designer to conduct coordination meetings with adjacent projects. If so, the designer will develop a coordination meeting schedule 14 business days after NTP.

The designer will be required to submit various project control documentation as outlined in the Third Party Contracts Quality Management Plan (TPCQMP).

2.3.4 PROJECT MEETINGS

The designer will conduct a project kick-off meeting and bi-weekly project management coordination meetings with the PM. Additionally, a monthly design check-in meeting will be held in coordination with periodic project review meetings. At the PM's discretion, these meetings will be a combination of in-person meetings and conference calls. The PM may also require the design consultant to conduct design coordination meetings and discipline-specific meetings with Metra and other stakeholders based on the requirements of the design review process.

If the designer is required to conduct coordination meetings with an adjacent project, they are to provide agendas for each meeting, facilitate the discussions during the meetings, and submit minutes documenting each meeting to the PM.

Templates for meeting agendas are discussed in Section 2.2.

2.3.5 MONTHLY REPORTING

The designer will prepare monthly progress reports for submittal to the PM in accordance with the design services contract.

The designer will submit monthly schedule updates along with the monthly progress report. Updates to the schedule must be approved in writing by the PM.

2.3.6 BASIS OF DESIGN

The contract may require the designer to develop a basis of design (BOD) to document the design approach, codes, technical criteria, specifications, standards, and agreements used during the preparation of the plans, specifications, and estimate (PSE). The BOD is a living document, and the design consultant will update the document throughout the project to add additional agreements and modify criteria as needed. The BOD will be submitted to the PM for review prior to the 30 percent design submittal or as directed by the PM based on the project-specific deliverable schedule.

2.3.7 DESIGN EXCEPTIONS AND DEVIATIONS

The designer will adhere to all design standards included as part of the design contract along with any listed in the basis of design developed for the project. These include published Metra, agency, and industry standards.

If, during design development, it is determined that some element of design cannot meet the applicable basis of design, the designer may recommend a variance from the standard. Variances may occur as a result of geometric constraints or the physical properties of infrastructure to remain as well as many other circumstances. Since Metra must ensure the safety of its passengers and the public, cost alone is generally not a sufficient reason for a variance from the standard.

The recommended variance must be submitted to the Metra PM in writing along with any supporting documentation required to demonstrate why the standard cannot be met. The designer will document the submittal along with any subsequent Metra approval on the Metra Design Variance Form (DVF). The form must explicitly state the issue, the justification for the variance, and the Metra party granting approval of the variance request.

This design manual provides Metra requirements for design and, in some cases, alternate designs that may be used if the requirement cannot be met. These alternate designs are designated by the use of the word “may”. If the designer wishes to use an alternate design, it will document this as a variance using the DVF, providing justification for why the requirement cannot be met.

2.3.8 CONTRACT MANAGEMENT

This section describes some general characteristics of the invoicing process. The process for invoicing for design services will be included as part of the designer's professional services agreement. This will include the contact email used for invoice submittals and the agreed-upon invoice submittal schedule.

Typically, the invoice submittal schedule will be structured either as a monthly or per milestone submittal process. Cost-plus-fixed fee contracts will typically specify regular monthly invoice submittals. These submittals must include all project work that occurred during the invoice period, including subconsultant fees and direct costs incurred. All required supporting documentation must be included as part of the invoice submittal.

For shorter duration contracts or contracts with a limited scope of work, the agreement may specify the conditions upon which invoices may be submitted. Conditions may be tied to specific deliverables or a defined percentage of project completion. The requirements for supporting documentation are still applicable to this invoicing schedule.

3. DESIGNER ROLES, RESPONSIBILITIES, AND TOOLS

This chapter discusses the roles of the Metra Project Manager (PM) and the designer in the project design process, the guiding principles for project design, the roles and responsibilities of the designer, the deliverables to be provided by the designer at each phase of design, and tools for design management.

The designer is responsible for plan development per the deliverable requirements delineated in the design contract. The Metra PM will oversee all aspects of the design. However, it is the responsibility of the designer to ensure the quality and accuracy of the design.

3.1 GUIDING PRINCIPLES OF METRA DESIGN MANAGEMENT

Metra retains consulting firms to provide planning and design services. This manual provides guidance for designers regarding the standard requirements for successful completion of Metra design contracts, including discussion of processes and procedures, design criteria, and deliverables. The goal is to provide clear and consistent expectations to designers engaged in, or seeking to engage in, design services to Metra. To this end, Metra's documented processes will govern project communication and documentation.

Quality is key for all projects on Metra's system. To ensure the delivery of a quality project, the consultant is required to conform to all requirements in the Third Party Contracts Quality Management Plan (TPCQMP).

Through the performance of the processes and tasks outlined in this manual and in the contract documents, the designer shall ensure that the scope, design intent, documentation, and contract requirements are followed to deliver a quality project that shall minimize impacts and improve the experience of the Metra customer. Any design variation requested by the designer should be referenced to the Basis of Design established for the project. The PM will review and respond, in writing, all requests for design variations. The Designer shall use the Design Variance Form.

3.2 PM REQUIRED GUIDANCE

The Metra PM is the designer's primary point of contact for all communication with Metra and outside parties. The PM will coordinate communications between the designer and project stakeholders. The PM is also the authority regarding any project commitments.

In many cases, a project will overlap with or occur adjacent to other projects being performed by Metra or other infrastructure agencies. In such cases, the designer will coordinate its efforts with the management staff of the other project(s) to mitigate the risk of impacts. This coordination will route through the PM, who may be managing multiple Metra projects and who is the Metra point-of-contact with other agencies. At the discretion of the PM, the designer may be directed to communicate as necessary to resolve inter-project issues or concerns that arise during design development. The PM will be copied on any communication with outside parties.

The designer may also be required to coordinate its design efforts with other Metra third-party contractors (TPCs) if the work of these TPCs affects the designer's project. Other Metra TPCs include geotechnical consultants, environmental consultants, surveyors, real estate agents, construction managers, and construction contractors. Communication with TPCs will be conducted through the PM, or, if the designer is directed to communicate directly with the TPC, the PM will be copied on all communications.

As part of developing the project scope, permits required to complete the proposed improvements will be identified. Submittals for permits must necessarily take place after the development of detailed design plans. The designer and PM will cooperatively determine the requirements for each permit submittal and develop the necessary documentation for each submittal package. Permit requirements often involve the input of subject matter experts (SMEs) who must be included as part of the design team.

For some projects, Metra will decide to pursue grants. Grant applications may require effort from the designer including the creation of grant narratives and exhibits. These will be identified in discussion with the PM.

3.3 PRIMARY DESIGNER RESPONSIBILITIES

The designer is responsible for completion of all project deliverables throughout the design phase. The designer must assign competent personnel to perform design and provide oversight of all design activities. The designer must provide adequate resources in equipment, office space, and supplies to meet the contract requirements.

The designer provides comprehensive design related services required for the development of deliverables for proposed Metra improvements. Consultant staff with expertise in the applicable project disciplines are an essential part of the professional services agreement. Ancillary and support services, such as geotechnical engineering, surveying, and environmental/wetland engineering, may also be required. The majority of Metra improvements are unique. Metra projects may involve engineering ranging from Americans with Disabilities Act (ADA) improvements at a station to major track and railroad bridge work. It is the responsibility of the designer to provide SMEs in all fields necessary to complete the project work.

The designer shall control design activities through the design process including the internal auditing of all project-related design documentation. This includes identifying the organizational interfaces between various entities involved with producing, reviewing, and regulating the proposed design. The designer shall be responsible for identifying all Authorities Having Jurisdiction (AHJ) over the project.

The designer shall incorporate Metra-furnished design criteria and all other applicable industry codes and standards, standard specifications, special conditions, and other design requirements into the design documents. The designer is responsible for the identification of all design inputs, regulatory requirements, and performance objectives. The designer shall include in the design documents all applicable inspection and test requirements, drawings, specifications, instructions, details, and standards.

The designer must ensure that all personnel assigned to tasks in the field at the project site have received required safety training and/or certification applicable to field conditions. Personnel must be properly equipped with personal protective equipment (PPE), as required.

The designer is responsible for work performed by subconsultants and ensuring that they meet all project design criteria. This includes providing documentation to demonstrate that work performed by subconsultants has been reviewed by the designer prior to formal submittal of design documents to Metra. All subconsultants must meet all Metra standards for document quality control consistent with the requirements stated in the professional services agreement.

Design documents shall be generated using digital modeling software and compliant with the standards mandated in the contract for design engineering services, including calculations, reports, estimates, supporting documentation, and all technical specifications.

The designer shall conduct internal quality audits on all calculations, drawings, specifications, reports, etc., and submit these quality checks to Metra for review. All records containing quality audits/checks shall be maintained as a contract deliverable.

The designer shall be responsible for the transmittal and tracking of design documents provided to the applicable reviewers and documentation of the submittals, subsequent reviews, comment dispositions, and any resultant design changes. Project records shall clearly track documents resulting from review and design team communication and between the designer and Metra. The designer will ensure that the tracking of drawings and specifications is done in accordance with the Engineering CADD Manual. The designer shall maintain the drawing log throughout the project.

The designer is responsible for promptly notifying the PM regarding all changed conditions that might affect the proposed design. These could include utility conflicts, changes in regulatory requirements, requests or requirements provided by stakeholders, or differing site conditions.

The designer shall meet all requirements for invoicing of the project, including all of Metra's contractual requirements for staff and contract diversity. The designer shall promptly reimburse all subconsultants for services rendered per the professional services agreement once those charges have been reviewed and approved and payment has been received from Metra.

3.4 PROJECT ROLES AND RESPONSIBILITIES

This section describes the roles of other parties involved in the design contract.

3.4.1 INTERNAL RESOURCES

Metra projects have the potential to impact multiple departments within Metra once they are in operation. It is therefore vitally important to include internal stakeholders in project development as early as possible.

The following is a list of typical departments and internal resources that should be included in the design process; this list is not exhaustive and other Metra resources should be included as appropriate:

- Community Affairs and Community Relations
- Strategic Planning and Performance
- Transportation
- Engineering
- Signals
- Mechanical
- Communications
- Information Technology
- Safety and Environmental Compliance
- Police and Security

3.4.2 EXTERNAL STAKEHOLDER MANAGEMENT

The Metra PM will coordinate communications between the designer and external project stakeholders and is also the authority regarding project commitments. The designer, working through the PM, will engage in a defined process of meetings and calls with external stakeholders throughout the project.

Agencies and entities most often included in a project external stakeholder matrix include:

- Rail operators and owners
- Municipalities and counties
- Transit agencies
- Utilities
- IDOT/ISHTA
- Major employment centers

External stakeholders play an important role in design development. Specific impacts and issues may not be apparent until detailed improvement plans are developed and presented for review and comment. The designer will act in cooperation with the PM to identify and resolve any issues and requirements presented by each stakeholder.

3.4.3 ENVIRONMENTAL DOCUMENTATION

Metra will work during the initial project planning stage to determine what environmental requirements apply to the subject project, if any. Some projects are required to follow National Environmental Policy Act (NEPA). If the project is funded with federal dollars or if there are other federal actions, Federal Transit Administration (FTA) and Metra are responsible for ensuring that projects demonstrate compliance with NEPA and all other applicable federal and state laws and regulations. Metra may also decide to develop a project such that it is eligible for federal funding and will opt to follow the NEPA process during the development and design stage, even if there are no federal funds.

The environmental process and preliminary engineering typically occur in parallel. Information required for a complete environmental analysis is often not available until the 30 percent design stage. However, it is Metra's policy to provide a completed environmental report no later than 30 percent design, and design development may be paused, if necessary, at that point to complete the analysis.

Often, Metra will use environmental consultants to perform the analyses required for a project, and these consultants are overseen by the NEPA team. The PM will coordinate between the NEPA team and the designer in determining environmental impacts to the project design. For some projects, Metra may instead choose to let a single contract that combines preliminary engineering and NEPA work under a single consultant, in which case the designer will work with the PM and the NEPA team to complete the work.

An environmental analysis may examine the project's impact to the following:

- Air quality
- Land use and zoning
- Traffic and construction impacts
- Historic resources
- Noise and vibration
- Parks and recreation areas
- Hazardous materials
- Wetlands, floodplains, threatened and endangered species

Depending on the findings from this analysis, the project scope may be expanded or modified to mitigate potential negative environmental impacts. Additional permitting may be required. All changes to scope will be coordinated with the PM. This coordination will involve a determination of changes to schedule and cost.

3.4.4 DESIGN REVIEWS

Reviews will occur throughout the design process, typically at the conclusion of each design stage (10 percent, 30 percent, etc.), but also at other key times in design development. Reviews will include all submittals from the designer. Design reviews will be coordinated through the Metra PM, who will identify reviewers for each of the design stages. Reviewers will include but are not limited to internal Metra resources, external stakeholders, contractors, and the construction management team.

Interdisciplinary Reviews (IDR) are conducted for design packages that involve work by more than one discipline. IDRs are a quality control function performed by discipline practitioners to ensure formal and documented technical review. This is especially important for complex projects.

A constructability review may be performed to anticipate and identify challenges to the actual construction of the project as the project moves through the stages of design. It infuses construction knowledge into the design process. Constructability reviews are also used to assess the ability to receive successful bids once the project is ready to go to construction. A constructability review will verify that the design and the specifications are clear and easily understood so that contractors can bid on the project in a way that allows for meaningful comparisons. The review will also assess the ability to construct the project, including the following:

- Practicality of achieving specified tolerances, access needed to properly install or construct work elements, and conflicts in construction sequencing
- Adequacy of information on the plans and specifications to not only construct the work but also for future maintenance, rehabilitation, and operational needs
- Survey verification and consistency with environmental mitigation and permitting requirements
- Other aspects that can affect the construction, such as site restrictions, economics of the proposed construction, availability of materials, construction equipment requirements, local workforce availability, and construction sequencing

In addition to the above reviews, a review involving experts on Metra's operations and force account labor shall provide a review no later than the 90 percent design stage. The goal of the operations review is to ensure that Metra can support the phasing plan required for construction of the project. The goal of the force account review is to determine which aspects of the project can and should be executed by Metra's own forces, as opposed to being subject to the bid process.

Section 3.6.7 provides more detail on tools used during the review process.

3.5 DESIGN DELIVERABLES

The designer is responsible for a number of deliverables throughout its contract with Metra, including milestone plans, specifications, and estimates (PSE). This section summarizes typical deliverables at typical milestones. The exact deliverables required of the designer may differ based on the requirements of the designer's contract. The milestones for delivery may also differ based on the designer's contract. All deliverables will be submitted to the PM on the approved schedule.

All documentation must be submitted under the proper transmittal cover sheet per the TPCQMP, including a description of the submittal, date, and project information. CADD model files will be submitted using the platform required in the design contract.

PSE documents are expected to become progressively more detailed as the project progresses, and contingencies should be reduced as the work becomes increasingly clearly defined. They shall adhere to all applicable Metra design criteria, including but not limited to the standards, specifications, and publications outlined in this manual, and will include detail consistent with the Engineering CADD Manual. Each subsequent round of plan development must reflect review comments made previously.

3.5.1 TEN PERCENT CONCEPTUAL DESIGN

Work during the 10 percent conceptual design phase may be performed by Metra. However, design consultants may be asked to provide the following:

- Develop design criteria
- Develop and analyze alternatives
- Identify regulatory and environmental requirements

Project scopes can vary greatly, but design deliverables resulting from conceptual design will typically include the following minimum level of detail:

- Plans
- A topographic survey of existing conditions (if required prior to 30 percent)
- Proposed horizontal alignment
- Proposed rail design
- Vertical profile adjustment
- Construction phasing and Maintenance of Traffic
- Specifications
- List of specifications
- Estimates
- Estimated construction cost
- Project Definition Report (to begin the environmental process)
- A description of proposed improvements
- Proposed bridge structure(s) including bridge type study, if applicable

- Hydraulic considerations

3.5.2 THIRTY PERCENT PRELIMINARY DESIGN

Submittals for the 30 percent design stage will completely reflect all comments from the review of the 10 percent plan submittal (if any) along with further design development and ongoing coordination. At the 30 percent preliminary design stage, design consultants may be asked to:

- Conduct site visit(s)
- Identify any fatal flaws
- Further define the scope of the improvements
- Perform a constructability review
- Develop a detailed project schedule (Baseline Schedule)
- Develop a detailed cost estimate (Baseline Cost Estimate)
- Finalize design criteria
- Determine land acquisition needs
- Develop a permit matrix

Plan preparation during the 30 percent design phase can include, but is not limited to, the following tasks:

- Site visits
- Geotechnical study
- Topographic survey (unless performed during 10 percent)
- Determination of design requirements (building on requirements developed during 10 percent, if performed)
- Evaluation of right-of-way needs based on alternatives
- Identification of utility and stormwater management impacts
- Identification of current and proposed signaling and PTC needs, including maintenance strategies during construction. The designer is generally not

required to perform signal or PTC design but is required to coordinate its design with representatives from appropriate Metra departments.

- Special protection requirements for existing railroad facilities and utilities
- Coordination with environmental analysis
- Existing and proposed plan development
- Preparation of budget estimates and schedules suitable for the purposes of planning. Costs for similar projects may be analyzed as part of this process.
- Development or revision of the preliminary scope of work, which shall describe stakeholder functional requirements
- Performance of analyses (e.g., alternatives analysis, cost-benefit analysis, operating budget impact analysis) required to support the decision-making process
- Exploration of innovative contracting methods, design ideas, and construction approaches
- Initial project construction schedule
- Maintenance of Traffic alternatives
- Community and governmental outreach

3.5.3 SIXTY PERCENT FINAL DESIGN

Submittals for the 60 percent design stage will completely reflect all comments from the review of the 30 percent plan submittal along with further design development and ongoing coordination. Plan deliverables at the 60 percent final design stage can include, but are not limited to, the following:

- Updated PSE
- General notes
- Summary of quantities
- Refinement of the suggested construction schedule
- Performance of a constructability review

- All roadway/track geometry and site layout including vertical and horizontal alignments
- Typical cross-sections
- Cross-sections
- Existing and proposed drainage
- Maintenance of Traffic plans
- Structural TSL Drawings
- Utilities
- Lighting, signage, and markings
- Buildings – architectural, electrical, mechanical, plumbing
- Service connections
- Erosion control
- Landscaping

Specifications shall include all current Metra contract language, Metra special provisions that have been developed for required pay items, and agency and stakeholder specifications related to inserted work. The designer shall provide a specification reference for all itemized work items. Specifications for lump sum items must contain language applicable to all work covered by that item; for example, building specifications must provide for interior and exterior construction, electrical, plumbing, lighting, etc.

The designer will prepare and submit a schedule of costs representing a construction cost estimate for all work included in the 60 percent plan submittal. The estimate shall provide for a unit cost for all itemized pay items and an extended cost for each based on the calculated quantity. The estimator shall provide tabulation spreadsheets to support the estimated quantities. Information shall include the plan location(s) and limits where applicable work is shown, and all other calculations used to determine quantities.

Lump sum items will also have a unit cost. However, the estimator must provide a cost analysis for the item that breaks out specific tasks included as part of the work for the item. The tasks should be quantified, as applicable.

3.5.4 NINETY PERCENT PRE-FINAL DOCUMENTATION

Submittals for the 90 percent design stage will completely reflect all comments from the review of the 60 percent plan submittal along with further design development and ongoing coordination. This submittal shall be detailed and must be sufficient for stakeholder and constructability review. Pay items and quantities should be computed to allow for a detailed and accurate construction cost estimate. All subconsultant work must be completely represented in the plans. In addition to those elements included in the previous stage, the following shall be included, as applicable:

- Final building plans
- Complete and sealed structural plans
- All schedules of work including all earthwork tabulations.
- Plats of right-of-way and easements
- Alignments and ties
- Roadway and track alignment details
- Final grading plans
- All Metra and agency standards and details
- Maintenance of traffic plans and details including all impacts to rail operations.
- Pavement elevations for roadways and parking lots
- Final marking and signing plans
- Site fencing and other site security details
- Final erosion control details
- Final landscaping plans
- ADA details
- Soil borings

In addition to all material contained in the 60 percent submittal, the 90 percent specifications shall include the following:

- Final construction milestones including completion and interim completion requirements and liquidated damages, as applicable
- All Metra diversity requirements
- Status of utilities with all contacts included and up to date
- An updated estimate of costs will be submitted. Detailed quantity calculations must be included with this submittal.

3.5.5 PROCUREMENT AND PERMITTING DOCUMENTS

Once an advertisement and bidding schedule is finalized, the designer shall submit the following bidding documents to Metra:

- Contract bid plans
- Contract bid specifications
- Schedule of prices
- Engineer's estimate
- All required data to be made available to prospective bidders, for example, geotechnical reports
- If applicable, All CADD, GEOPAK, and 2-D, and 3-D engineered model files

Once the bidding phase has ended, the designer shall incorporate all changes made by addenda, if applicable, into an Issued for Construction (IFC) set of documents.

All IFB and/or IFC drawings, including any revisions, shall have the seal of the Professional Engineer(s), Structural Engineer(s), etc., as required by the scope of work, contractual documents, and state regulations for professional engineers and structural engineers.

The designer will be required to submit other supporting documentation related to the final design package as part of its closeout submittal.

3.5.6 PROJECT IMPLEMENTATION

As part of its bid package deliverable, the designer will have prepared an engineer's estimate (EE) for the contract work items. When bids are received, they may be directed to the designer for bid analysis. Bid analysis will involve a comparison of the bidder's prices to those made in the EE. The designer will note any deviation between bid and estimated prices and create a report to the PM noting its findings. The report will include observations regarding the nature of the pay item(s) in question and the amount of deviation from the estimate.

The designer shall respond to requests for information (RFI) that may be generated during the construction phase. RFIs may be generated by the contractor, CM, or the PM and will be directed to the designer by the PM. All documentation concerning an RFI must follow the Metra document control procedures. A response to the RFI must be provided within the timeframe specified in the contract. The designer is required to evaluate the RFI and direct any response to the PM in writing for routing back to the source of the inquiry. The designer must properly document all plan, specification or quantity changes associated with its response. Evaluation of an RFI may involve meetings and site visits as part of the evaluation.

If specified in the construction contract documents, a supplier or contractor may be required to submit shop drawings. Shop drawings may be routed by the PM to the designer for its review. The designer may be required to review the drawings to determine compliance with the contract specifications, standards, details, and other specified criteria. If a review is performed, the designer will respond in writing to the PM stating its acceptance or rejection (with justification) of the drawings.

3.6 DESIGN MANAGEMENT TOOLS

This section describes the tools that will be used by the designer to assure product quality, maintain ongoing and productive communications, and provide for a transparent and responsive design development and review process. The designer will be expected to use Metra applications for drawing creation, submittals, and archiving as specified in the design contract and as directed by the PM.

3.6.1 QUALITY MANAGEMENT

The designer has the primary quality control responsibility for services provided to Metra as part of its contract. Refer to the TPCQMP for all quality requirements.

The designer shall perform a quality control check for all calculations, drawings, specifications, reports, etc. prior to their submittal to Metra for review and/or final project records. The designer shall document performance of this quality control check and submit documentation along with its deliverable. Design activities are controlled through review, verification, and validation processes throughout all phases of design along with internal audit of project-related documentation.

3.6.2 SCHEDULE MANAGEMENT

Before the start of work, the designer shall submit a work schedule that details the schedule for completion of all contract milestones and all other submittals defined by the design contract. The PM shall provide written approval once the schedule is satisfactory.

This master schedule shall be maintained and updated by the designer throughout design development. Dates and durations for required subconsultant submittals, review periods, permit and regulatory submittals and advertisement, bid review, and construction support services must be included in the master schedule.

If any changes to the master schedule are required, the designer must discuss proposed changes with the Metra PM and obtain approval for the revised schedule.

3.6.3 STAKEHOLDER MANAGEMENT

The Metra PM will coordinate all communications between the designer and project stakeholders and is the authority regarding any project commitments. The PM may choose to delegate responsibility for portions of these communications to the designer, but in all cases the PM must be kept informed.

Metra projects are required to develop and adhere to a stakeholder matrix. This matrix is maintained by the designer during the design phase of the project in coordination with the PM.

3.6.4 COMMUNICATIONS PLAN

The designer shall be in regular communication with the PM and other key parties throughout the project. Each project will have a communications plan that is developed during the project planning phase; the designer shall be responsible for maintaining and updating the communications plan during the design phase. The plan, as approved, shall be followed throughout the duration of the project.

This plan shall include the following elements:

- Reference to internal and external stakeholders
- Reference to members of the project design team
- A schedule for:
    - Project kickoff meeting

  - Regular project progress meetings
  - Regular project check-in meetings
- A process for documenting all other design development meetings
- A process for documenting phone logs, other electronic communications, physical submittals, and all other transmittals
- A process for submitting documents
- A process for document review
- A process for invoicing and change requests
- A process for documenting audits and quality reviews
- A process for documenting communications after project letting
- The project closeout process

3.6.5 DOCUMENT MANAGEMENT

The designer will complete all design in accordance with the requirements of its contract, as well as the requirements of the Engineering CADD Manual. CADD model files will be submitted using the platform specified in the design contract.

The designer shall maintain a drawing index throughout the project, with the title and number of each drawing. The drawing index will be included with each design submittal.

See the Engineering CADD Manual for all requirements concerning plan drawing revisions.

3.6.6 CADD MANAGEMENT

For drawing production, the designer is required to follow all requirements set forth in the Engineering CADD Manual. CADD files will be transferred to Metra in the correct file format at the milestones specified in the design contract.

3.6.7 DESIGN REVIEWS

Required design reviews will be defined in the contract scope for each project. Reviews can be tied to plan development milestones or related to other, specific items or phases of work. Other deliverables such as technical reports and memoranda may also be reviewed separately.

The PM will identify all tools that will be used by the designer to facilitate project reviews. Design reviews shall generally be performed through a Bluebeam session following the process outlined below.

Once the PM has determined that all design document submittal requirements have been met, they will initiate creation of an online review session. The Bluebeam session will be sent out to individuals assigned for review.

During the review, Metra and other specified parties will provide comments on the submittal within the Bluebeam session. At the end of the designated review period, the PM will review all comments to determine if the review is complete and will then prioritize comments to decide which require disposition by the designer.

After review by the PM, the comments from the Bluebeam session will be transmitted to the designer. The designer's disposition of comments will be made in the Bluebeam review session. The PM will use this to track the disposition of comments. Dispositions will be reviewed by the PM and marked as "Addressed", if resolved. Comments requiring further discussion or clarification may be resolved through follow-up communications with the reviewer and/or at a scheduled Design Milestone Review (DMR) meeting.

At the conclusion of comment disposition, the PM will export comments and dispositions to a Microsoft Excel (.xlsx) file in Metra's Disposition of Review Comments (DORC) Log. A log of the Bluebeam session with all documents and comments will be stored in Metra's records.

In addition to those comments received in the Bluebeam review, the designer shall document any comments received during any live review session. The designer will take minutes of any live review sessions to ensure that all comments are documented for resolution. These comments and dispositions will also be documented in the Comments will be documented in the DORC log.

All comments must be addressed, and a disposition documented and provided to the PM. If the designer has any concerns regarding disposition of comments collected during the review process, it is the designer's responsibility to discuss these concerns with the PM as soon as possible to clearly communicate its concerns regarding the comments in question.

A log of the Bluebeam session with all documents and comments will be stored in Metra's records.

3.6.8 ESTIMATING, BUDGETS AND COST MANAGEMENT

As design progresses, the designer will develop construction cost estimates associated with the proposed work. These estimates will become increasingly detailed as final design progresses. A contingency will be added to each cost estimate. This contingency will decrease with progressive milestone submittals and will reduce to zero for the bid documents. The cost estimate is considered part of the milestone submittal package. This requirement will also be included in the contract for design services.

The designer will structure the cost estimate in consultation with the PM and consistent with the nature of the bid pay items to be included in the bid documents. The costs for "Lump Sum" items will be determined through a breakdown of work associated with the item. This can include sub-quantities for specific work, breakdown by trade, material costs, labor costs, storage and transport costs, and all other factors related to specific work that can be quantified. The sources of all costs reflected in the estimate must be clearly identified as part of the estimate. Verifiable and recognized industry price/cost data shall be used and clearly referenced as part of the estimate.

In keeping with the design services contract, the designer will submit cost estimates and the associated quantity calculations as part of the project deliverables. As-bid quantities, calculations, and cost estimates shall be submitted by the designer as part of their project closeout.

All cost estimates developed throughout the design process shall be compared to the concept estimate and/or construction cost budget defined for the project. The designer shall make all reasonable efforts to maintain project costs in keeping with the concept estimates. Deviations from these previous estimates must be communicated to the PM along with all data and descriptions that support the cost increase. These can include increases related to scope changes, design refinements or technology upgrades, changing standards, cost inflation, or project delays.

3.6.9 CHANGE CONTROL AND CHANGE MANAGEMENT

During development of the design services contract, both the scope of design services and the scope of construction will be discussed and documented. These scopes will be based on determinations made in preliminary design, the nature of the work required, and anticipated design/construction schedules. The designer will document, in writing, all changes to the proposed project scope resulting from design development. The designer will submit a description of the change to the PM along with all supporting documentation and impacts to the project schedule and cost. This submittal shall be made and approved prior to proceeding with work impacted by the change. Design costs resulting from unapproved changes will not be reimbursed by Metra.

All changes should also be related to previously documented project risks as posted to the project risk register (see Section 3.6.10).

The designer shall be responsible for documentation of all changes made to IFB and/or IFC documents resulting from addenda. These do not include as-built drawings, which will be submitted by the construction contractor.

3.6.10 RISK IDENTIFICATION AND MANAGEMENT

As scope changes are an intrinsic part of project design development, Metra requires the creation and maintenance of a project risk register in its design management process. This document will be developed by the Metra PM and maintained throughout the duration of the project. The designer will be required to provide necessary information to the PM in order to keep the register updated. Key information found in the register includes:

- Identification of potential risks/changes to project budget and schedule
- A detailed description of the risk
- Quantification of project impacts associated with the description
- Mitigation measures and alternatives
- A detailed description of project impacts resulting from the changes or mitigation measures.

The designer has the responsibility to inform the PM of any recognized project schedule/budget risks in a timely manner and follow up that notification with all information required to describe and quantify the risk.

The description of risk must be closely tied to both the detailed project schedule and project budget. Impacts to both are to be quantified as accurately as possible. Consideration must also be given to the Metra construction program to determine impacts to adjacent or follow-up construction projects as well as specific stakeholder and regulatory requirements.

A presentation of mitigation measures and/or alternatives will be developed after discussion with the PM along with any other communication with stakeholders and regulatory authorities. Depending on the nature of the risk and potential impacts to the project, a determination of project scope change may involve consultation and direction from multiple Metra in-house stakeholders. In all cases, the designer must provide appropriate information to the PM to inform decision-making and accurately update the risk register.

At the end of this process, the designer shall provide all follow-up information, plan and specification revisions, calculations, and communications that describe the actions taken to resolve the risk.

4. TRACK

4.1 OVERVIEW

This section includes design criteria that establish the minimum standards for the design and construction of track on the Metra system. The design criteria are based on best industry practices and meet or exceed all regulatory requirements.

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of a conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

4.2 STANDARDS, CODES, AND REGULATIONS

Track design, construction, and maintenance shall conform to the latest edition of all applicable standards, codes, and regulations, including the following:

Code, Standard, Reference, or Guideline
Federal Railroad Administration
Title 49 Code of Federal Regulation Part 213, Track Safety Standards
Federal Transit Administration
AREMA Manual for Railway Engineering
Metra Engineering Department Standard Drawings

4.3 DESIGN SPEEDS

Design speeds shall be as stated in Metra's System Special Instructions, latest edition, for the designated district. Maximum system design speed shall be used for design purposes if possible. Track alignment shall be based on FRA Class 5 track with a maximum authorized speed of 90 mph.

4.4 TRACK STATIONING

Track stationing shall be consistent with Metra Signal Department stationing. Track stationing shall be continuous along the length of all main tracks. Stationing shall begin at the point of switch of a turnout, continue to the point of intersection, then follow the diverging route of the turnout.

4.5 TYPICAL SECTIONS

See Drawing 2001 for the typical track section.

4.6 TRACK GEOMETRY

The purpose of the geometric design criteria is to ensure a safe, efficient, and comfortable ride for passengers.

4.6.1 HORIZONTAL GEOMETRY

See Section 5.3.4 for track center spacing requirements. Curves shall be designed for maximum system track speed.

4.6.1.1 TANGENT LENGTHS

Minimum tangent lengths between horizontal curves shall be equal to three times the maximum design speed, in miles per hour, or 100 feet, whichever is greater.

Tangent lengths between points of switches of turnouts shall be a minimum of 100 feet.

Tangent lengths between points of switches of turnouts and curves, platforms, or grade crossings shall be a minimum of 100 feet.

Tangent lengths between horizontal curves and platforms or grade crossings shall be a minimum of 100 feet.

4.6.1.2 CURVE GEOMETRY

Curvature is limited to a maximum of 12 degrees in all mainline and yard trackage.

Every effort shall be made to keep mainline curvature under four degrees. Curvatures exceeding four degrees shall be documented as a design variance.

Conventional high carbon continuous welded rail (CWR) is limited to mainline maximum curvature of eight degrees. Use head hardened, heat treated, or alloy rail for curvature in excess of eight degrees.

Track spacing shall be adjusted for curvature. See Section 5.3.4.

4.6.2 SUPERELEVATION

Spirals are required to transition both curvature and superelevation. Spirals shall be used on mainline curves between tangents and all curves and between any two parts of a compound curve.

Superelevation shall be tapered uniformly in the spiral transitions between curves and tangents. In no case will the rate of change exceed one inch in 50 feet. The standard length of spiral provides a change of not more than one inch in 62 feet. At speeds above 50 mph, spiral lengths shall be increased per E.S. 2302. The tables compute the spiral lengths based upon the distance to develop the actual superelevation (Ea) and the unbalance lateral forces (Eu).

All mainline curves and curves in passing sidings shall maintain a minimum of one-half inch (1/2") of superelevation.

Maximum superelevation on a curve shall not exceed 3.5 inches.

Turnouts, industry sidings, and yard tracks are not permitted to have superelevation in their curvature.

Equilibrium elevation is that elevation which exactly overcomes the effect of negotiating a curve at a given speed for any given degree of curvature such that the resultant component of the centrifugal force and weight of the car falls in a direction perpendicular to the plane of the track.

Unbalance in elevation is that amount of elevation greater or less than equilibrium elevation for any given degree of curvature or speed. Metra passenger equipment can safely and comfortably negotiate curves with as much as three inches (3") of unbalance. Superelevation is typically set for maximum authorized passenger train speeds.

Superelevation is achieved by maintaining the inner rail of the track on curves and raising the outer rail to meet the specified superelevation.

Track spacing shall be adjusted for superelevation. See Section 5.3.4.

4.6.3 VERTICAL GEOMETRY

Vertical curves shall be designed per the recommended practices in AREMA MRE Section 5.3.6.

$$L_{VC} = \frac{D * V^2 * K}{A}$$

Where

A = vertical acceleration in ft/sec/sec

D = absolute value of the difference in grades expressed as a decimal

K = 2.15 conversion factor to give L_{VC} in feet

L_{VC} = length of vertical curve in feet

V = velocity of the train in miles per hour

The recommended vertical acceleration (A) is selected based on the type of operations and is the same for both sag and crest vertical curves.

Freight: A = 0.10 ft/sec/sec

Passenger: A = 0.60 ft/sec/sec

Vertical curves are not permitted in the platform area, within turnouts, or within other special trackwork. Vertical curves shall begin or end no less than 100 feet from the ends of platforms and no less than 25 feet from the ends of turnouts or other special trackwork.

The minimum distance between vertical curves shall not be less than 100 feet.

4.7 TRACK MATERIAL

4.7.1 GEO-TEXTILE FABRICS

Geo-textile fabrics shall comply with AREMA MRE Chapter 1, Part 10. Geo-textile fabrics used in grade crossings funded by the Illinois Department of Transportation (IDOT) shall also comply with IDOT standards.

4.7.2 SUB-BALLAST

Sub-ballast shall comply with AREMA MRE Chapter 1, Part 2. For permanent construction, six (6) inches of CA6 virgin stone compacted to 95 percent maximum dry density shall be used. Sub-ballast is generally placed by the contractor. Sub-ballast is not used on bridges.

4.7.3 BALLAST

Ballast shall comply with AREMA MRE Chapter 1, Part 2. Ballast is generally placed by Metra force account labor.

To support stray current and corrosion control efforts, nonporous, well-drained, high-resistivity ballast material shall be used.

4.7.4 CROSS TIES

Cross ties shall be timber ties and shall comply with AREMA MRE Chapter 30. Cross ties are generally installed by Metra force account labor.

4.7.5 SWITCH TIES

Switch ties shall comply with AREMA MRE Chapter 30. See Drawings ST-20-136, ST-15-136, ST-10-136, ST-10-115Y, ST-10-115ML, ST-8-115, and ST-6-115.

4.7.6 TIE PLATES

The rail fastening assembly shall consist of conventional rolled steel tie plates with shoulders and punched with square holes. See AREMA MRE Chapter 5, Part 1, for details.

4.7.7 RAIL

All rail shall comply with AREMA MRE Chapter 4, Part 2.

On the following lines, 136RE rail shall be used for mainline track:

- Rock Island (between Blue Island and Joliet only)
- Milwaukee District

On the following lines, 115RE rail shall be used for mainline track:

- Rock Island (between La Salle Street and Blue Island only)
- Southwest Service
- Metra Electric District

For yard track on all lines, 115RE shall be used.

Head hardened rail shall be used in curves greater than 3 degrees.

CWR shall be used on all mainline and yard track. For other rail joining methods, refer to AREMA MRE Chapter 4, Part 3.

4.7.8 COMPROMISE AND TRANSITION RAIL

Compromise rail shall be used between Metra mainline and industrial tracks of different rail sections.

Transition rail shall be used between new and worn rail. See Drawings TR-001, TR-002, TR-003, and TR-004.

4.7.9 SPIKING

Cut spikes shall be used for standard rail fastening. See AREMA MRE Chapter 5, Part 2, for details. Spike patterns for tangent and curved track are shown in Drawing TM-007.

4.7.10 RAIL ANCHORING

Rail anchoring shall be in accordance with the Metra CWR Plan.

4.7.11 RESILIENT FASTENERS

A resilient fastening system shall be used in all new construction of switches and grade crossings. Standard fastening shall be used for maintenance of existing track constructed with cut spikes.

4.7.12 RAIL WELDING

New mainline and yard rail shall be CWR and shall be installed in accordance with the procedures in Section 3 of the Metra CWR Plan.

4.7.13 RAIL JOINTS

When ties are used in conventional bolted track or at the ends of CWR, care shall be taken to ensure that the juncture of two rails is properly supported and fastened. The magnitude of impacts on a tie placed under the juncture of two rails can be destructive to the rail seat and fastenings.

Special considerations may be required when ties are installed within the limits of insulated joints or special trackwork such as turnouts and crossovers.

Insulated joints shall be installed as required by the signaling system.

4.7.14 SWITCH HEATERS

All mainline switches shall be furnished with switch heaters, either electric or forced air. The type to be used will be determined by the Metra Signal Department.

4.7.15 EMBEDDED TRACK

Design embedded track in accordance with AREMA Chapter 12, Part 8.

4.7.16 DIRECT FIXATION TRACK

Design direct fixation track in accordance with AREMA Chapter 12, Section 4.9

4.8 SPECIAL TRACKWORK

4.8.1 GENERAL

Special trackwork refers to the trackwork units that are used for tracks to converge, diverge, or cross each other. Special trackwork includes turnouts, crossovers, and track crossings. All special trackwork design shall be based on Metra Standard Drawings.

4.8.2 SPEED THROUGH SPECIAL TRACKWORK

	Diverging Move Maximum Authorized Speed	
Turnout Size	**Passenger**	**Freight**
No. 8	10 mph	10 mph
No.10	10 mph	10 mph
No. 15	25 mph	25 mph
No. 20	40 mph	40 mph

Passenger train design speeds for turnouts and crossovers are based on three inches of unbalanced superelevation for curves without spirals. Speeds are according to Metra's System Special Instructions.

4.8.3 SPECIAL TRACKWORK PLACEMENT

Consideration for placement of switch machines and switch stands, location and visibility of control signals, and easy access for operation and maintenance shall be given when locating special trackwork.

Points of switch shall be located on tangent track and shall meet the following requirements:

- 100 feet minimum from point of switch (PS) to horizontal or vertical curves
- Less than 100 feet from horizontal curves without superelevation is permitted with approval from the Chief Engineering Officer
- 100 feet minimum from PS to the edge of road crossings (including sidewalks)
- 50 feet minimum from PS to insulated joint
- 50 feet minimum from PS to opposing point of switch
- Crossovers shall be located in parallel tracks only
- Standard crossovers shall be of 15 feet track center for new construction, or match existing mainline track centers

The use of special trackwork such as equilateral turnouts and slip switches shall require the approval of the Chief Engineering Officer. Design for conditions listed below shall require the Metra's approval:

- Crossovers in non-parallel tracks
- Crossovers with track centers more than 15 feet
- Turnouts in curves
- Turnouts or crossovers in paved areas

4.8.4 DIAMOND CROSSINGS

For the replacement of existing diamonds where the speed of the train on the secondary track is set to slow speeds (10 mph or less), flange bearing crossing frogs, also called one-way low speed (OWLS) frogs are preferred. The use of an OWLS frog will be negotiated between Metra and the other railroad. HMA underlayment may be used for any diamond replacements, provided the work can be coordinated with Metra Operations.

4.9 TRACK APPURTENANCES

4.9.1 SWITCH STANDS

In yards, low ergonomic switch stands are used. On the mainline, high stands are used. The proper type to use shall be determined during design and approved by the Chief Engineering Officer.

4.9.2 DERAILS

Derails are required on tracks leading to mainline track to prevent unwanted movement or fouling of the main track. Derails are also placed in yards based on the requirements of the Mechanical Department.

4.9.3 GUARDRAIL

Where guardrail is already installed, it shall be replaced in kind.

Inner guardrails shall be placed at the following locations:

- All spans where structural steel is exposed and is subject to structural damage by derailment
- On individual spans that are 100 feet long or longer
- On structures where the total structure is 800 feet long or longer
- On spans where one span crosses a waterway that is 15 feet or more in depth

For additional details reference AREMA MRE Chapter 7.

4.9.4 BUMPING POSTS

Bumping posts shall be installed at the end of each stub-ended track. A minimum distance of three feet shall be provided from the train stopping position to the face of the bumping post, if space permits, 10 feet shall be provided. The face of the bumping post shall be located a minimum distance of eight feet from the end of the track.

Bumping posts on yard tracks shall be Western-Cullen-Hayes model WAC or approved equal. The bumping post shall be fastened to the rail.

Bumping posts on terminal tracks are significant structural elements that must be custom designed for the terminal project. These will be subject to additional design criteria by Metra.

Coordinate with Metra Signals to ensure that dead-ended tracks have insulated joints installed to isolate bumping posts or similar devices that are electrically grounded, as needed. Insulated joints shall be located so that a vehicle will not bridge the insulators.

4.9.5 RAIL EXPANSION JOINTS

Rail expansion joints may be used to reduce the likelihood of rail breakage, relieve radial forces where they cannot be feasibly resisted, or facilitate track maintenance where track and fastenings must be disturbed.

The provisions of AREMA MRE Chapter 15, Section 8.3.4.3 “Number and Positioning of Rail Expansion Joints on Bridges with Continuous Welded Rail” shall apply on non-ballasted bridges with CWR.

Where rail expansion joints are used in track having bolted rail joints, consideration shall be given to the possibility and consequences of bolted joint failure and excessive longitudinal movement of rail through the expansion joint. All such installations shall require approval by Metra.

See Drawing ST-136EXPJT.

5. CLEARANCES

5.1 OVERVIEW

This section includes design criteria that establish the minimum standards for clearances on the Metra rail system. The design criteria are based on best industry practices and meet or exceed all regulatory requirements.

Deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of a conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

5.2 STANDARDS, CODES, AND REGULATIONS

Clearances used in track design shall conform to the latest edition of all applicable standards, codes, and regulations, including the following:

Code, Standard, Reference, or Guideline
Federal Railroad Administration
Title 49 Code of Federal Regulation Part 213, Track Safety Standards
Illinois Commerce Commission Administrative Rules, Title 92: Transportation
AREMA Manual for Railway Engineering
Metra Track Maintenance, ROW, and Structures Engineering Instructions
Metra Engineering Department Standard Drawings
Host Railroad Design Standards and Standard Drawings

5.3 LINES MAINTAINED BY METRA

See Chapter 7 Bridges and Structures, Section 7.7.4 Clearances, for additional clearance requirements related to structures.

5.3.1 HORIZONTAL CLEARANCE

5.3.1.1 BASE CLEARANCES

The minimum base horizontal clearance shall be 8'-6" from track centerline. Wayside elements have different minimum horizontal clearance requirements, to include:

- Highway bridge abutments and piers
- No less than 9'-0" from the centerline of the nearest track
- Crash walls are required for clearances less than 25'-0"
- Utility poles
- Locate as close to the right-of-way line as possible, but no less than 13'-6" from the centerline of the nearest track
- See Metra's Pipeline Manual and Wireline Manual for additional restrictions on placement (Real Estate & Leasing | Metra)
- Switch stands and related equipment
- Main tracks
- Main track switch stands exceeding 2'-10" in height and not exceeding four feet in height shall have horizontal clearances of no less than eight feet from the centerline of an adjacent track to the nearest part of the switch stand above the base of rail
- Main track switch stands exceeding four feet in height shall have horizontal clearances of no less than 8'-3" from the centerline of an adjacent track to the nearest part of the switch stand above the base of rail
- Subsidiary tracks
- Subsidiary track switch stands exceeding 2'-10" in height and not exceeding four feet in height shall have horizontal clearances of no less than 7'-6" from the centerline of an adjacent track to the nearest part of the switch stand above the base of rail
- Subsidiary track switch stands exceeding four feet in height shall have horizontal clearances of no less than eight feet from the

centerline of an adjacent track to the nearest part of the switch stand above the base of rail

- Signals
- See Drawing 1003 “Standard Clearances for High Mast Signals”
- Dwarf signals: No less than 7’-6” from the centerline of an adjacent track to the center of the dwarf signal if 2’-10” or less above top of rail.
- High mast signals: No less than 12’-6” from the centerline of an adjacent track to the center of the high mast signal.

5.3.1.2 CLEARANCE COMPENSATION

Minimum clearances shall be compensated for track curvature and superelevation to provide additional clearance to obstructions under these track geometry conditions.

At curves, increase the required horizontal clearance, to both the inside and outside of the curve, by 1-1/2” for each degree of curvature, represented by the following formula:

$$C_{HC} = 1.5 * D_c$$

Where C_{HC} = compensation to horizontal clearance for track curvature, inches

D_c = degree of curvature

For superelevated tracks, on the low-rail side of the track, increase the required horizontal clearance by:

$$C_{HS} = \left(\frac{h}{5}\right) * E_a$$

Where C_{HS} = compensation to horizontal clearance for superelevation, inches

h = height of obstruction above TOR, feet

E_a = applied superelevation, inches

5.3.1.3 SPECIAL ISSUES

On tangent track adjacent to curved track, clearance compensation for curvature and superelevation shall be extended on the tangent portion to account for the trucks at either end of an individual rail vehicle being located on curved and tangent track.

Refer to AREMA MRE Chapter 28, Section 1.1, for clearance compensation on tangent adjacent to curves. In summary, on tangents, the amount of additional horizontal clearance required is reduced with increasing distance from the curve. The table that follows is an excerpt from AREMA MRE Table 28-1-1 and illustrates the clearance to be provided.

Distance from Obstruction to Curved Track (feet)	Increase per Degree of Curvature (inches)
20	1-1/2
40	1-1/8
60	3/4
80	3/8
20	1-1/2

A comparable tapering of the additional horizontal clearance required due to superelevation shall be included using a similar technique to the above.

5.3.1.4 YARD AND OTHER NON-MAINLINE AREAS

Clearances within yards shall follow the same principles as mainline track. Consideration shall also be provided for servicing of railcars within yards and walkways and/or cart paths shall be provided where necessary.

5.3.1.5 STATION PLATFORMS

Station platforms shall comply with the clearance requirements discussed in Chapter 8, Stations and Parking.

5.3.2 VERTICAL CLEARANCE

5.3.2.1 BASE CLEARANCES FOR OVERHEAD STRUCTURES

The base vertical clearance for overhead structures shall be 23'-0" on diesel-operated districts and 26'-0" on the Metra Electric District. See Drawings 1001 and 1002.

5.3.2.2 BASE CLEARANCES FOR SIGNALS

The base vertical clearance from top of rail to the bottom of a signal bridge shall be 25'-0". See Drawing 1004.

5.3.2.3 CLEARANCE COMPENSATION

The base vertical clearance shall be compensated for vertical track curvature and superelevation.

At vertical curves, increase the required clearances by the following formula:

$$C_{VC} = \left(\frac{1}{8}\right) * 0.90 * |G_2 - G_1|$$

Where C_{VC} = compensation to vertical clearance for vertical curve, feet

G_1, G_2 = entrance and exit grade of vertical curve

Where the horizontal alignment of the track includes superelevation at an overhead obstruction, increase the required vertical clearances by the following formula:

$$C_{VS} = 1.43 * E_a$$

Where C_{VS} = compensation to vertical clearance for superelevation, inches

E_a = applied superelevation, inches

5.3.2.4 SPECIAL ISSUES

For vertical clearances above track for overhead electric or other wires, refer to Metra's Guidelines for Utility Installations, Part 1 – Wire Lines and Communications Cables.

5.3.2.5 YARD AND OTHER NON-MAINLINE AREAS

Clearances within yards should follow the same principles as mainline track. Consideration should also be provided for servicing of railcars within yards and walkways and/or cart paths shall be provided where necessary.

5.3.2.6 STATION PLATFORMS

Station platforms shall comply with the clearance requirements discussed in Chapter 8, Stations and Parking.

5.3.3 LINE CLEARANCE RESTRICTIONS

Some Metra lines have additional clearance restrictions that may affect design. The designer shall confirm any clearance restrictions with Metra Operations prior to starting design.

5.3.4 TRACK CENTERS

5.3.4.1 MAINLINE TRACKS

New track construction shall have a minimum track center spacing of 15’-0” on tangent alignment, with an absolute minimum spacing of 13’-0” subject to approval by the Chief Engineering Officer. In curves, minimum track spacing shall be increased for track curvature and superelevation. For track curvature, track spacing shall be increased 1-1/2 inches per degree of curvature. For superelevation, when the outer track is superelevated more than the inside track, track spacing shall be increased by 3-1/2 inches per 1 inch of superelevation difference.

5.3.4.2 SIDINGS

A minimum of 25’-0” shall be provided between mainline track and siding track.

5.3.4.3 YARD TRACKS

Where mainline tracks are adjacent to yard ladder tracks, track centers of a minimum of 25’-0” shall be provided, with an additional 2’-0” provided if switches are manually operated. Within yards, for parallel tracks where switches are operated on both tracks, track centers of a minimum of 17’-0” shall be provided, with an additional 2’-0” provided if switches are manually operated. See Chapter 15, Shops and Yards, for more detail on yard tracks.

5.3.5 PLACES OF SAFETY

5.3.5.1 MAINTENANCE WALKWAYS

A 2'-6" wide maintenance walkway shall be provided on the outside of all new track located outside the minimum required clearance envelope.

5.3.5.2 SAFETY NICHES

Safety niches shall be provided where adequate horizontal clearances are not provided for over a distance of 25 feet along the track. The niches shall have minimum dimensions of 7'-0" high by 2'-6" wide by 1'-0" deep. The bottom of the niche shall be at grade or no higher than 18 inches above finished grade. The back wall of the niche must be positioned to provide the required horizontal clearance from track centerline. Niches are to be provided at least every 25'-0" on center through an area of reduced clearance.

5.4 LINES MAINTAINED BY FREIGHT RAILROADS

On lines owned or operated by freight railroads, or where freight trains operate on Metra track, the most stringent criteria will govern the required clearances.

6. CIVIL AND DRAINAGE

6.1 INTRODUCTION

This section includes design criteria that establish the minimum standards for the design of civil and drainage structures on the Metra track system. The design criteria are based on best industry practices and meet or exceed all regulatory requirements.

Deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of any conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

6.2 STANDARDS, CODES, AND REGULATIONS

In addition to Metra's design criteria, the applicable codes and regulations of the authority having jurisdiction (AHJ) apply. Metra civil and drainage projects generally interact with public roadways, public water management systems, and/or public waterways. It is the designer's responsibility to identify all AHJs that must be involved in a project and to follow the appropriate codes and regulations.

The latest edition of all regulations will apply. Relevant regulations include but are not limited to:

Code, Standard, Reference, or Guideline
Illinois Department of Transportation BDE Manual, Survey Manual, Drainage Manual, and other relevant manuals
Wisconsin Department of Transportation Facilities Development Manual
City of Chicago Department of Water Management Regulations for Sewer Construction and Stormwater Management
Metropolitan Water Reclamation District of Greater Chicago Watershed Management Ordinance
Lake County Watershed Development Ordinance
McHenry County Stormwater Management Ordinance
DuPage County Countywide Stormwater & Floodplain Ordinance
DuPage Water Commission

Code, Standard, Reference, or Guideline
Kane County Stormwater Management Ordinance
Will County Comprehensive Stormwater Management Plan & Stormwater Technical Guidance Manual
Fox River Water Reclamation District
Kenosha County and Wisconsin Department of Natural Resources regulations

Note that municipalities may have regulations that are more stringent than the county ordinances shown above.

6.3 SURVEY

Horizontal and vertical control shall be established to Second Order, Class II accuracy as specified in American Society of Civil Engineers (ASCE) “Technical Standards for City Property, Highways, and Bridge Surveys” and the American Congress on Surveying and Mapping (ACSM) “Survey Standards”.

In the City of Chicago, state-plane coordinates, and Chicago City Datum (CCD) shall be used. For other jurisdictions, state-plane coordinates and USGS NAVD88 or a local vertical datum shall be used. Latitude and longitude shall be provided relative to the North American Datum of 1983 (NAD83).

6.3.1 HORIZONTAL AND VERTICAL CONTROL

The horizontal and vertical control for all surveys, alignments and grades shall be based on a network of Project Control Survey established by Metra for the project.

6.3.2 ACCURACIES

Survey shall meet or exceed State of Illinois requirements as given in the Illinois Department of Transportation (IDOT) Survey Manual. Minimum accuracy of survey work based on the control network shall be one part in 15,000 for linear measurements and five seconds per instrument station for angular measurements.

The error of closure in feet for establishment of vertical elevations shall not exceed

$$0.035 * \sqrt{M}$$

Where M = distance in miles.

6.4 SITE GRADING

6.4.1 ROADWAY AND PAVING

Roadway and pavement within Metra stations and parking facilities shall conform with the requirements in Chapter 8, Stations and Parking. Roadway and pavement within Metra yards and shops shall conform with the requirements in Chapter 15, Shops and Yards.

Roadways in right-of-way (ROW) adjacent to a project shall follow the requirements of the agency that owns the roadway ROW.

6.4.2 TRACK ROADBED CONSTRUCTION

The track roadbed structure consists of the sub-ballast and subgrade. See Chapter 4 for more detail on track structure.

The responsibility for track construction is divided between bid work, performed by contractors, and force account (FA) work, performed by Metra or the ROW owner. Contractors install up to top of sub-ballast, Metra or the owner installs track work from bottom of ballast up.

For replacement or reconstruction projects, subgrade shall be even with the existing top of finished grade. On existing grade, roadbed work shall protect the existing hardpan. For new construction, subgrade shall be made up using CA6 sub-ballast compacted to 95 percent unless otherwise designed by the consultant geotechnical engineer.

Sub-ballast shall comply with the requirements of Section 4.7.2. Sub-ballast shall be graded at a two percent slope from the crown. For single tracks, the crown shall be at center of tie. For double tracks, the crown shall be between the two tracks. When needed, adjustments to the location of the crown shall be made for drainage or curvature. The designer shall determine the appropriate crown in locations with more than two tracks.

A three-foot minimum horizontal space from the toe of the ballast shall be provided to accommodate a walkway wherever possible. The sub-ballast may be extended further where an access roadway is to be provided. If required, access roadway width should be no less than 10’-0” from toe of ballast on the field side.

The sub-ballast and subsequent subgrade shall be graded to provide a minimum 3H:1V sideslope.

6.4.3 HMA OR GEOSYNTHETIC UNDERLAYMENT (UNDER DEVELOPMENT)

6.4.3.1 LANDSCAPING

Landscaping, including slope stabilization seeding within the ROW shall conform to local ordinances and code requirements. By the Illinois Commerce Commission (ICC) regulation, ROW must be kept free of unnecessary obstructions (including landscaping) for a distance of 500 feet from the end of any highway-rail grade crossing.

Landscaping for Metra stations and parking facilities shall conform to the requirements in Chapter 8, Stations and Parking.

6.4.4 EROSION CONTROL

Permanent erosion control measures shall be required when determined by environmental regulations, including locations where the minimum 3H:1V sideslopes cannot be provided.

Temporary erosion control measures shall conform to local and state environmental regulations. As required, the designer shall prepare, as a deliverable, a Stormwater Pollution Prevention Plan (SWPPP) in accordance with federal, state, and local regulations. The designer shall work with Metra to obtain any required approvals for the SWPPP. The SWPPP will be executed by the contractor and construction manager for the project.

6.4.5 SOIL CONTAMINATION

Existing roadbeds shall be assumed to be special waste, and excavation and disposal of these materials shall be accounted for in design and construction. Metra’s Safety and Environmental Compliance Department shall be engaged as a stakeholder when excavation and disposal is part of the project. The designer shall categorize excess excavated material as special waste, non-special waste, Clean Construction or Demolition Debris (CCDD), and any other identified categories.

6.4.6 PERMITS

All appropriate permits and easements applicable to the local jurisdiction must be obtained prior to commencement of construction activities. The designer shall identify appropriate jurisdictions and required permits and develop a permit plan in coordination with Metra stakeholders. See Metra's Project Permit Coordination Manual for additional details on the permitting process and the designer's responsibilities.

6.5 GEOTECHNICAL

Much of the Metra system is located on existing roadbed that has been in service for decades. Some corridors previously included more tracks than are currently in service. Sufficient geotechnical testing shall be performed by the design team to determine if and where adequate existing roadbed exists. Quality existing roadbed can be utilized where appropriate, but the presence of existing roadbed itself should not preclude thorough geotechnical analysis.

6.5.1 GEOTECHNICAL SUBSURFACE INVESTIGATION

Geotechnical field exploration for roadbed and associated fills and cuts shall conform to the requirements outlined in AREMA Chapter 1, Part 1, Roadbed. Geotechnical field exploration for structures shall be performed in accordance with AREMA Chapter 8, Part 22, Geotechnical Subsurface Investigations, and shall be conducted under the supervision of a Professional Engineer registered in the state where the work will take place.

Depending on the type and significance of the work required, the designer's geotechnical engineer shall, at a minimum, research all geotechnical information available. This information includes but is not limited to:

- Topographic and geologic maps
- Aerial photographs
- Geologic and subsurface exploration reports
- Related articles in engineering and geologic journals
- Study of local ground features
- Survey of existing and adjacent structures
- Condition of adjacent structures
- Information about previous and future planned use of the site

Where more complex or new structural work is to be completed, geotechnical field investigation shall be a project requirement and shall conform to the requirements of ASTM D420. Existing information may only be utilized in lieu of data obtained from new borings with the written approval of Metra.

The number and location of explorations shall be performed so that the soil profiles obtained will permit an accurate estimate of the extent and character of the underlying soil and/or rock masses and will reveal important irregularities in the subsurface conditions. The depth of investigation shall be sufficient to characterize subsurface conditions within the foundation depth. The spacing, number, and depth of borings shall be coordinated with Metra. It is recommended that at least one boring occur at each abutment and pier location for new structures.

Prior to the geotechnical field investigation, a detailed work plan shall be submitted to Metra for review and approval. The following should be included as part of this detailed work plan:

- Review of existing geotechnical information
- Objectives of investigation
- Utility clearance procedures
- Proposed boring/testing locations and depths
- Description of drilling, sampling, and spoil disposal methods
- Project-specific safety plan
- Traffic control and management plan (if applicable)

Requirements for all environmental and geotechnical exploration permits shall be checked with federal, state, and local government agencies, and all necessary permits shall be obtained before the start of field exploration. All permit applications prepared by consultants shall be reviewed by Metra prior to submission.

The groundwater elevation shall be determined in each boring at the time of drilling where possible, and when the groundwater elevation has stabilized. In areas of loose, cohesionless, or non-plastic fine-grained soils, it is important to determine the groundwater elevation to evaluate the potential of liquefaction. If long-term observations of groundwater are desired, recommendations given in AREMA MRE Chapter 8, Section 22.6, Determination of Groundwater Level, shall be followed. If evidence of contaminated soils or groundwater is encountered during drilling, the driller shall immediately stop drilling operations and contact Metra.

A complete geotechnical report shall be submitted to Metra and shall be signed and sealed by a Professional Engineer registered in the state where work will take place. The report shall include the following investigation results and recommendations:

- General geologic setting
- Specific site subsurface conditions and groundwater levels
- Soil types and classifications (include boring logs, test pit records, and lab results in appendices; ground surface elevations at boring locations shall be provided, with datum noted)
- Evaluation of site for potential accelerated corrosion issues
- Possible presence of hazardous materials
- Geologic hazards
- Anything special about the site based upon the geotechnical engineer's experience or observations in the immediate area
- Recommended compaction for required 2:1 railroad embankment slopes
- Estimated settlements, including:
- Embankments
- Foundations
- Down drag on foundations

Feasible and recommended foundation type(s) for bridges and miscellaneous structures for the project, including retaining walls. The following shall be included for each foundation type, at a minimum:

- Axial capacity charts for pile foundations (driven and drilled) and recommended bearing/bottom elevations and materials (including rock sockets, if necessary)
- Recommended allowable bearing pressure for spread footings (bridges and retaining walls)
- Recommended soil profile and properties for use in lateral pile analysis

- Recommended design earth pressures for active, at-rest, and passive conditions
- Potential constructability issues, such as
- Groundwater
- Shoring
- Cobbles
- Drivability of piles
- Corrosion mitigation recommendations for new steel and concrete elements exposed to severely corrosive soil and/or brackish water conditions
- Recommendations for surface and subsurface drainage

6.6 EARTHWORK (UNDER DEVELOPMENT)

6.6.1 EXCAVATION AND SHORING

See Metra's Temporary Shoring Guidelines for the requirements related to excavation and shoring.

6.6.2 BACKFILL

For all backfilling operations adjacent to a structure, drainage provisions for backfill shall be compatible with the assumed water conditions in design.

Structural fill may be partially composed of on-site excavated materials that meet the requirements in this section and as approved by the Geotechnical Engineer. If imported fill is required, on-site excavated materials should be used at the lowest lifts of the backfill and imported fill should be used near the finished subgrade. Imported fill should meet the following requirements for structural fill: the material should be a soil or soil-rock mixture free of organic matter or other deleterious substances, it should not contain rocks or lumps over six inches in greatest dimension and not more than 15 percent by weight larger than 2-½ inches, it should not contain more than 40 percent by weight passing the No. 200 sieve, and it should have a maximum plasticity index of 15.

Surcharge loads due to earthwork or embankment construction may result in settlements or base instability, and these potential effects shall be evaluated by the Geotechnical Engineer, who shall provide recommendations to mitigate these conditions.

Fill should be spread in lifts not to exceed a maximum uncompacted thickness of six inches, moisture conditioned, and compacted using appropriate compaction equipment. Fill should be compacted to a minimum of 95 percent relative compaction in all areas, except within five feet behind retaining walls where a minimum of 90 percent relative compaction is recommended. When backfill material is within three feet of the subgrade elevation, a compaction of at least 98 percent will be required. Compaction acceptance shall be based on test method ASTM D1557.

Competent soils that are located above the ground water table will generally be stable with a slope of 2(H): 1(V) or flatter, but it is the Geotechnical Engineer’s responsibility to assure that an adequate factor of safety is achieved for slopes.

6.7 STORMWATER

6.7.1 DRAINAGE

Efficient track drainage is of upmost importance to the reliable operation and maintenance of the railroad. The drainage system consists of the drainage ditches parallel to the railroad embankment and any culverts or other structures that convey runoff. Any construction shall not inhibit or alter the flow of an existing drainage system or add runoff onto the ROW.

If new construction causes a change to the drainage system, or if the drainage system is not functioning properly, drainage system modifications shall be made to accommodate system conditions. The drainage structures shall meet the hydraulic criteria detailed in this section and in Chapter 7 Bridges and Structures. A drainage structure that is removed, added, modified, or replaced within the ROW will require a hydraulic study.

To the extent possible, drainage systems shall be designed to convey water away from trackbeds and facilities without draining through adjacent tracks and facilities, by means of gravity-based conveyances, without ponding or scouring.

6.7.2 HYDROLOGY AND HYDRAULICS

In general, the design of drainage systems shall accommodate a 100-year storm, to include facilities, stations and storage yards, culverts beneath at-grade track, storm drain systems adjacent to tracks, and drainage structures crossing under bridge structures. See Chapter 7 Bridges and Structures for discussion of structure sizing and hydrology. Drainage ditches along track shall accommodate a 50-year storm.

The expected discharge shall be computed using the Rational Method using local parameters for the project.

6.7.3 HYDRAULICS FOR PARALLEL DRAINAGE SYSTEMS

Sufficient lateral and vertical clearance must be provided to accommodate construction of the ditch based upon the 100-year event. Ditch design shall be supported by a hydrology and hydraulics report submitted to Metra as a design deliverable. Offsite tributary areas to trackside ditches must be considered.

Metra’s standard flat-bottom drainage ditch (trapezoidal, 10 feet bottom width, a minimum of 2:1 sideslopes, with flowline elevation a minimum of 3 feet below the subgrade elevation) shall be used.

Where acquisition of adequate ROW is a limiting factor or site characteristics justify smaller drainage systems, a request for variance with sufficient supporting documents may be submitted to Metra for consideration.

The applicant must provide hydraulic data (energy grade line, water surface elevation and velocity) for both existing and proposed conditions.

Consideration shall be given to the effects of localized and contraction scour and mitigation, if deemed necessary, and these shall be shown on the design plans.

6.7.4 STRUCTURES AND DETENTION

All structures shall be sized appropriately for expected discharge and comply with applicable local standards. Spacing shall also follow local standards but shall be no more than 500 feet maximum.

Track underdrains shall be 12 inches minimum diameter, located within a trench, with the centerline of underdrain a minimum of 6’-6” from centerline of track and the trench invert a minimum of 4’-6” below top of rail, where applicable. The underdrain shall be provided with a geotextile “sock” to prevent the entry of aggregate. The trench shall be surrounded with geotextile fabric and provide six inches of buffer around the drain using a bed of aggregate filter material.

Underdrains shall have a clean-out installed at the upstream end to allow for cleaning to the outfall. Five-hundred-foot intervals shall be used for intermediate clean-outs.

Culverts and storm pipes shall be sized appropriately, with a minimum 12” in diameter. Culverts are further discussed in Chapter 7 Bridges and Structures. Culverts under track shall have a minimum cover of 5’-6” from top of tie to top of culvert. Culvert materials and class shall follow IDOT standards under roadways.

Stormwater detention shall be provided only as required by the AHJ.

6.8 EXISTING UTILITIES

Prior to the start of design, the designer shall determine the location of all existing utilities, both within the railroad ROW and on all lands adjacent to it that are part of the project improvements. The designer shall coordinate with the Metra Project Manager (PM) to gather utility data within the railroad ROW from appropriate parties within Metra. JULIE and DIGGER do not perform locates of Metra utilities; these must be coordinated with the appropriate parties within Metra. In the City of Chicago, the Information Retrieval (IR) process with the Office of Underground Coordination (OUC) must be used for collecting atlases for all utilities outside of railroad ROW. Contact JULIE for utility locates outside Chicago and the railroad ROW. Note that parallel railroad ROWs exist in some locations and the designer must be sure to contact all parties.

6.9 UTILITY CROSSINGS

This section applies to:

- The design and construction of pipelines carrying flammable or non-flammable substances under, across and along Metra property and facilities
- The design and construction of wirelines carrying power or communication cables over, under, across and along Metra property and facilities
- Tracks owned by others (sidings, industry tracks, etc.) over which the Metra operates its equipment

Metra owns its property for the primary purpose of operating a railroad. All occupancies shall therefore be designed and constructed so that rail operations and facilities are not interfered with, interrupted or endangered. In addition, the proposed facility shall be located to minimize encumbrance to the property so that the railroad will have unrestricted use of its property for current and future operations.

For the installation, maintenance, or replacement of utilities on Metra ROW, the following manuals shall be utilized and followed, in addition to the information found herein:

- Guidelines for Utility Installations, Part 1 – Wire Lines and Communications Cables
- Guidelines for Utility Installations, Part 2 – Pipelines: Flammable and Non-Flammable Materials
- General website for additional information, applications, and documents

6.9.1 RIGHT OF ENTRY

No entry upon Metra property for the purpose of conducting surveys, field inspections, obtaining soils information or any other purposes associated with design and construction will be permitted without a proper entry permit prepared by Metra. The applicant must pay the associated fees and execute the entry permit.

Consultants and contractors may be exempt from this requirement based on the provisions of their contract with Metra. The designer shall verify the requirement with the Metra PM.

It is to be clearly understood that the issuance of an entry permit does not constitute authority to proceed with any construction. Construction cannot begin until a formal agreement is executed by Metra and the applicant receives permission to proceed with the work, from the designated construction monitoring agency of Metra.

The application for a Right of Entry permit shall be obtained at the following link: Right of Entry Application Form.

6.10 GRADE CROSSINGS

Design and construction of new highway-rail grade crossings should be avoided. Where creation of a new crossing is necessary, consideration should be given to grade separation if possible.

All grade crossings in the State of Illinois are subject to the regulatory approval of the ICC. Additional concurrence or approval may also be required from the municipality or county within which the crossing is situated.

Highway-rail grade crossings shall be designed in accordance with all federal, state, and local regulations, as well as best practices documented by AREMA and others.

The following measures should be considered where grade crossings must exist:

- Optimal design of approach roadway, site improvements and crossing warning device
- Speed of approaching trains
- Positive barrier system to restrict access of traffic crossing the tracks

Grade crossing design involves multiple disciplines within Metra, and projects involving grade crossings must involve all disciplines and stakeholders as early as possible in the process to reduce the potential for rework.

Key internal stakeholders for grade crossing projects include:

- Track
- Civil
- Signals
- Stations and Parking (for grade crossings adjacent to Metra stations)
- Metra Community Relations

Key external stakeholders include:

- ICC
- FRA
- Host railroad(s)
- IDOT
- Chicago Department of Transportation (CDOT)
- Other local authorities including municipality or county

6.10.1 GENERAL STANDARD PRACTICES

Design and implementation of at-grade crossings must comply with federal and state guidelines. At a minimum, the following references shall be consulted for the safe and efficient design of crossings:

Code, Standard, Reference, or Guideline
Illinois Commerce Commission Administrative Rules, Title 92, Part 1535 Crossings of Rail Carriers and Highways
American Railway Engineering and Maintenance of Way Association's Manual for Railway Engineering
Manual on Uniform Traffic Control Devices
Federal Highway Administration
Federal Railroad Administration

Code, Standard, Reference, or Guideline
Federal Transit Administration
Americans with Disabilities Act
Any additional requirements set forth by the local department of transportation

6.10.2 WARNING SYSTEMS

All projects at or adjacent to grade crossings, new or existing, must work with Metra Signals to ensure that appropriate warning systems are in place and are not adversely impacted by any planned construction.

6.10.3 EMERGENCY NOTIFICATION SIGN

All Metra grade crossings are equipped with an emergency notification sign (ENS) in compliance with federal and state requirements. See Standard Drawing RS-ENS.

6.10.4 CIVIL DESIGN REQUIREMENTS

Use local requirements for the roadway abutting the crossing. The type of crossing surface to be used shall be determined by Metra.

6.11 MAINTENANCE OF TRAFFIC

Roadway maintenance of traffic (MOT) must be coordinated with local departments of transportation that govern the roadway system prior to commencement of construction or maintenance work.

Metra projects frequently interact with CDOT and IDOT, and other local authorities. The designer shall identify key stakeholders including state and local authorities and work with those stakeholders and Metra to determine MOT requirements that could impose constraints on the project. Most authorities require a permit or other coordination process to establish a detour route. Routing and scheduling for detours will be affected by the authority.

The results of coordination with authorities may be a job-specific MOT plan and/or may consist of standard MOT drawings gathered from IDOT or other appropriate authorities.

7. BRIDGES AND STRUCTURES

7.1 INTRODUCTION

This section includes criteria that establish the minimum design standards for the bridges and structures on the Metra rail system. The design criteria are based on best industry practices and meet or exceed all regulatory requirements.

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of any conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

For design of any bridges or structures not explicitly mentioned in this chapter, the designer shall refer to the AREMA Manual for Railway Engineering (MRE) for the base acceptable criteria for design.

7.2 CODES AND REGULATIONS

Bridge and structure design, construction, and maintenance shall conform to the latest edition of all applicable standards, codes, and regulations, including the following:

Code, Standard, Reference, or Guideline
Federal Railroad Administration
Occupational Safety and Health Administration
AREMA Manual for Railway Engineering
American Society for Testing and Materials
American Public Transportation Association
Chicago Department of Transportation
Illinois Department of Transportation
National Environmental Policy Act
National Fire Protection Association
U.S. Army Corps of Engineers

7.3 DESIGN CONCEPTS

7.3.1 PERMITTING AND NEPA

Since permitting of structures can be complex and involve multiple agencies, the designer shall identify all applicable permits for discussion with Metra as early in the design process as possible. This is especially the case for structures that may impact waterways or other protected resources. Refer to Metra's Permitting Manual (under development) for additional detail.

If the designer is also providing NEPA services, then this process shall begin as early as possible to avoid schedule delays due to awaiting NEPA approvals. If the designer is not providing NEPA services, then it shall engage with Metra and/or Metra's NEPA consultant as early as possible to avoid schedule delays. Refer to Metra's NEPA Manual (under development) for additional detail.

7.3.2 DESIGN LIFE

The design life for all structures, including bridges and retaining walls, shall be 100 years.

7.3.3 TOLERANCES

Tolerances shall conform to relevant chapters of the AREMA MRE.

7.3.4 DESIGN METHODOLOGY

Design methodology shall conform to relevant chapters of the AREMA MRE.

7.3.5 TRAIN OPERATIONS AND MAINTENANCE OF RAILROAD TRAFFIC

The design consultant shall work with Metra to identify current and future railroad operation requirements during the conceptual design stage.

It is essential that the construction be performed with a minimum interference with rail traffic. Continuity of safe rail operations will be required for the duration of the project. Any construction activities that will impact railroad operations shall be approved by and coordinated with Metra and any other impacted railroads.

Shoofly or detour tracks may be used where feasible if they are the best way to maintain railroad traffic. For bridge projects, if shoofly tracks cannot be provided, the new superstructure shall be constructed adjacent to the final location and rolled into place. The construction plans shall include the complete details of the temporary bridges and/or roll-in structure.

All construction shall be completed in compliance with Metra's Construction Manual.

7.3.6 STAGED CONSTRUCTION

Construction staging shall be reviewed and approved by Metra throughout the design process. A detailed sequence of construction for maintaining traffic shall be shown on the design plans. When construction requires the total interruption of rail traffic, an estimate of the time required shall be included in the procedure, and the time frame will be subject to discussion with approval by Metra.

The designer shall consider all necessary temporary drainage controls when phased construction is required. Plans shall clearly depict the temporary controls that will be provided. Metra reserves the right to request drainage calculations demonstrating the adequacy of the temporary drainage controls.

7.4 ALLOWABLE STRUCTURES

This section summarizes the types of structures that are permitted within Metra right-of way (ROW). It also provides requirements for the design and construction of structures over or under Metra ROW by third parties. Such projects shall also meet applicable criteria in other sections of this manual.

7.4.1 OVERHEAD STRUCTURES

Overhead structures are any structures that are constructed over Metra's ROW.

Plans and specifications for new, rehabilitated, or modified structures over Metra ROW shall meet the requirements discussed in this section, which are intended to provide safe and continuous passage of train traffic during and after construction.

All overhead structure projects require the procurement of all applicable property rights, construction agreements, and approvals from Metra.

7.4.1.1 GENERAL

The station and distance from the nearest Metra milepost at the intersection of the centerline of track and the centerline of the overhead structure shall be clearly shown on plans.

Overhead bridge girder splices shall not be located in span(s) located over Metra property unless written approval is granted by Metra through the Design Exception and Deviation process (Section 2.3.7). If approval is granted, the girder splices and any associated temporary support towers shall be located at least 15’-0” from the centerline of the nearest track.

The use of cast-in-place main load-carrying elements and spliced precast/prestressed girders over operating tracks is prohibited.

The use of stay-in-place deck forms for cast-in-place deck construction is encouraged.

Lighting and roadway signs to be mounted on the overhead structure shall not be positioned in the spans directly over Metra tracks.

The plans for the overhead structure shall show dimensioned locations of all existing utilities, as well as the location of all proposed utilities, within Metra’s ROW. The plans shall define the responsibility for locating, marking, or installing and protecting such utilities. Metra is not responsible for locating utilities.

If fiber optic cables are presently buried on Metra ROW, or if such installations are scheduled during an overhead bridge project, then the presence of such facilities shall be considered in the overhead structure design and appropriate measures for protection of the fiber optic cables shall be addressed on the plans and in the contract documents.

All construction shall be planned and designed to ensure the overhead structure is constructible without adversely impacting normal railroad operations. This includes site access considerations and equipment placement necessary to safely perform all construction. The Contractor’s equipment will not be permitted to work from the tracks. See Metra’s Construction Manual for further information on construction.

Any adverse effects, as deemed by Metra, caused by overhead structures or their construction shall be the sole responsibility of the owning agency or Contractor.

7.4.1.2 CLEARANCES

The existing and proposed minimum horizontal and vertical clearances shall be clearly shown on plans.

Horizontal clearance from the centerline of nearest track to the face of any pier, bent, or abutment shall be a minimum of 18’-0”, measured perpendicular to the centerline of the nearest track. On curved track, the horizontal clearance shall be increased 1-½" per degree of curvature. The toe of subsurface footings shall be a minimum of 13'-0" from the centerline of the nearest track. For distances less than 25'-0", design shall comply with the crashworthiness requirements discussed by AREMA.

It is preferred that all substructures be located entirely outside of the Metra ROW. Where site conditions make this impossible, a detailed ROW plan shall be submitted to Metra for review and approval.

A pier footing within 25 feet of the nearest existing or future track shall be a minimum of six feet below the base of rail.

Provisions for future tracks, drainage, facilities, or access roads may also be required. Construction of piers and end slopes shall be such that they do not interfere with existing track ditches. Where site conditions make this impossible, an explanation of such conditions, along with drainage plans and calculations, shall be submitted to Metra for review and approval. Also, the horizontal and vertical clearances to future tracks shall be shown on the plans. Substructure protection shall be provided as specified in AREMA Chapter 8, Section 2.1.5 for all tracks, including future tracks.

Attention shall be given to the need to provide a walkway adjacent to switches and tracks where trainmen are required to work on the ground.

The minimum vertical clearance, obtained from the level of the top of high rail and a point offset 6'-0" on either side of the centerline of track, shall be no less than 26'-0". Deflection due to live load and deflections in formwork during construction shall be considered in the vertical clearance requirement.

Temporary construction clearances may be requested, however, Metra has no obligation to approve such a request.

As-built clearances shall be clearly shown and submitted to Metra upon completion of the project. Size, depth, and location of all foundation components shall be included.

The profile of the existing top of rail (1,000 feet each side of the proposed road crossing) shall be plotted on the plans. If the track is in a sag at the proposed bridge location, the vertical clearance from the top-of-rail to the bridge shall be increased sufficiently to permit raising the track enough to remove the sag. A note shall be added to the profile stating: “The elevations of the existing top-of-rail profile shall be verified before beginning construction. All discrepancies shall be brought to the attention of Metra.”

Unless Metra signals are to be relocated at the expense of the project sponsor as a part of the project, proposed vertical and horizontal clearances shall be adjusted so that the sight distance to railroad signals is not reduced.

7.4.1.3 DRAINAGE

Drainage plans shall be included with bridge and roadway plans submitted to Metra for approval. The plans shall indicate all proposed drainage encroachments onto Metra ROW. Drainage ditches and structure details shall be developed in accordance with this manual and AREMA MRE Chapter 1.

These plans shall include hydrologic computations indicating the rainfall intensity and duration of the design storm used, as well as the method of analysis. A 100-year recurrence interval shall be the minimum design storm. If the proposed project will not change the quantity and/or character of flow in the ditches and/or drainage structures within Metra ROW, the plans shall include a general note stating this, and the note shall be supported by the hydrologic computations.

Maintaining existing drainage and providing for future drainage improvements is of the utmost importance. Existing track ditches shall be maintained. If the proposed construction will change the quantity and/or character of flow in the track ditches, the ditch design shall be modified as required to handle the drainage. The ditch design shall be submitted to Metra for review and approval.

To evaluate the impact of the proposed project relative to existing site drainage, cross sections perpendicular to the centerline of track shall be submitted along with the drainage plans. At each bridge site, a minimum of five cross sections will be required to adequately depict the site conditions: one cross section is to be taken at the centerline of the road crossing, one at each limit of construction and one located midway between each end and at the center. The existing railroad ditch and the proposed toe of slope for the end fill shall be located on all cross sections.

Drainage from an overhead structure shall be collected by drainpipes or other means and drained away from Metra ROW. Improvements to the adjacent drainage systems may be required at project expense to ensure the impacted system will meet the 100-year storm event condition. If stormwater is drained on or to Metra ROW or drainage ditches, calculations shall be submitted to Metra for review and written approval.

No scuppers or other deck drains, roadway drainage, catch basins, inlets, or outlets are permitted to drain onto Metra property. Any variance of this policy must have the approval of Metra. If a variance is granted, maintenance of the drainage structures shall be the responsibility of others and not Metra. Drainage from scuppers and deck drains must be conveyed through pipes to a point off Metra property. If a variance of this policy is granted, deck drains and scuppers shall not be permitted on the portion of the bridge between the parallel track ditches. If the drainage must be conveyed into a railroad ditch, calculations shall be provided to Metra for review and approval that indicate the ability of the ditch to carry the additional runoff.

Where the project design calls for an increase in the drainage flow through the railroad embankment, the flow shall be handled by means of a separate drainage structure. Additional under-track drainage facilities shall be shown on the ROW plan and designed in accordance with other sections of this manual.

Horizontal clearances shall provide sufficient space for construction of the required track ditch parallel to the typical roadbed section. The ditch shall be located as close to the edge of ROW as possible.

Approval of the drainage plan does not relieve the submitting agency and/or designer of ultimate responsibility and liability for a satisfactory drainage design.

If demolition of existing substructure is required, demolition located in or adjacent to the track ditch shall extend a sufficient depth below grade to enable restoration of the existing/proposed track ditch, but in no case less than 2’-0” below final grade.

The designer shall consider all necessary temporary drainage controls when phased construction is required. Plans shall clearly depict the temporary controls that will be provided. Metra reserves the right to request drainage calculations demonstrating the adequacy of the temporary drainage controls.

7.4.1.4 PROTECTIVE FENCING AND BARRIER RAIL

All new overhead structures shall have protective fencing and/or barrier rail provided.

Fencing shall extend a minimum of six feet above the top of the sidewalk or driving surface and may be placed on top of a protective barrier. The protective fence limits shall extend the width of Metra's ROW, the entire span length over the Metra tracks, or 25 feet beyond the centerline of the outermost track, whichever is greater.

Fence openings shall not exceed 3"x3". Fencing shall include anti-climb shields to minimize the likelihood of climbing on the outside of the protective fencing.

Protective fencing is subject to approval by Metra.

Barrier rail for overhead structures crossing Metra ROW shall be a minimum of 42 inches in height for structures in areas that may be subject to snow removal, and a minimum of 30 inches in height elsewhere.

Cast-in-place concrete barrier rail without openings shall be provided on both sides of the superstructure to retain and redirect errant vehicles. The barrier rail shall keep the deck's storm runoff from being deposited onto Metra ROW.

All parallel overhead structures with a gap of two feet or more shall be protected with fencing. Structures with a gap of less than two feet shall either have the gap covered or be fenced on both sides.

7.4.2 UNDERPASS STRUCTURES

Underpass structures are any structures that pass below Metra's ROW.

If equipment or materials will be at a sufficient elevation to foul existing tracks, then the agency and/or its Contractor must obtain a right-of-entry from Metra prior to starting work.

7.4.2.1 CLEARANCES

Underpass structures shall meet the requirements of Section 7.7.4.1.

If resurfacing or any other activity is to be performed below the underpass structure, the owner of the roadway shall submit a request for approval from Metra. This request must provide the existing measured and posted clearances of the structure and the proposed configuration after work is completed.

7.4.3 PEDESTRIAN STRUCTURES

For pedestrian structures within or adjacent to Metra stations intended for use by passengers, see additional requirements in Section 5.7 *Grade-Separated Pedestrian Crossings* in the Station and Parking Design Guidelines.

Pedestrian structures shall be designed to cross the entire ROW. The structure shall be of sufficient length to accommodate any future track(s) as directed by Metra.

New pedestrian crossings must have agreements in place with Metra including property ownership, construction, and maintenance.

7.4.3.1 GENERAL REQUIREMENTS

New pedestrian crossings designed and built by third parties shall be grade separated. Pedestrian grade separations shall comply with all applicable federal, state, and local laws, and shall provide an accessible facility under the Americans with Disabilities Act of 1990 (ADA) and the Rehabilitation Act of 1973 (Section 504).

The design of precast and cast-in-place concrete box sections used for pedestrian underpass structures shall comply with AREMA MRE Chapter 8, Part 16, and the requirements of this manual. In the case of discrepancy, the more stringent shall govern. When other structure types are proposed, the design shall comply with appropriate sections of the AREMA MRE and this manual.

The minimum inside clear dimensions of a pedestrian underpass shall not be less than nine feet wide by nine feet in height prior to the floor installation. The width and height of the structure shall be determined based on analysis of the ability to provide adequate visibility through the structure.

The structure depth shall be no less than 5’-6” from top of structure to top of tie.

The crossing shall be at 90 degrees to the track(s).

Where concrete box structures are used, precast box sections shall be utilized to minimize rail service disruptions. The length of precast box sections shall be at least of sufficient overall length that any cast-in-place section(s) can be installed after the track(s) is put back into service and shoring is installed for protection of the track.

Precast box sections shall be positively connected to provide closure of the joints, engage the gasket seals, and prevent the possibility of future separation of the box sections. The connections shall be provided on the top (two minimum), and on each side (one minimum) of the box sections. The connections may be bolted, welded, or a combination of both. Any open holes left after erection shall be fully grouted.

7.4.3.2 WATERPROOFING

An underpass structure shall be waterproofed such that it remains watertight over its useful lifespan. The designer shall provide a schedule for the maintenance and periodic replacement of the waterproofing system over the lifetime of the structure. The waterproofing system shall be protected from damage during installation.

Precast section joints shall be of watertight construction, incorporating a rubberized gasket installed between the tongue-and-groove sections.

Cast-in-place sections shall incorporate waterstops at all construction joints.

Appropriate protection of the waterproof layer shall be included in design.

The outer layer shall have minimum one percent slope away from the crown at centerline of track to ensure proper drainage.

The waterproofing system shall be protected from damage during installation.

Details of the proposed waterproofing system shall be submitted to Metra for acceptance prior to fabrication and construction.

7.4.3.3 DRAINAGE

Pedestrian underpass structures shall include an inside drainage collection system to remove water from maintenance cleaning and storm runoff from adjacent approach ramps and stairways. The inside structure's floor shall be sloped as required to facilitate draining to a drainage collection system. The drainage collection system shall be installed on each side of the floor along the full length of the structure, and then routed to an existing storm drainage system. A sump with pump and lift station may be considered if connecting to an existing storm drain by gravity flow is not practical.

Pedestrian underpass structures shall also have a sub-drainage system installed along the external walls below floor level, in conjunction with pervious backfill material and/or geo-composite drainage board to collect water from groundwater fluctuations and surface infiltration. When the structure is located in an area with a high groundwater table, a permanent dewatering system may be considered in addition to the sub-drainage system.

7.4.3.4 INSTALLATION

Specifications shall include direction for track monitoring during installation. See Section 7.20.5.

7.4.3.5 ACCESS

The structure shall provide access that includes stairways and approach ramps that provide adequate sight distances for pedestrians. Access shall be ADA compliant.

Metra ROW shall be adequately protected against unauthorized access by providing railings or fences. Railings or fences shall be a minimum 6 feet in height, and of a construction type that will discourage climbing over the railing or fence to gain access to the Metra ROW. Fencing shall be provided on both sides of the ROW and shall extend a minimum of 250 feet from the pedestrian underpass structure, measured perpendicular to the structure.

7.4.3.6 LIGHTING

The structure, stairways, and approach ramps shall be lighted for security and personal safety. Lighting on the approaches and within the underpass shall appear bright, while avoiding glare and shadows. This may be accomplished by carefully selecting surface textures and colors.

When the ratio of the structure length to height exceeds 10:1, lighting shall operate continuously.

During the day, lighting shall be bright enough to allow pedestrians to see into the underpass. At night, lighting shall enable pedestrians in the underpass to see the areas surrounding the exits. This may be accomplished by reducing the lighting intensity at each entrance to the underpass.

Recessed lamps that create pools of light should be avoided. Since pedestrian underpass lamps are generally located at a relatively low level, they shall be made of polycarbonate or other material that is resistant to vandalism.

An emergency lighting system shall be installed to provide illumination if the main power supply fails.

7.4.3.7 MAINTAINABILITY

The structure shall be designed for ease of maintenance. Lighting fixtures, signage, aesthetic treatments, and other materials proposed for use in the structure shall be included in the design considerations to reduce maintenance frequency and requirements. Signage shall be adequately fastened to supports and out of reach to the extent possible. Aesthetic treatments shall be inlaid or anchored and protected by other means from vandalism. Concrete shall have graffiti protection if warranted, and handrails and exposed metals shall be protected from corrosion.

7.4.4 TRAIL CONSTRUCTION UNDER BRIDGES

Metra recognizes that communities often wish to establish recreational paths in areas adjacent to active railroads. While Metra will cooperate in the establishment of these paths, important requirements must be met, including safety precautions taken to protect the public and Metra employees.

Trails can be allowed over or under the tracks, provided appropriate safety measures are provided. When a pathway occurs at an established highway-rail-at-grade crossing, it will be considered if it is within the highway easement across Metra ROW and appropriately signed and protected. The cost of signs, crossings, and warning systems will be paid by the project sponsor.

Parallel bicycle and pedestrian trails shall be located off Metra property. Pathways that would permit pedestrian, bicycle, and other recreational traffic to move parallel to trains on Metra ROW, or to cross at-grade, are not permitted.

7.4.4.1 PLAN REQUIREMENTS

Plans shall show all clearances between the proposed trail and the bridge structure. Metra ROW lines shall be clearly shown on the plans.

A canopy shall be installed under the Metra bridge, with the minimum clearance between the top of the canopy and the underside of the bridge being five feet. The canopy shall be adequately designed to resist the impact of debris falling from the Metra bridge. Debris with potential to fall includes, but is not limited to, tie plates which are approximately 18” x 8” x 1 ½” and weigh approximately 36.5 pounds. The canopy shall extend at least 15 feet beyond the bridge fascia on either side of the bridge.

Fencing shall be provided along the trail in the vicinity of the undergrade bridge to prevent trespassing near the active Metra track area and facilities. Gates must be provided to readily permit Metra access to the undergrade bridge areas from below the bridge. Metra will provide a lock.

The trail in the vicinity of the bridge must be able to be closed and the canopy removed as necessary to permit Metra access for inspection and maintenance of the bridge. The trail must remain closed until the Metra work is completed, and the canopy and fencing are restored. Metra will not be responsible for any damage to the portions of the canopy and fencing that occur due to Metra inspection, maintenance, operations, or other work.

A procedure shall be provided for periods when the trail will require closure in the vicinity of the undergrade bridge due to Metra inspection, maintenance, or other operations.

Details shall be provided for signage against trespassers.

7.5 GEOMETRY

7.5.1 TRACK SPACING

Refer to Chapter 4, Track Geometry for Metra’s track spacing requirements.

7.5.2 FUTURE TRACK CONSIDERATION

The need for future tracks shall be considered and discussed with Metra at the conceptual design phase. Alignments of future tracks shall be shown on the plans.

7.5.3 STRUCTURE SEPARATION

Adjacent railroad structures, including access road structures, shall have a minimum clear distance of five feet between structures. Non-railroad structures adjacent to railroad structures shall have a clear distance of at least 25 feet from the railroad structure. All non-railroad structures shall be outside of Metra ROW. Replacement of existing structures may be exempt from these requirements if approved by Metra.

7.5.4 ACCESS ROADS

The need for access roads shall be considered at the conceptual design phase. Any grade separation structure shall provide for safe access to Metra facilities within the ROW. When more than two tracks are provided, including future tracks, space shall be provided for access roads on both sides of the tracks. The following requirements shall apply to access roads:

- Metra access roads under a bridge
- The outside edge of the access road shall be located a minimum of 27 feet from the centerline of the nearest track, including future tracks.
- The minimum vertical clearance over access roads shall be 18 feet.
- Access roads on a Metra bridge
- Access roads on a railroad bridge structure shall be designed for the same live loading as the tracks in the event that future tracks are constructed in the location of the access road.
- A removable barrier shall separate the ballast section and the access road.
- Unless directed by Metra, access roads on independent structures shall be a minimum of 13 ft wide. The superstructure shall be designed for American Association of State Highway and Transportation Officials (AASHTO) live loading and the substructure shall be designed for AREMA live loading. An independent access road structure shall be a minimum of five feet from the primary railroad structure.
- When no access road is provided for on or adjacent to the bridge, turnarounds shall be provided on either side of the structure.

7.6 BRIDGES OVER WATERWAYS

Design of bridges over waterways shall comply with all applicable requirements including those of the Army Corps of Engineers. See also Section 7.16 Hydraulics and Erosion.

New and replacement bridges, as well as modifications to existing bridges, that span waterways shall meet the following requirements:

- Bridges shall be sized such that the 100-year flood elevation does not rise above the low chord of the bridge.
- Local flood flow criteria shall be evaluated and adopted if it is more conservative than the Metra criteria.
- Information on the hydraulic opening for the existing and proposed bridges shall be provided, including the energy grade line, water surface elevation, and flow velocity.
- Hydrologic and hydraulic design shall be in accordance with the AREMA MRE and applicable local jurisdiction procedures, as well as the requirements of Section 7.16.
- The design of bridges to resist scour shall be in accordance with the provisions of AREMA MRE Chapter 8 Section 5.6 and associated Commentary, and/or the Federal Highway Publication HEC 18 "Evaluating Scour at Bridges".

7.7 NEW BRIDGE DESIGN

7.7.1 BRIDGE LAYOUT

The following items shall be considered when the initial bridge layout is prepared:

- All bridge spans shall be simply supported. Continuous spans are not permitted.
- Railroad bridges shall be laid out in the direction of increasing mileposts.
- All girders shall be oriented parallel to the track. For bridges through curves, the girders, abutments, and piers shall be located with reference to chords.
- All diaphragms shall be oriented perpendicular to the girders/beams, and to the chords of tracks on curved structures.
- The bridge shall be located to provide optimal railroad grade, profile, and alignment of structures and the track.
- The distance from the centerpoint of bridge to the nearest milepost shall be shown on the plan. Bridges shall be identified by the milepost of the center point.
- The preferred angle of roadway crossings relative to the centerline of track is 90 degrees. However, in locations where a 90-degree crossing is not practical, the angle of the roadway crossing relative to the centerline of track shall not exceed 30 degrees.

- The skew angle for structures utilizing precast concrete slabs or concrete box girders shall not exceed 15 degrees. Skewed through girder structures are not permitted without an approved design exception by Metra.

- Walkways (or a minimum of 10'-0" clearance to the handrail) are required on both sides of the track. This includes all temporary spans required during construction. On temporary structures with multiple tracks, the centers shall be filled.

- Vandal fencing shall be provided on all underpass structures in urban areas and on underpass structures in rural areas where pedestrian traffic patterns, history of vandalism, or other conditions near the project site may warrant the use of vandal fencing.

- Bridge structures shall be designed in a manner to permit inspection and future maintenance. Provisions shall be made for replacement of bearings. Jacking locations shall be appropriately detailed.

- The exterior overhang of the deck slab, measured from the centerline of the outside supporting member to outside face of curb, shall not exceed 4'-0". Any steel supporting member added due to this requirement shall be of the same section as those used under the track. Any such exterior beam added shall be assumed to carry an appropriate portion of the dead load.

7.7.2 DESIGN LOADS

Bridges and other civil structures shall be designed for all loads specified in Chapters 7, 8, 9, and 15, as applicable, of the AREMA MRE

Design loads shall include provisions for the potential presence of future additional tracks. The designer shall assume that these tracks may be located anywhere on the structure.

Under normal working loads, some composite action may be expected between a concrete deck and its supporting steel members, regardless of whether shear transfer devices are furnished. The bottom of the deck slab shall be placed at least one inch below the top of supporting steel members. For design purposes, however, the supporting steel members shall be proportioned to carry the entire load (Cooper E-80) without taking into account any stresses which may be induced in the concrete slab by composite action. Composite action may be assumed in the calculation of live load deflection to meet the requirements of AREMA 15.1.2.5 for concrete decks and steel decks that have adequate shear transfer connections.

Shear transfer devices shall be installed for bridges with concrete decks supported by steel members.

7.7.2.1 DEAD LOADS

In addition to the actual self-weight of the structure, the following dead loads shall be applied as applicable:

Track rails, inside guard rails, and their fastenings	200 pounds / linear foot of track
Ballast and ties (combined)	120 pounds / cubic foot
Hot-mix asphalt (HMA) underlayment	140 pounds / cubic foot
Earth-filling materials	120 pounds / cubic foot
Waterproofing and protective covering	Estimated weight
Future utilities	Five pounds / square foot of deck

Dead load for bridges shall include a minimum of 18 inches and a maximum of 30 inches of ballast from top of deck to top of tie to allow for additional ballast placement during future track raises. Structures shall be constructed to the required grades with the minimum depth of ballast under the tie of eight inches for timber ties.

7.7.2.2 LIVE LOADS

All structures subject to rail live load shall be designed for AREMA Cooper E-80 loading, except for steel superstructures that are governed by the AREMA Alternate Live Load on 4 Axles (AREMA MRE Figure 15-1-3).

For multiple track structures, the track shall be assumed as placed anywhere on the structure. The number of tracks on the structure shall be determined using a minimum track spacing of 13’-0” on center.

The live load distribution to supporting superstructure elements shall be in accordance with AREMA MRE Chapter 8, Section 2.2.3.c for concrete span elements, and AREMA MRE Chapter 15, Section 1.3.4 for steel span elements. This means that it shall not be assumed that the live load is necessarily equally distributed to the concrete or steel span elements supporting the track(s).

The live load distribution shall consider waterproofing and any underlayment or protection course as needed, as well as the future case of 12 inch additional ballast.

7.7.2.3 IMPACT AND ROCKING EFFECT

Impact and rocking effect shall be in accordance with AREMA. The impact load prescribed by AREMA shall be used for the material under consideration for design. For example, the provisions of AREMA MRE Chapter 8 will apply for a concrete pier cap and Chapter 15 will apply for a steel pile above groundline, regardless of the superstructure type.

7.7.2.4 LONGITUDINAL FORCES

Longitudinal force on bridges shall be distributed in accordance with AREMA MRE Chapter 15 (including the Commentary). The longitudinal deflection of the structure due to the longitudinal force shall not exceed one inch. Vertical reactions at girder bearings resulting from the applied longitudinal force and associated force couples (if any) shall be considered in the substructure design.

For simultaneous loading from two or more tracks, the proportion of longitudinal force per track shall be used in conjunction with the specified live load in accordance with the AREMA MRE Chapter 8, Section 2.2.3.c(6).

7.7.2.5 DERAILMENT

The supporting members whose centerlines measure not more than 11’-0” from the outside face of curb shall be considered as carrying the derailed load. An impact load, equal to 0.8 x live load (80 percent of live load), shall be provided. Allowable unit stresses in steel (or φVn and φMn for concrete) shall be not more than 70 percent greater than the normal allowable unit stresses.

7.7.2.6 SEISMIC DESIGN CONSIDERATIONS

Seismic design shall comply with AREMA MRE Chapter 9.

7.7.3 STRUCTURE TYPE SELECTION

A structure selection analysis shall be performed for all structures. A bridge type study shall then be developed that includes the results of the structure selection analysis, and all backup information shall be included in the study appendices. This study shall be submitted to Metra prior to 30 percent design.

The analysis shall consider and include, at a minimum, the following:

- Ease of construction, compatibility with operational requirements during construction, and construction scheduling constraint.
- Economy, durability, and maintenance needs. To provide the specified design life, maintenance requirements of competing alternates should be evaluated by using lifecycle costing methodologies. Assumptions of lifecycle costing methodology shall be documented in the report.
- Geometry of the feature being crossed and optimization of span length
- Structure depth restrictions due to vertical clearance and hydraulic requirements
- Number of tracks
- Track horizontal and vertical alignment
- Available ROW
- Subsurface conditions
- Drainage
- Physical constraints near the structure (e.g., at-grade crossings, utilities, overhead structures)
- Environmental issues

The analysis shall compare the structure types (including spans, substructures, and foundations) and their impacts on a) the project cost and schedule, b) the environment, and c) existing physical constraints.

The result of the analysis shall be a recommended structure type that balances the impact on costs (short term, including impacts on physical constraints and track outages during construction, and long term, including maintenance and track outages for possible damage), schedule, and the environment. It is not acceptable to recommend a structure type that deviates from Metra standards based solely on cost.

The design shall address construction sequencing during the early phases of the design and structure selection process. The design shall minimize Metra signal changes for the existing track(s) and shoofly (if applicable). In the case of highway-rail grade crossing structures, the preferred sequence is to close the highway or relocate traffic to another location rather than providing a temporary highway crossing at the site.

Structures are to be designed to be redundant and remain serviceable after damage by accidents.

The use of timber is not permitted for new permanent structures, except for use as track ties.

7.7.3.1 SUBSTRUCTURE AND FOUNDATION TYPES

Each structure site poses a unique set of circumstances for substructure and foundation type selection.

The geotechnical engineer of record shall review existing subsurface data and, if appropriate, shall conduct additional site investigation to obtain surface data necessary to provide a recommendation of the foundation type. A deep foundation (piles or drilled shafts) shall be used when a shallow foundation cannot be designed to carry the applied loads safely and economically. It shall also be used where scour, erosion, or unacceptable settlements may occur, and the soil conditions permit its use, even though bearing capacity of the soil is sufficient to make use of shallow foundations.

The following foundation types are preferred:

- Driven steel H-pile
- Precast/prestressed concrete pile
- Cast-in-place concrete-filled steel pipe pile (pipe may be used as a sacrificial form in brackish areas or in corrosive soils)
- Cast-in-place concrete drilled shafts (rock sockets may be required to achieve bearing requirements)
- Spread footings
- Micropiles

The foundation types have no order of preference; the preferred type shall be determined by site geotechnical investigation.

Open and encased pile substructures shall have a minimum of three piles per transverse row of piles. Concrete piers shall either be solid wall piers (minimum 4'-0" in thickness) or shall have a minimum of two columns.

Bridge piers adjacent to roadways shall be protected from vehicular traffic in accordance with AASHTO and the State Department of Transportation standards.

Special consideration shall be given for construction under rail traffic. Foundation and substructure elements shall be positioned and designed in such a manner to reduce their impact on rail traffic when constructed. An example would include driving a pile through an existing bridge deck in a manner that does not interfere with the existing rail. Precast elements shall also be considered for accelerated construction. An example would include the addition of a precast riser block to pier caps to allow the pier cap to be constructed initially below the existing low chord.

Abutments skewed relative to the centerline of track shall include an extension to the backwalls and seats perpendicular to the track to provide a uniform transition and support for the track from the approach embankment to the bridge deck. This extension shall be full depth of the backwall and seat.

The substructure shall accommodate the possibility of future superstructure widening without requiring significant modifications to the seats, backwalls, and wingwalls.

Spread footings shall not be used to support structures in a stream or river environment without protection from undermining. All new structures to be placed in a stream or river environment shall have a scour analysis performed and included as part of the calculation package.

7.7.3.2 SUPERSTRUCTURE TYPES

Railway superstructures shall be constructed with concrete and/or steel materials.

The superstructure shall accommodate anticipated future expansion, minimizing any modifications needed to the superstructure and disruption of Metra operations.

The following is a list of underpass structure types that are acceptable to Metra, listed in the order of preference. Metra's preferred superstructure type is the highest listed feasible alternative unless a detailed type selection report provides justification that a lower alternative is more beneficial to Metra and to the project.

- Rolled beams with steel or concrete deck. There shall be a minimum of two beams per rail, with a sacrificial beam on each side of the track (i.e., six total for single track, 10 total for two tracks).
- Steel plate girders with steel or concrete deck. There shall be a minimum of two girders per rail, with a sacrificial girder on each side of the track (i.e., six total for single track, 10 total for two tracks).
- Prestressed precast concrete box beams for spans less than 50'-0".
- Prestressed precast AASHTO-type beams with concrete deck for spans less than 50'-0".
- Steel through plate girders with steel plate deck will only be considered when conditions preclude any other structure type.

Cast-in-place concrete superstructures are not permitted.

7.7.4 CLEARANCES

7.7.4.1 PERMANENT VERTICAL CLEARANCES BELOW STRUCTURE

Underpass structures shall be designed to ensure that the structure will be protected underneath from oversized or unauthorized loads by providing sufficient vertical clearance and protective devices unless otherwise specified by Metra.

Minimum vertical clearances stipulated by the city, county, state, etc. shall not be violated. Legal requirements must be adhered to unless written permission for a waiver is provided by the appropriate regulatory authority.

All structures with vertical clearances less than 15’-0” shall be protected with a sacrificial device in the form of a redundant steel beam on each side of the structure.

The vertical clearance shall not be violated due to the deflection of the superstructure, the use of a sacrificial impact protection device, or any other reason.

Information concerning roadway profile and design roadway vehicle shall be documented and considered in the vertical clearance design.

Any request for variance from the vertical clearances defined above shall be subject to the design exception and deviation process (Section 2.3.1). The variance request shall provide exhaustive justification. Cost shall not be the determining factor.

7.7.4.2 PERMANENT HORIZONTAL AND VERTICAL CLEARANCES ON STRUCTURE

Permanent horizontal and vertical clearances on an underpass structure shall conform to the requirements of AREMA Chapter 15, Section 1.2.6, with the following modifications:

- The minimum horizontal clearance to the handrail from the nearest track shall be 10’-0”. Handrail components shall not extend over the inside face of curb.
- The minimum horizontal clearance from centerline of track to the inside face of curb shall be 9’-6”.
- On bridges with tracks on curved alignment, the horizontal clearances shall be increased either 6 inches total or 1.5 inches per degree of curvature, whichever is greater.
- Proposed structures to accommodate multiple tracks – existing and future – with spacing less than 20 feet shall be designed to accommodate a minimum 20-foot spacing measured centerline to centerline.

The minimum horizontal clearance between bottom flanges of steel beams and girders shall be 18 inches.

7.7.5 BRIDGE BEARINGS

Bridge bearings shall be designed in accordance with AREMA Chapter 15, Part 5. Allowable bearing pressures for concrete structures can be found in AREMA Chapter 8, and steel structures can be found in AREMA Chapter 15.

Selection of bearing type shall be based upon the criteria found in AREMA MRE Chapter 15, Section 5.1.5. The use of pot-type multi-rotational bearings is not permitted. All bearings shall have a physical restraint detail to provide resistance to shear and ensure the bearings do not shift under load. It is recommended to use fixed bearings at abutments to reduce the longitudinal deflections of the structure due to longitudinal forces by allowing the forces to be resisted by the passive pressures behind the abutment. Analysis of deflections may be based upon relative stiffness or other method; calculations shall be provided for review and approval.

7.7.6 BRIDGE DECKS

7.7.6.1 GENERAL REQUIREMENTS

All new structures shall include a ballasted deck. Open deck spans and direct fixation of rail to the superstructure are not permitted.

The preferred deck type is a concrete deck for superstructures consisting of rolled beams or deck plate girders. Through plate girder and truss spans shall utilize steel decks. The deck and curbs/ballast retainers shall be designed to prevent ballast or other material from spilling through and falling to the roadway or waterway below.

The deck shall be a uniform ballast pan across all tracks and provide for a ballast walkway between all tracks and on the field side of the exterior tracks. Intermediate curbs are not permitted.

Curbs shall include provision for two, four-inch ducts each to accommodate signal and utility needs. A detail shall be provided in the plans for the tie-in between the conduits in the curbs on the bridge to the corrugated metal pipe conduits off the bridge.

The deck width shall be a function of the future track and access road requirements, the number of existing tracks, the minimum 9’-6” horizontal clearance to the curbs, the curb thickness, and a minimum 20’-0” spacing between centerlines of all tracks.

The minimum required depth of ballast shall be eight inches, measured from the top of waterproofing protection panels to the bottom of tie. Metra may require 12 inches below timber ties to accommodate the future use of concrete ties at that location.

Pairs of inner guardrails are required on the gage side of the track at through trusses, pony trusses, deck trusses on towers, deck plate girders on towers, through plate girders with spans over 100 feet, movable spans, and any other structures as designated by Metra. Temporary open deck shoofly spans shall add guard timbers on the field side of the track. Metal guardrails and guard timbers shall be in accordance with AREMA MRE Chapter 15, Section 1.2.12.

The minimum thickness of concrete deck shall be 8 inches, measured from the low points in the deck to a line parallel with the top of the supporting member.

The top of the ballast curb shall extend a minimum of 2’-0” above the bridge deck to accommodate the 12 inches of future ballast and shall be increased as necessary to accommodate additional ballast depth for other reasons (e.g., superelevated tracks).

Waterproofing membranes and asphalt protection panels shall be applied to all bridge decks, and all material shall be in accordance with the AREMA MRE Chapter 8, Part 29, and other sections of this manual. The waterproofing must be provided for the full width of the deck and the sides of curbs. A minimum six inches of ballast shall be placed as soon as practical after placement of asphalt panels to prevent distortion of the panels from sunlight.

All reinforcing in the concrete deck and curbs shall be epoxy coated.

Joint details between spans and at ends of bridges shall be watertight.

The V-drip groove located on the bottom of the deck slab shall end three feet before the face of the abutment.

If an approach grade descends toward the bridge, drainage from the approach shall be intercepted by an appropriate system so that it will not drain onto the bridge.

7.7.6.2 DERAILMENT

The deck slab beyond the outermost support shall be adequate to resist a derailment condition involving an axle load, plus an impact load equal to

$$\frac{2.333 * LL^2}{1.4DL + 2.333 * LL}$$

distributed uniformly over 5’-0” in a direction parallel to the track and 7’-6” in a direction at right angles to the track. The 7’-6” dimension shall be measured from the inside face of curb. The factored moments and shears shall not exceed 1.25 times the moment capacity φMn and φVn, respectively.

7.7.6.3 STEEL DECKS

On through girder or truss spans, or in other locations where steel decks have been approved by Metra, the following requirements shall apply for the steel deck plates:

- Steel deck plates shall be shop welded with a pair of 5/16-inch continuous fillet welds to each floorbeam or deck girder. Deck units shall be shop assembled with multiple beams per unit, and areas to be field welded shall be masked and field painted after welding is complete. Deck plates are not permitted to overhang the beam when these units are fabricated. Welds shall be applied at the interface between the edge of deck plate and the top of flange, and at the interface between the underside of the deck panel and the edge of flange, for a total of four longitudinal welds per panel.

- The closing deck plate between adjacent deck units shall be welded to the beams with continuous 5/16-inch fillet welds at each beam. After the deck plates are welded to the beam, the space between the deck plates shall be filled with bituminous mastic or other approved material compatible with the deck waterproofing membrane being utilized on the structure.

- The minimum thickness of the steel deck plates shall be as follows:

Plate Thickness	Maximum Clear Distance Between Beams
1/2”	1’-6”
5/8”	2’-0”
3/4”	2’-4”

- For multiple deck girders with steel deck plates, a field splice shall be welded in the deck plate at or near the centerline of bearing of the girders. A closing deck plate shall be provided, spanning from the abutments to this field splice that is normal to the girders and normal to the long direction of the main deck plates to avoid splicing deck plates over the abutment backwall.

7.7.6.4 DECK DRAINAGE

The top surface of the deck shall be sloped transversely not less than one percent to drain. The deck shall be sloped away from the parapet to prevent ponding against the parapet. Low points in the top of deck shall be located not less than 6’-0” from the centerline of the track and shall be within the outside beams or girders of the bridge. If the bridge is a multiple track structure, a deck drain shall be placed between adjacent tracks.

Concrete decks shall be designed and constructed to direct water to deck drains. When a deck is level, or the slope is less than 0.5 percent hot-mix asphalt (HMA) underlayment shall be used to provide the required slopes. An end dam, two inches minimum above top of crown, shall be provided to prevent water from flowing off the end of each span.

A longitudinal collection system shall be provided to dispose of the drainage without permitting it to enter the ballast section or backfill beyond the bridge. The collection system shall have a minimum slope of one percent to provide positive drainage. Deck drains shall be cast iron and the down spouts shall be ductile iron. Deck drains shall have a heavy-duty grate cover. Downspout shall be provided with clean outs in each direction.

7.7.7 WATERPROOFING AND DAMPPROOFING

7.7.7.1 WATERPROOFING

The following requirements pertain to the furnishing and installation of all materials for the waterproofing of concrete or steel ballasted decks with a butyl rubber membrane waterproofing system.

All waterproofing materials and installation, including the asphalt panel protective covering, shall be comprised of compatible materials and shall be in accordance with AREMA MRE Section 8, Part 29, unless otherwise noted herein.

The butyl rubber sheeting shall not be less than 3/32-inches thick and shall be furnished in sheets as large as feasible to keep the number of field splices to a minimum.

Rubber-based bonding adhesive for securing the butyl rubber membrane shall be compatible with the membrane and with the material with which it is bonded. It shall remain workable to its brittle point (-40 degrees F). It shall be applied in accordance with the manufacturer's directions and shall conform to the following requirements:

- Viscosity 2,000 – 2,500 cps
- Total Solids 32 – 35 percent
- Base Synthetic Rubber
- Color Transparent

Samples of the sheeting and adhesive, and evidence that the sheeting and adhesive meet the required physical and resistance requirements, shall be submitted to Metra for approval.

Field splices shall be of the tongue and groove type. The grooves shall be formed by heat vulcanizing a supplemental piece to the sheeting in the factory. The field splices shall be made by using butyl gum tape at the upper and lower contact surfaces of the splice and cementing the parts of the joint together with approved cement. Samples of the joint, tape, and cement shall be submitted to Metra for approval.

The sealing compound for sealing unavoidable gaps between asphaltic panels shall be compatible with materials containing bitumens and any other materials in contact with it. The type of sealing compound, with evidence of compatibility, shall be submitted to Metra for approval.

The asphalt mop coat shall conform to the requirements of ASTM D449, Type 2. As an alternative to the asphalt mop coat, a third layer of asphalt protection may be added.

Where an underlayment is necessary to achieve proper longitudinal deck slopes for drainage, HMA shall be used. The use of other underlayment types, including Portland cement with welded wire fabric reinforcement, is subject to the design exception and deviation process (Section 2.3.7).

All material shall be handled and stored in accordance with the manufacturer's recommendations.

7.7.7.2 DAMPPROOFING

All surfaces of concrete masonry that will be in contact with backfill or embankment shall be dampproofed, with asphalt primer and asphalt, in accordance with AREMA MRE Chapter 8, Part 29, and the following:

- Surfaces to be dampproofed shall be covered with a uniform coat of hot primer at a rate of one gallon per 100 square feet.
- After the primer has been allowed to cure, two successive uniform mop coats of hot asphalt shall be applied at a rate of 4-½ gallons per 100 square feet per each coat. The first coat shall be allowed to cure before the second coat is applied.

7.7.8 WALKWAYS AND HANDRAILS

See Section 7.10 Walkways and Handrails for requirements.

7.7.9 STRUCTURAL STEEL

Structural steel shall be in accordance with AREMA MRE Chapter 15 and as stipulated herein. In case of discrepancy, the more stringent criteria shall govern.

All structural steel shall be painted. Steel preparation and painting shall be in accordance with all Metra requirements.

7.7.9.1 MATERIALS

7.7.9.1.1 FRACTURE CRITICAL MEMBERS

All Fracture Critical Members (FCM) as defined by AREMA shall be designated as FCM on the plans, and all required testing procedures for FCM shall be noted in the plans. In addition to those members designated as FCM by AREMA, all welded plate girders shall be considered as fracture critical, regardless of any provided redundancy.

All FCM shall be fabricated in accordance with the Fracture Control Plan in AREMA Chapter 15, Section 1.14.

The fabricator shall be certified under the AISC Quality Certification Program as follows:

- Welded Plate Girders Category III
- Certified Bridge Fabricator – Intermediate or Advanced

Except as noted in the AREMA Fracture Control Plan, structural steel shall meet the current requirements of the ASTM Specifications for Structural Steel, Designation A709, Grade 50, and the following supplementary requirements:

- SS-F2 (Fracture Critical – Charpy Test Zone 2)
- S29 (Fine Austenitic Grain Size)
- S93 (Limitation on Weld Repairs)

Extraordinary care shall be taken in the handling of FCMs. Lifting dogs, tongs, grips, chains, cables, or other lifting devices placed in direct contact with the FCM that may gouge, scratch, score, scrape, or otherwise damage the surface, edges, or corners of FCMs shall not be used.

Procedures for handling FCMs using lifting straps, timber cushions, or other protective devices shall be developed and submitted to Metra for review and approval prior to handling any materials designated as FCM.

7.7.9.1.2 NON-FRACTURE CRITICAL MEMBERS

All primary members or components requiring improved notch toughness shall be identified on the plans.

The fabricator shall be certified under the American Institute of Steel Construction (AISC) Quality Certification Program as follows:

- Welded Plate Girders Category III
- Certified Bridge Fabricator – Intermediate or Advanced

Structural steel plates and shapes used as primary members or components shall meet the current requirements of the ASTM Specifications for Structural Steel, Designation A709, Grade 50, and the following supplementary requirements:

- SS-T2 (Non-Fracture Critical – Charpy Test Zone 2)
- S29 (Fine Austenitic Grain Size)

The minimum thickness of any steel member is one-half inch.

Preformed bearing pads shall be provided.

The bearing sole plates shall be welded directly to the girder flanges in the shop to help ensure proper alignment with the bearing stiffeners. The minimum thickness of any sole plate is one inch.

Flanges of plate girders shall be no greater than three inches in thickness.

Inspection walkways shall be installed between any girders which have a depth of 5’-0” or more beneath the deck.

No more than two tracks are permitted on through plate girder structures. The use of intermediate through plate girders in double track applications will not be permitted.

All stringers for through plate girder and truss applications shall frame into floorbeams.

End floorbeams of through plate girders and trusses shall be provided and connections shall be designed such that the bridge can be jacked up by placing jacks between the end floorbeams and the pier or abutment. Jacking stiffeners shall be provided at points of jacking.

Intermediate floorbeams of through plate girders and trusses shall frame into the girder web or chord members using double connection angles and high strength bolts.

All stringers shall have top and bottom flanges clipped at an angle not greater than 45 degrees to permit field removal and installation.

Embedded steel plates shall meet the requirements of ASTM A36 or A709, Grade 36, or greater.

Shear studs shall be C1015, C1017, or C1020 cold drawn steel conforming to ASTM A108.

Threaded rods/inserts shall conform to ASTM A706.

All material shall be handled in a manner that will prevent members from being distorted or damaged. Stored material shall be piled securely. Material shall be placed on level platforms, skids, or other supports above the ground and shall be kept clean and properly drained to prevent corrosion. Girders and beams shall be supported on skids placed near enough together to prevent damage from deflection.

All materials shall be carefully loaded to avoid damage in transit, and in accordance with the following:

- Girders shall be shipped in an upright position and adequately blocked and braced to prevent damage during shipping. The fabricator shall submit girder loading diagrams to Metra for approval well in advance of the anticipated shipping date. These diagrams shall include proposed blocking, bracing, and tie-down details. Metra shall not be liable for damage to the steel during shipment or any other property during transport.

- Members weighing more than three tons shall have the weight marked.

- All small parts such as rivets, bolts, pins, washers, and small connection plates shall be packed in containers of adequate strength. The contents of each unit shall be plainly marked on top and side of each container.

7.7.9.2 LAYOUT

7.7.9.2.1 INTERMEDIATE STIFFENERS

All intermediate stiffeners shall be welded to the top flange.

A bolted stiffener connection plate is required at the bottom flange connection if the stiffener is opposite a diaphragm on the other side of the web. If an intermediate stiffener is not connected to a diaphragm and is not opposite a diaphragm on the other side of the web, it should not be attached to the bottom flange; it should be a “tight fit” with no weld and no stiffener connection plate.

The stiffener connection plate shall be bolted to the flange prior to welding to the stiffener (if the stiffener is welded).

Intermediate stiffeners shall be provided on exterior girders and beams opposite diaphragms on the other side of the web.

7.7.9.2.2 BEARING STIFFENERS

Bearing stiffeners shall be milled to bear or welded to the top flange with a full penetration groove weld.

Bearing stiffeners shall be milled to bear or welded to the bottom flange with a full penetration groove weld. The addition of a stiffener connection plate which is bolted to the bottom flange (similar to the intermediate stiffener application) is also permissible.

7.7.9.2.3 CROSS FRAMES AND DIAPHRAGMS

Supporting steel members having a depth greater than 3’-6” and spaced more than 4’-0” on centers shall be braced with cross frames.

The angle of cross frame diagonals with the vertical shall not exceed 60 degrees or be less than 30 degrees.

Supporting steel members not requiring cross frames shall be braced with approved diaphragms that are as deep as the member will permit. The diaphragms shall be connected to the member’s web by means of bolting suitable angles or welding equivalent connection plates.

Cross frames and diaphragm spacing shall not exceed 12 feet.

Jacking stiffeners are required in all end diaphragms. Any alternative jacking locations shall be submitted to Metra for review and approval, with jacking stiffeners provided as appropriate.

Access holes, minimum 15-inches in diameter, are required in all end diaphragms. Access holes are not required for intermediate diaphragms.

7.7.9.3 BOLTED CONNECTIONS

All bolted connections shall be in accordance with AREMA MRE Chapter 15, and high strength bolts shall meet the requirements of the ASTM Specifications for High Strength Bolts for Structural Steel Joints, Designation F3125, Grade A325. Grade A490 bolts shall not be used. Connections shall be designed as slip-critical for Class “A” contact surfaces.

The minimum high strength bolt diameter for structural steel connections shall be 7/8 inch.

The minimum anchor bolt diameter for bearings is 1-¼”.

Permanent bolted connections using high strength bolts shall be installed and tightened using the turn-of-the-nut method.

Tension control bolts are not permitted.

High strength bolts shall be mechanically galvanized in accordance with ASTM B695. Hot-dipped galvanized high strength bolts are not permitted.

When lateral bracing systems are required for plate girders, then the connections to the girders shall be bolted.

Nuts shall meet the requirements of ASTM A563.

Washers shall meet the requirements of ASTM F436.

Swedged anchor bolts shall meet the requirements of ASTM F1554, Standard Specification for Anchor Bolts, 36ksi, 55 ksi, and 105 ksi yield strength.

Anchor bolt washers shall be zinc coated in accordance with ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

All packing washers, if any, must be in place when the work is assembled. While pins are being driven into place, threads shall be protected by pilot and driving nuts supplied by the Contractor. After the nuts are tightened, the threads adjacent to the nut shall be burred a minimum of two threads at two locations opposite of each other.

Connections shall be accurately fitted up before high strength bolts are placed. A sufficient number of the holes at a connection point shall be filled with erection pins to “fair-up” all holes. Light drifting will be permitted but drifting to match unfair holes will not be permitted. Such holes shall be reamed or drilled under the direction of Metra. All material within the grip of the bolt shall be steel. There shall be no compressible material such as gaskets or insulation within the grip. Bolts oriented vertically shall be installed with the heads on top of the connected pieces.

All joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of dirt, loose rust, loose scale, burrs, and other matter that could prevent solid seating of the parts. Faying surfaces of all non-galvanized joints, including splice plates, shall be given a blast cleaning, in accordance with the Steel Structures Painting Council Specifications SSPC-SP7 Brush-Off Blast Cleaning, and shall be free of loose rust prior to final bolting. Galvanized faying surfaces shall be roughened by hand wire brushing prior to final bolting.

Bolts and nuts shall be protected from dirt and moisture at the job site. Only as many fasteners as are anticipated to be installed and tightened during a workday shall be taken from protected storage.

Fasteners not used shall be returned to protected storage at the end of the day. Fasteners shall not be cleaned of lubricant that is present in the as-delivered condition.

Fasteners that show signs of rust or dirt shall be cleaned and lubricated prior to installation. Any additional lubrication required must be applied prior to installing bolts in the holes.

Bolts and associated nuts and washers shall be identified by rotational-capacity lot number and stored in a manner that will retain this identification.

7.7.9.4 WELDED CONNECTIONS

Welding electrodes for arc welding shall meet the current requirements of the specifications for mild steel arc-welding electrodes Series E70, American Welding Society (AWS) 5.1, Low Hydrogen Classification for shielded metal arc welding (SMAW) and AWS 5.17 for submerged arc welding (SAW).

Only SAW or SMAW may be used for structural steel fabrication. No other welding process will be permitted.

Flange-to-web welds of welded plate girders shall be full penetration groove welds using the SAW welding process.

No more than two flange section transitions shall be permitted.

Welded splices will not be allowed in plate elements of bolted flanges.

7.7.9.5 SHOP DRAWINGS

Shop drawings shall follow the requirements of AREMA MRE Chapter 15, Section 1.1, except as described below.

The Contractor shall furnish an electronic set of detailed shop drawings in PDF format to Metra for review and approval prior to starting fabrication. Unchecked drawings shall not be submitted. By approving and submitting shop drawings, the Contractor represents that all field measurements, field construction criteria, materials, catalog numbers, and similar data have been determined and verified, and the shop drawings have been checked and coordinated with the requirements of the work and the Contract Documents. Included in the shop drawing submittal shall be the welding procedures associated with the shop drawings. After approval of the shop drawings, the Contractor shall supply Metra with one electronic set of the approved fabrication drawings.

The rejection of or the procedure for the correction of the shop drawings will not be considered as cause for delay.

Approval of the shop drawings by Metra shall not relieve the Contractor from furnishing material of proper dimensions, quantity, and quality, nor will such approval relieve the Contractor from the responsibility for errors of any sort in the shop drawings.

7.7.9.6 SHOP INSPECTION AND TESTING

Metra may arrange for inspection by an independent inspection firm under a separate contract. This inspection will be in addition to the fabricator’s Quality Control Program.

The fabricator shall notify Metra and its inspector of the scheduled date for beginning fabrication and shall not begin fabrication until Metra’s inspector is present.

The fabricator shall furnish copies of certified mill inspection reports to Metra for all structural steel requiring improved notch toughness.

The fabricator shall furnish copies of their fabrication procedures to Metra for review and approval. The procedures shall include, but not be limited to, the following, as applicable:

- Plate girder fabrication
- Non-FCM weld repairs
- FCM non-critical weld repairs
- Correction of camber
- Horizontal curvature
- High strength bolting
- Warpage and tilt of flange correction
- Repair of mislocated holes
- Plate straightening
- Girder flange bending
- Shop inspection procedure

The fabricator shall meet the requirements of the AREMA Fracture Control Plan described in AREMA MRE Chapter 15, Section 1.14 for all members and components designated as fracture critical.

All critical repairs of welds shall be submitted to Metra for review and approval prior to commencing the repairs. The repairs shall meet the requirements of AWS D1.5 12.17.6, which includes adequately describing the deficiency and the proposed method of repair. The repair procedures shall detail the location(s) of the discontinuity in the member. The submission shall also include a welding procedure specification (WPS) that shall be based upon AWS D1.5 Section 3 and an acceptable procedure qualification record (PQR). The WPS shall include, at a minimum, the following:

- Type of material and weld process
- Joint detail

- Position of the weld
- Filler metal specification AWS
- Electrode and manufacturer
- Single or multiple pass

Weld repair soundness shall be verified by Ultrasonic Testing (UT), Magnetic Particle Testing (MT), or other testing as required by Metra.

For the first weld repair, UT will be performed on 100 percent of non-critical and critical full-penetration welds on all fracture critical weld repairs. All welds will receive 25 percent MT.

If after the first weld repair an unacceptable weld is still found through testing as noted above and the Contractor elects to repair the weld, the Contractor will be required to submit written weld procedures as defined above. A second weld repair will be automatically deemed as a critical repair.

If after the second weld repair an unacceptable weld still exists, the Contractor will be required to:

- Complete all submissions as noted above, and approval must be obtained from Metra prior to commencing the work. 100 percent UT and MT will be required. In addition, due to the amount of times the section has been heated, Hardness testing will be required per AWS D1.5, Section 4.10.4.1.

If after a third weld repair, UT, MT, or Hardness testing fail to provide an acceptable result, then the girder shall be rejected, and a new girder shall be fabricated.

Welding inspection shall verify that all welds and welding procedures meet the requirements of the current American Welding Society (AWS) Bridge Welding Code, D1.5.

All welds shall be inspected visually and by use of nondestructive testing. All nondestructive testing shall be performed by the fabricator and witnessed by the railroad's inspector.

Weld inspection shall be performed in a timely manner without disruption of normal shop operations. Copies of all weld inspections and nondestructive testing reports shall be furnished to the Railroad.

The fabricator shall perform the following weld inspection and testing:

- Unless noted otherwise herein, all structural steel welds shall be tested in accordance with the current AWS Bridge Welding Code, D1.5.
- All transverse tension groove welds in FCM, when allowed by Metra, shall be RT and UT tested 100 percent. In non-FCM components of FCMs, all transverse tension groove welds shall be RT and UT tested 100 percent.
- Butt welds in both girder flanges and girder webs shall be 100 percent radiograph tested (RT).
- 50 percent of flange-to-web welds shall be inspected by ultrasonic testing (UT).
- All flange-to-web fillet welds, if allowed by Metra, are to be magnetic particle tested 100 percent.
- Ten percent of all welds not mentioned above shall be magnetic particle tested.

Deck plate-to-floorbeam or longitudinal girder welds may be visually inspected.

7.7.9.7 ERECTION

Before starting work, the Contractor shall submit an erection plan consisting of proposed methods, equipment, etc., to Metra for review and approval.

Metra's approval shall not relieve the Contractor of the responsibility for the safety of the method or equipment, or from carrying out the work in full accordance with the plans, specifications, and supplemental specifications.

No field welding or flame cutting will be allowed on steel spans.

Tack welding, for the purpose of eliminating field erection bolts or for holding steel parts together while bolting, will not be permitted.

The Contractor shall provide the falsework, erection devices, all tools, and machinery work. Drift pins sufficient to fill at least half of the bolt holes for main field connections shall be provided.

The falsework shall be designed by a Professional Engineer, licensed in the State of the work being completed, constructed in accordance with the Contractor's plans as approved by Metra, and shall be properly maintained. Equipment for removing falsework shall not be supported on or attached to any portion of the new structure.

All steel beams or girders placed shall be securely tied and/or braced to prevent overturning immediately after erection, and until diaphragms, floorbeams, or cross frames are permanently in place. The methods to be used shall be submitted on the erection drawing.

When railroad or roadway traffic must be maintained beneath girders or beams already placed, traffic shall be protected against falling objects during the erection of any structural members, during the placing of cast-in-place concrete, and during the erection and dismantling of forms. The protection shall consist of nets and/or flooring with no larger than one-inch openings.

Steel construction shall be cleaned and painted.

7.7.9.8 ABRASIVE BLASTING

Abrasive blasting operations shall be conducted in full compliance with all current national primary and secondary ambient air quality standards 40 CFR 50 (for particulate matter - 40 CFR 50.6; Lead - 40 CFR 50.12, and nuisance dust). Abrasive blasting operations shall also be compliant with all applicable local and state air quality requirements.

All collection, containment, disposal, and transportation for disposal must be compliant with all applicable federal, state, and local air pollution, water pollution, solid waste, and hazardous waste regulations, ordinances, or statutes.

7.7.10 CONCRETE

Concrete for structures and foundations shall be in accordance with AREMA MRE Chapter 8, and as stipulated herein. In the case of discrepancy, the more stringent shall govern.

The Contractor shall furnish and deliver to the jobsite the required materials as specified on the plans or in other project documents, including this manual. The Contractor shall unload and stockpile materials in an orderly manner at locations designated by Metra.

Materials shall be protected from damage due to weather. No deteriorated or damaged material shall be used.

The Contractor shall submit shop drawings for steel reinforcement, construction joint layout, and mix designs for review and approval by Metra prior to commencing the work.

Anchor bolts to be placed in new concrete shall be installed in preformed holes rather than drilled holes.

Footings for all substructures shall be located and designed to allow a minimum of 10 feet measured perpendicular to the nearest active track from the face of shoring required to facilitate footing construction.

7.7.10.1 ABUTMENTS

Abutments shall be designed in accordance with the requirements of AREMA MRE Chapter 8, with the following additional requirements:

- The abutments shall be wide enough to provide for a 14’-0” shoulder, measured from the centerline of the nearest track on each side. In case of multiple track bridges, the abutment width shall be sufficient to provide for a standard 14’-0” shoulder on both sides of the exterior tracks (or both tracks if two tracks). Wingwalls shall be designed to support two horizontal: one vertical embankment slopes. Mechanically Stabilized Earth (MSE) and sheet pile walls are not permitted as wingwalls.

- There shall be a minimum of four inches between end of structural steel and face of backwall.

- The front face of backwall and centerline of track shall serve as reference for the abutment layout.

- A minimum edge distance of six inches shall be provided from the edge of the masonry plate or shoe to the edge of concrete.

- The minimum wall thickness for high abutments, at the base, shall be 0.2 times the height of abutment, measured from the top of footing or pile cap to abutment seat.

- Underdrain pipes are required behind bridge abutments and shall be installed along the face of the abutments, even on skewed structures. The pipes shall be perforated, bituminous coated corrugated metal pipe and shall be a minimum eight inches in diameter. Polyvinyl chloride (PVC) underdrain pipes are not permitted.

- The drainage system shall collect the water from behind the abutment using a drainage blanket of two feet of porous backfill material. The drainage system shall be connected to non-perforated pipe and shall be piped to daylight, tied into a curb and gutter system, or tied into a storm sewer system, with a minimum one percent slope.

- Handrails shall be provided on the tops of wingwalls. A minimal separation shall be provided between the handrails on the bridge deck and the handrails on the wingwalls to prevent a falling hazard. See Section 7.10.2 for handrail requirements.

- The top surfaces of abutments and piers not covered by bearing pads shall be sloped to drain.

- At certain locations, where the face of the abutment or retaining wall stem is exposed to public view, it may be desirable to treat the face architecturally. Such treatment may include the use of textured form liner, sandblasting, or bush-hammering. Such architectural treatment shall not reduce the minimum clearances for reinforcing steel as specified in AREMA and as otherwise stipulated in this manual, nor shall it be permitted to reduce the effective wall section.

- Sloping embankments in front of the abutments shall be paved or have grouted rip rap on top of filter fabric.

7.7.10.2 DRILLED SHAFTS

Drilled shafts for piers and abutments shall be designed in accordance with other sections of this manual.

Drilled shafts within the influence of track live load surcharge shall be designed with temporary casing for protection against cave-in, subsidence, and/or displacement of surrounding ground. Casings placed within the live load influence zone shall be left in place. Casings shall be designed for live load due to the track surcharge in addition to all other loads. Drilled shafts and piling shall be designed to allow the drilling or pile driving operation to proceed without disrupting rail operations.

7.7.10.3 PIERS

Piers shall be designed in accordance with the requirements of AREMA MRE Chapter 8, with the following additional requirements:

- A minimum edge distance of six inches shall be provided from the edge of masonry plate or shoe to the edge of concrete.
- A minimum of 18 inches shall be provided beyond the outside edge of the outermost masonry plate or shoe to the end of the pier.
- A minimum clearance of four inches shall be provided between the ends of structural steel.
- Single-column piers are not permitted for underpass structures. A solid wall pier with a minimum thickness of 4’-0” or a minimum of two columns supporting each track shall be provided. The minimum column thickness at the base shall be 0.2 times the height of the column.
- Bridge piers adjacent to roadways shall be protected from vehicular traffic by use of a concrete barrier or other type of guard rail. The type, design, and detailing of the concrete barrier or guard rail that is used shall be in accordance with AASHTO standards.

7.7.10.4 MATERIALS

All cement shall conform to the following:

- Standard Concrete: Cement shall be Portland cement, Type I, IA, II, or IIA, conforming to the requirements of ASTM Designation C150.
- High Early-Strength Concrete: Cement shall be Portland cement, Type III or IIIA, conforming to the requirements of ASTM C150.
- Cement shall have an alkali content of 0.6 percent or less, expressed by percent Na2O plus 0.685 percent K2O by mass of the cement. Only one brand of cement may be used in any part of the structure, and cement of the same brand from different mills shall not be mixed or used in any part of the structure, except as approved by Metra.

- All cement shall be inspected and tested by a testing laboratory employed by Metra. Where the Contractor furnishes the cement, the Contractor shall specify in their order to the manufacturer that the cement is to be so inspected and tested and shall advise of the name and address of the testing laboratory. The Contractor shall also write to the testing laboratory, stating the location of the project, the number of barrels of cement involved, and the name and location of the mill, sending a copy of that letter to Metra.

- The minimum cement content shall be 6.50 bags/cy (610 lbs/cy).

Concrete shall be air-entrained using an air-entraining admixture of the neutralized vinsol resin type and conforming to the requirements of ASTM C260. The concrete shall have an air content between four percent and six percent, tested in accordance with ASTM C173.

Any admixtures other than air-entraining agents that are used to alter the normal properties of concrete for densifying, dispersing, retarding, accelerating, plasticizing, coloring, or waterproofing, shall be used only upon the written approval of Metra, and shall conform to the requirements of ASTM C494. Chemical admixtures for flowing concrete shall conform to the requirements of C1017.

Any admixtures other than air-entraining agents, if approved by Metra, shall be in addition to the cement content, and not in lieu of cement. Fly ash may be permitted based on application, if an appropriate, well-tested mix is proposed and if the construction process is appropriately adapted for the slower strength gain. Slag cement is not permitted. The use of fly ash shall be in accordance with AREMA MRE Chapter 8, Part 1.

Set accelerating admixtures incorporating calcium chloride are not permitted.

The minimum concrete compressive strength at 28 days shall be 3,500 psi for walls and substructure components, and 4,000 psi for superstructure elements and drilled shafts. Higher compressive strength concrete may be required if design conditions warrant. Concrete mixes shall be in accordance with the IDOT Standard Specifications for Road and Bridge Construction.

7.7.10.4.1 AGGREGATES

Coarse and fine aggregates shall be in accordance with AREMA 8.1 and the requirements of this section.

Aggregate shall meet the following impurities limits:

Maximum Percent by Weight		
Description	Fine	Coarse
Clay lumps	1.0 percent	0.25 percent
Coal and lignite	0.5 percent	0.25 percent
Alkali	Trace	Trace
Material finer than a No. 200 sieve	3.0 percent	0. 5 percent*
Other deleterious substances (such as shale, mica, coated grains, soft and flaky particles)	3.0 percent	-
Soft fragments	-	2.0 percent
Other deleterious substances (such as friable, thin, elongated, or laminated pieces)	-	1.0 percent
* When the material finer than the No. 200 sieve consists essentially of crusher dust, the maximum amount permitted shall be 1.5 percent.		

When subjected to five alternations of the sodium-sulfate soundness test, the aggregates shall show an average loss of weight of not more than eight percent for fine aggregate and 12 percent for coarse aggregate. Aggregates having a potential alkali reactivity as determined by ASTM C289 shall not be used.

Fine aggregate shall consist of coarse, sharp, hard, strong, durable, fine aggregate of nature sand, free from adherent coating; and washed to remove clay, loam, alkali, organic matter, or other deleterious substances.

Fine aggregate shall be graded from coarse to fine within the following limits:

Sieve	Percentage Passing
3/4 inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

Fine aggregate shall have not more than 45 percent retained between any two consecutive sieves, and its fineness modulus shall not be less than 2.3 nor more than 3.1. Fineness modulus is the summation of the cumulative percentages retained on standard sieve sizes (Nos. 4, 8, 16, 30, 50, and 100) divided by 100.

If the fineness modulus varies by more than 0.20 from the value assumed in selecting proportions for the concrete, the fine aggregate shall be rejected unless suitable adjustments are made in the concrete proportions to compensate for the difference in grading.

The amount of clay or loam in the fine aggregate shall not exceed 1.0% by weight. Unless otherwise specified, all fine aggregate shall conform to the requirements of ASTM C33. Particular attention is directed to the requirements of testing for:

- Organic Impurities – ASTM C40

- Soundness – ASTM C88
- Reactivity – ASTM C289

The fine aggregate, when tested in accordance with ASTM C40 and showing a color darker than the standard color, shall be rejected. A fine aggregate failing in the test may be used, provided that, when tested for mortar-making properties, the mortar develops a compressive strength at seven and 28 days of not less than 95 percent of that developed by a similar mortar made from another portion of the same sample which has been washed in a three percent solution of sodium hydroxide, followed by thorough rinsing in water. The treatment shall be sufficient to produce a color lighter than standard with the washed material.

Fine aggregate considered potentially reactive by Metra shall not be used.

Coarse aggregate shall consist of hard, durable, crushed stone or gravel.

Coarse aggregate shall be graded between the limits specified by ASTM C33.

Sampling and testing of coarse aggregate shall be in accordance with the following ASTM standards:

Sampling	ASTM D75
Sieve Analysis	ASTM C136
Weight of Aggregates	ASTM C29
Resistance to Abrasion	ASTM C131 and C535
Soundness	ASTM C88
Material Passing No. 200 Sieve	ASTM C117
Organic Impurities	ASTM C40
Coal and Lignite	ASTM C23

Clay Lumps in Aggregates	ASTM C142
Specific Gravity and Absorption of Coarse Aggregate	ASTM C127
Potential Alkali Reactivity	ASTM C289

Crushed stone or gravel tested for abrasion in the Los Angeles machine in accordance with ASTM C131 and C535 shall have a loss not greater than 50 percent, except that aggregates for pavements shall have a loss not greater than 40 percent.

7.7.10.4.2 WATER

Water shall be reasonably clear and free from oil, salt, sugar, acid, alkali, organic, and other injurious substances.

Water shall be tested in accordance with and meet the requirements of AASHTO T26 unless known to be of potable quality.

Water shall not contain impurities in excess of the following limits:

- Acidity or alkalinity: 0.05 percent
- Total organic solids: 0.05 percent
- Total inorganic solids: 0.05 percent

Water for use in concrete shall not be taken from shallow, muddy, or marshy surfaces. Where the source of water is relatively shallow, the intake shall be enclosed to exclude silt, mud, grass, or other foreign materials, and the bottom of such enclosed area shall be maintained not less than two feet below the intake of the suction pipe. Water from suspect sources shall not be used until tested and approved in accordance with ASTM C1602.

Non-potable water may be used if mortar cubes made with the water in question have seven and 28-day strengths equal to at least 90 percent of similar specimens made with the sand cement and potable water. Testing shall be performed in accordance with AASHTO T71.

7.7.10.5 INTERFACING WITH EXISTING CONCRETE

Surface preparation and anchorage shall be as specified in AREMA MRE Chapter 8, Part 14. Dowels shall be grouted in place with an epoxy grout intended for dowel bars and shall be applied in accordance with ASTM C881 and the manufacturer's recommendations. Horizontal dowel holes shall be drilled downward on a slope of approximately one inch per foot.

The surface of the existing material to which the new concrete will be bonded shall be cleaned by either sandblasting, waterblasting, hammers, or wire brushes, so that all foreign material and loose or unsound concrete is removed and a clean, sound surface remains. The exposed surface shall be washed with clean water or air cleaned with oil-free air to remove all loose dust. Grease and oil shall be scrubbed and removed with a detergent and the surface shall be washed with clean, potable water.

New concrete will be bonded to clean, sound material with an epoxy bonding compound. The bonding system shall meet the requirements of ASTM C881, Type II, Grade 1 or 2, and shall be subject to approval by Metra. The bonding system shall be applied in accordance with the manufacturer's recommendations. It is further recommended that the bonding compound be applied as a spray application by use of a Binks bottom discharge pressure vessel operating at approximately 100 psi. The bonding compound shall not be applied to surfaces that have visible or standing water.

When joining new concrete to existing concrete and the compound cannot be placed immediately prior to placing new concrete, a non-epoxy bonding compound conforming to ASTM C1059 Type II shall be applied.

7.7.10.6 COLD WEATHER CONCRETE PLACEMENT

Concrete placement in cold weather shall be in accordance with ACI 306R.

All snow, ice, and other frozen materials shall be removed from the site prior to placement.

Concrete shall not be placed when the ambient air temperature is below 40 degrees F unless authorized by Metra.

The Contractor shall place and maintain concrete at the following temperatures for a given section thickness:

- < 12 inches: 55 degrees F
- 12-36 inches: 50 degrees F
- 36-72 inches: 45 degrees F
- > 72 inches: 40 degrees F

Concrete shall be maintained at the appropriate temperature for at least 72 hours after placement to allow for initial curing. Maintain concrete at a temperature above 32 degrees F for the remainder of the specified curing period.

The Contractor shall have adequate equipment and means available to heat concrete materials. The equipment used shall heat the mass uniformly to avoid hot spots.

When concrete placement is authorized by Metra at temperatures less than 40 degrees F, the aggregates and water shall be heated to not less than 70 degrees F and not more than 150 degrees F.

Any variance to the limiting construction temperatures shall be subject to Metra's approval, but such approval shall not relieve the Contractor from responsibility for satisfactory results.

Reinforcement bars, forms, fillers, and other materials in contact with concrete shall not be less than 35 degrees F at time of placement. If the temperature falls below 35 degrees F, then the items in contact with concrete shall be preheated.

7.7.10.7 HOT WEATHER CONCRETE PLACEMENT

The temperature at the time of placement during hot weather shall not exceed 90 degrees F. Any variance to this temperature limit shall be subject to Metra's approval, but such approval shall not relieve the Contractor from responsibility for satisfactory results.

The Contractor may cool the aggregates by fogging, sprinkling, or other suitable means, provided there is no variation in the moisture content.

Crushed or flaked ice may be used as a portion of the mixing water on a pound for pound basis, provided all ice is melted before placement of concrete.

Water may be cooled by refrigeration.

Cooling of the forms and reinforcing steel shall be acceptable, except that pools of water within the forms shall not be permitted.

Rate of evaporation from concrete shall not exceed 0.2 lb/in^2/ hr based on ACI 305R Table 2.1.5. The Contractor shall apply fog spray, evaporation retardants, or other measures to stay below this rate.

7.7.10.8 MASS CONCRETE

Mass concrete requires measures to be taken to deal with the generation of heat from the hydration of the cement. In mass concrete the temperature differential between the internal concrete temperature and the surface concrete temperature may cause volume changes in the concrete, which then cause cracking. Where the minimum cross section dimension exceeds four feet, concrete shall be designated as mass concrete. However, smaller sizes may also be designated as mass concrete depending on factors including type and quality of cement, volume-to-surface ratio of the concrete, weather conditions, concrete placing temperatures, degree of restraint to volume changes, and the effect of thermal cracking on function, durability, and appearance.

Mass concrete placements shall be designated on the project drawings by the designer.

The maximum temperature in concrete after placement shall not exceed 158 degrees F.

The maximum temperature difference between center, or hottest portion of the concrete, and the surface of the placement shall not exceed 35 degrees F, unless thermal modeling is performed to determine a maximum allowable temperature difference such that thermal stresses do not exceed the tensile strength of the concrete. The thermal model shall be signed and sealed by a Professional Engineer licensed in the state where the work is to be performed.

The temperature of concrete at point of placement shall not exceed 70 degrees F, nor be less than 35 degrees F.

ASTM C150 Type III or IIIA cement (high-early strength) is not permitted.

Accelerating admixtures shall not be used unless specifically permitted by design

Unless otherwise specified, the concrete shall be cooled gradually so the drop in concrete surface temperature during or at the conclusion of the specified curing period does not exceed 20 degrees F in any 24-hour period.

Thermal control measures shall be submitted in writing and approved by Metra prior to placing mass concrete. Thermal control shall be in accordance with ACI 207.1R.

7.7.10.9 REINFORCEMENT

Reinforcing bars shall meet the requirements of this section.

Bars shall be intermediate grade, new billet steel, conforming to ASTM A615, Grade 60. Bars shall be free from dirt, paint, oil, grease, thick rust, and other foreign substances.

Reinforcing bars shall be accurately cold bent to the shapes and dimensions specified on the plans. The minimum bend diameter shall be as follows:

- Bar sizes No. 3 through No. 8: 6 bar diameters minimum
- Bar sizes No. 9 through No. 11: 8 bar diameters minimum
- Bar sizes No. 14 and No. 18: 10 bar diameters minimum

Bars shall be bent in the plane for which they are designed. Maximum allowable deviation out-of-plane shall be ½-inch for No. 7 bars and under and shall be one inch for No. 8 bars and over.

Reinforcement supports shall be all plastic or all stainless steel.

Tie wires used for tying reinforcing bars shall be a minimum diameter of No. 16 gauge, black, soft iron wire.

Dowels shall be made from new, deformed billet steel conforming to the requirements of ASTM A615, Grade 60.

Welded wire mesh shall conform to ASTM Designations A82 and A185.

Epoxy-coated reinforcing bars shall conform to ASTM A775, “Standard Specification for Epoxy-Coated Reinforcing Bars”.

Grout for anchor bolt and dowel placement shall be non-shrink, non-metallic, and conform to the requirements of ASTM C1107 and CRD C632, Grade B. The minimum compressive strength after 28 days shall be 5,000 psi.

Reinforcement shall be inspected and approved by Metra prior to concrete placement.

Reinforcement shall be placed and adequately supported before concrete is placed and shall be secured against displacement.

Reinforcement supported from the ground shall rest on precast concrete blocks not less than four inches square and having a compressive strength equal to or greater than the specified compressive strength of the concrete being placed.

Reinforcement supported from formwork shall rest on bar supports and spacers made of concrete, metal, plastic, or other materials approved by Metra.

At all formed surfaces that shall be exposed to the weather in the finished structure, bar supports, and side form spacers spaced no more than four feet on centers shall be provided. Bar supports, spacers, and all other accessories within ½” of the concrete surface shall be non-corrosive or protected from corrosion.

The minimum clear distance from the face of concrete to any reinforcement shall be as follows:

- Where concrete is deposited directly against the ground, three inches of cover shall be maintained.
- At other surfaces, minimum cover shall be two inches.

No bending of partially embedded bars will be permitted.

Bars having kinks or bends not specified on the plans or shop drawings shall not be placed unless authorized by Metra.

Splicing of reinforcing bars shall conform to AREMA MRE Chapter 8. Butt welding is not permitted. Splices must be located such that the entire lap is placed within one concrete placement, and where practicable, splices shall be staggered so the neighboring bars will not have adjacent laps. Mechanical splices are not permitted unless approved by Metra. If approved, the mechanical splice shall fully develop the strength of the reinforcing bar and shall be certified by the manufacturer.

Exposed reinforcing bars intended for bonding with future extensions shall be protected from rust and corrosion by use of adequate covering.

Tack welding of reinforcing bars is prohibited.

Reinforcement shall be continuous through construction joints.

Reinforcement shall be clean and free from loose scale, dirt, grease, oil, form release agent, dried concrete, thick rust, or other materials that reduce concrete bonding.

7.7.10.10 PLACEMENT

Concrete shall not have a free fall of more than five feet unless through an approved metal chute or tube. The tremie method shall be used for placing concrete in pipe piles, under water, in deep walls, and in other locations where concrete would drop greater than five feet. The tremie tube shall have a minimum diameter of eight inches and shall be constructed in sections having watertight joints. The discharge end shall always be entirely immersed in concrete during delivery, and the tremie tube shall be kept full until delivery is complete. The tremie tube may be supplied by pumped concrete or the traditional hopper method. If the hopper method is used, fresh concrete shall be delivered to the hopper in a consistent, uninterrupted flow. Intermittent large placements into the hopper that would vary the pressure shall be avoided.

Concrete shall be placed in uniform layers of between 6-12 inches deep and each layer shall be placed and consolidated before the next layer is placed. If it is necessary by reason of an emergency to place less than a complete horizontal layer in one operation, such layer shall terminate in a vertical bulkhead. In any given layer, the separate batches shall follow each so closely that each one shall be placed and compacted before the preceding one has taken initial set, in order that the freshly placed concrete is not injured and there is no line of separation between batches. Each layer of concrete shall have an amplitude of 3/8-inch to secure efficient bonding with the next layer above. A succeeding layer placed before the underlying layer has set shall be compacted in a manner that will entirely remove the tendency to produce a construction joint between the layers. Layers completed at the end of a day's work or placed just prior to temporarily discontinuing operations shall be cleaned of all objectionable material as soon as the surface has become sufficiently firm to retain its form. To avoid visible joints upon exposed faces, the top of the concrete adjacent to the forms shall be finished by being smoothed with a plasterer's trowel. Horizontal layers so located as to produce a construction joint at a location where a "feather edge" might be produced in the succeeding layer shall be so formed by inset formwork that the succeeding layer will end in a body of concrete having a thickness of not less than six inches.

No construction joints shall be allowed unless directed by Metra. All pours shall be monolithic where possible. Retempering (remixing) of concrete shall not be allowed. When the work of placing the concrete is delayed until the previously placed concrete has taken its initial set, the point of stopping shall be deemed a construction joint. The method and manner of placing concrete shall be so regulated as to place all construction joints across regions of low shearing stress and in such locations that they will be hidden from view to the greatest possible extent. The method and sequence of placing concrete shall be specified for the construction involved.

7.7.10.11 CURING

All concrete surfaces, except those surfaces protected by forms that remain in place five days or longer, shall be cured in accordance with AREMA MRE Chapter 8, Section 1.17 and as stated herein.

Curing shall begin as soon as the concrete has hardened sufficiently to withstand surface cleaning and immediately after forms have been removed from formed surfaces.

Surfaces requiring a Class 2 finish may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

Standard concrete shall be kept moist and at a temperature of between 50 degrees F and 90 degrees F for a period of seven days after placement. High-early strength concrete shall be kept moist and in the temperature range for at least three days. Longer periods of curing may be required when temperatures are below 50 degrees F.

Use of a fog or mist spray may be required during and after finishing until curing materials can be applied.

Failure to provide sufficient curing materials of whatever kind the Contractor may elect to use shall be cause for immediate suspension of concreting operations.

Membrane curing compounds are permitted on all cast-in-place concrete surfaces, except those that will abut other new concrete. Curing of such abutting surfaces shall utilize wet curing methods. Membrane curing shall be compatible with the specified concrete surface sealer, or the membrane curing compound shall be removed to promote adhesion of the sealer to the concrete.

7.7.10.12 JOINTS

When the structures or portions of the structures are designed to be monolithic, they shall be cast integrally, except as modified herein.

Construction joints shall be made only where shown on the plans, unless otherwise approved by Metra.

Construction joints shall be formed as follows:

- Before new concrete is placed against hardened concrete, the surface of the hardened concrete shall be cleaned, and all laitance removed.

- After the hardened surface is cleaned and immediately before the new concrete is placed, the existing surfaces shall be thoroughly wetted, and all standing water removed.

- Where a construction joint is required to resist water pressure, special care shall be taken in finishing the surface to which the succeeding concrete is to be bonded. The consistency of the concrete shall be carefully controlled, and the surface shall be protected from loss of moisture.

- A thin bonding layer of mortar, usually 1/8 inch to ½ inch in thickness, shall be spread on the moist concrete surface. Mortar shall be mixed as dry as practicable and shall consist of a ratio of fine aggregate to cement of 2:1. In lieu of mortar, a commercial bonding agent may be used, subject to Metra's approval, when applied in accordance with the manufacturer's recommendations.

- The reinforcement shall continue through the joint. There shall be no construction joint in the area of a reinforcement splice.

- The joints shall be adequately keyed with raised keys, and hollow-bulb 9" x 3/8" PVC waterstops (bulb ¾ inch inside diameter, 1 ½ inches outside diameter) shall be embedded in the first placement, continuous across the joint. One half of the waterstop is embedded in the first placement and the remaining material shall be embedded in the following placement. The concrete shall be thoroughly vibrated to ensure uniform contact over the entire surface of the waterstop. The waterstops shall be made from virgin raw materials and shall conform to the requirements of the U. S. Army Corps of Engineers Specification CRD C572.

Expansion joints shall be provided in accordance with AREMA MRE Chapter 8, and/or as directed by Metra, and shall be formed as follows:

- Expansion joints shall consist of a minimum ½ inch wide pre-molded joint filler or other suitable material.

- No steel reinforcement shall be allowed to cross expansion joints.

- Joints shall be sealed with a non-sag joint sealant and shall conform to the requirements of ASTM D1751.

- If required, open joints shall be constructed by using removable inserts that will not chip or otherwise damage the concrete during removal.

To prevent cracking under live loads, ¼ inch control joints shall be provided in concrete curbs and concrete ballast retainers and shall be spaced at 10'-0" maximum for the length of the structure.

7.7.10.13 PRECAST/PRESTRESSED CONCRETE

Unless otherwise noted herein, all precast/prestressed concrete shall be in accordance with AREMA MRE Chapter 8, Part 17.

Prestressing strand shall be 0.60 inch in diameter, seven-wire, uncoated and low relaxation, in accordance with the requirements specified in ASTM A416; the Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete; ACI 318; and AREMA MRE Chapter 8, Part 17; and shall have an ultimate tensile strength of 270 ksi.

The minimum compressive strength of prestressed box beams and girders shall be 8,500 psi, unless otherwise noted in the design documents and approved by Metra.

Tolerance for location of lifting devices for precast members shall be ±1/2 inch.

The area around all lifting loops shall be recessed so that the loops can be removed to a depth of ¾ inch and grouted.

All box-shaped or AASHTO-type precast, prestressed concrete beams for all spans shall be designed with end and interior diaphragms installed perpendicular to the centerline of webs. Interior diaphragms shall be spaced equally across the span length. The keyway between box beams shall be filled (e.g., with a WT-shape).

Transverse tie rods shall be provided for all concrete spans with single cell box beams and shall be used at end spans and intermediately spaced at maximum intervals of 25'-0". A minimum of three tie rods shall be provided for each span.

The minimum size of tie rods shall be 1-1/4 inches in diameter. Tie rods shall be threaded steel bars with a minimum fy = 36 ksi. Tie rods shall be tensioned as necessary to ensure that all beam sides are in contact without causing any vertical displacement of the beams from the bearings. The tie rods shall be protected in one of the following ways:

- Tie rods, plates, and nuts shall be hot dip galvanized per ASTM A123 and A153.
- The annular space between the tie rod and the edge of the hole shall be filled with grout. The tie rod anchor assembly shall be recessed into the concrete and shall have one-inch minimum grout cover.
- Ends of strands are to be cut flush with the end of the product and painted with an approved coating.

For AASHTO-type beams, the designer shall provide a minimum of 18 inches clear between the bottom flanges to accommodate inspection and repair.

7.7.11 TIMBER BRIDGES

Use of timber for new construction shall be limited to temporary works, for timber cross ties and guard timbers, or for repair and rehabilitation of existing timber structures.

Unless otherwise noted herein, all timber design shall be in accordance with AREMA MRE Chapter 7. All working unit stresses shall conform to AREMA MRE Chapter 7, Section 2.5, Allowable Unit Stresses for Stress-Graded Lumber.

Timber materials and products shall be stored in a clean, dry location, elevated above the ground, and protected from the weather.

7.7.11.1 MATERIALS

Structural bridge timber shall be Southern Yellow Pine Grade Dense Structural 65.

Timber piles shall be Southern Pine conforming to ASTM D25 (in the event of conflicts with AREMA, the more stringent shall apply). The piles shall be first class piles, unused, uniformly tapered, and one piece from butt to tip.

The designer shall prepare specifications for the preservation of timber for permanent construction in accordance with applicable environmental requirements and shall submit to Metra for review and approval.

Structural timber members, including planking for bridge walkways, if used, shall be a minimum of three inches thick.

7.7.12 APPROACH SLABS

If Metra approves the use of a skewed bridge, then approach slabs shall be required.

7.8 STRUCTURAL ATTACHMENTS

The designer shall account for Metra-owned utilities (including signals, communications, and fiber optics) and existing third-party utilities permitted through agreement when designing a structure.

Structure-mounted utility attachments over Metra ROW shall satisfy the requirements set by Metra. Prior to installation or modification of utilities over Metra ROW, the owning third-party must coordinate all work with Metra. This work may be subject to a separate license agreement. See Section 6.10 in Chapter 6 Civil and Drainage for additional considerations related to utilities.

Lighting and roadway signs mounted on a structure crossing the Metra ROW shall not be positioned on spans directly over active tracks, or within 25’-0” from centerline of the nearest track.

Lighting and roadway signs shall not be installed on Metra ROW, including in underpasses, unless written approval is granted by Metra. Attachments owned by a third party shall be inspected, maintained, repaired, or replaced to the satisfaction of Metra, without cost to Metra. In the event the owner fails to properly inspect and maintain such structures or attachments, and if, in Metra’s opinion, the structure or attachment jeopardizes the safe and efficient operation of its property, Metra shall be entitled to remedy such failure and recover from the owner all costs incurred by Metra.

Replacement or repair of attachments that change the size, shape, location, or weight of the existing attachment shall be submitted to Metra for review and approval prior to installation. Calculations and shop drawings shall be promptly made available upon Metra request. Any alteration of existing approved attachments without Metra approval shall be removed at the owner’s expense.

Welding and drilling are not permitted for attachments to structural steel. Attachments must be clamped.

7.9 CRASH WALLS

Substructure protection including crash walls shall be provided as specified in AREMA MRE Chapter 8, Section 2.1.5 for all tracks, including future tracks.

7.10 WALKWAYS AND HANDRAILS

Walkways on existing open deck structures to be rehabilitated and all handrails shall meet the requirements of Federal Railroad Administration (FRA), OSHA, and AREMA MRE Chapter 15, Section 8.5.

The walkway and handrail components shall be fitted and shop-assembled in the largest practical sizes for delivery to the site and shall be fabricated with the joints tightly fitted and secured. Mechanical fittings shall be provided to accommodate the site assembly and installation.

Expansion and contraction of members shall be accommodated without damage to connections or members.

Components shall be installed plumb and level, straight and true, accurately fitted, and free from distortion or defects.

The handrails and walkways shall be installed in accordance with the manufacturer's instructions. Any damage to the galvanized coating shall be repaired as directed by Metra.

Special situations such as a movable span or through truss may require construction that prohibits the practical application of the requirements herein. In such circumstances, a request for exception shall be made through the design exception and deviation process (Section 2.3.7.) The request shall include a proposed alternate detail for review and approval.

7.10.1 WALKWAYS

Existing structures where the entire deck is to be replaced shall provide a new deck that meets the requirements of this manual. Where construction of a new ballasted, concrete deck in conjunction with the existing beams or girders is not practical, the walkways for the new deck shall meet the following requirements:

- All bridges over public vehicular roadways shall have walkways installed on both sides of the bridge.
- Ballasted or solid deck bridges with curbs and/or handrails extending at least 3'-6" above the top of tie, and with walking space extending at least 5'-0" beyond the end of tie on both sides of the bridge, do not require the addition of walkways.
- Bridges within 500 feet of a signal or switch, or within yard limits, shall have a walkway installed on the same side as the signal or switch. If both a signal and switch are present, the walkway shall be located on the switch stand side. Within yard limits, the walkway shall be located on the side of track that will provide the greatest benefit to employees working in the area, as determined through conversations with yard personnel. Walkways may be requested for bridges not meeting these requirements if there are circumstances that present a safety hazard to train crews.

Existing structures with only a partial replacement of the deck will require a walkway on the new deck portion only, with barricades at the walkway's ends as applicable. If the remaining portion of the deck is not scheduled to be installed within the next three years, then Metra shall determine whether the walkway is required.

If an existing walkway has loosened, or has had one or more supports removed, the walkway shall be considered ineffective, shall be treated as non-existent, and shall be removed. All loosened or unsupported pieces of walkway material (grating, boards, etc.) shall be removed to clear the work area. The hole or defective area shall be made obvious with cones or other barriers placed at least six feet beyond either side of the hole or defective area.

Non-ballast walkway surfaces shall be a minimum 2'-6" wide. Walkway grating shall be rectangular welded grating made of ASTM A1011 steel, hot-dip galvanized after fabrication. Bearing bars shall be 1-½ inches x 3/16 inches at 1-3/16-inch centers and twisted square bars at four inch centers.

On bridges over roadways or other locations where spillage of ballast is not permissible, walkways shall be constructed of solid material and a curb or toe board shall be provided at a height of four inches minimum from the top of walkway.

When walkway structures are used, a detail shall be provided showing the walkway transition from the bridge to roadbed at the bridge ends. Where there is a vertical distance from the roadbed walking surface to the bridge walkway, the roadbed walkway profile shall be adjusted to eliminate the vertical separation, or other means shall be utilized to provide a safe transition. The design shall not restrict drainage at the abutments and shall be submitted to Metra for review and approval.

7.10.2 HANDRAILS

Materials for handrails shall be in accordance with other parts of this manual, and shall consist of the following:

- Posts: L 4 x 4 x 1/2 steel angles, ASTM A36.
- Rails: 1-1/2-inch diameter, Schedule 40, ASTM (either 53 or 500) steel pipes. Splice connectors for railings shall also be Schedule 40 pipe.
- Fittings: Elbows, T-shapes, wall brackets, and escutcheons shall be ASTM A36 steel.
- Mounting: Brackets, base flanges for horizontal surfaces, and angled base flanges for stair stringers and ramps shall be ASTM A36 steel.
- Hardware: No pop rivets, sheet metal screws, or self-tapping screws are permitted.

All handrail materials shall be hot-dip galvanized after fabrication.

The handrail assembly shall include base plates anchored to the concrete curbs or bolted to the walkways. A 1/8-inch-thick neoprene pad shall be placed between the base plate and top of curb or walkway.

Handrail posts shall not be closer than six inches from the edge of joints in curbs and concrete ballast curbs.

Condensation drainage holes shall be drilled in the exterior components of the handrails at the bottom and low point of members at locations that will not encourage water intrusion.

Exposed joints on the handrails shall be made butt-tight, flush, and hairline. Exposed edges shall be eased to a small, uniform radius.

The handrails shall be assembled with mechanical fittings to accommodate tight joints and secure installation.

Handrails shall be placed to minimize gaps between superstructure handrail sections and handrail sections installed on the substructure to minimize fall hazards.

7.11 BRIDGE INSPECTION

The designer shall perform an inspection of the bridge prior to the start of design.

Refer to the most current edition of the AREMA Bridge Inspection Handbook for direction on how to conduct a thorough bridge inspection of a railroad structure. Each inspection shall be coordinated with Metra and shall conform to all Metra safety and procedural requirements.

For additional detail on Metra's bridge inspection types and requirements, see the Metra Bridge Inspection Handbook (under development).

7.12 BRIDGE LOAD RATING

In accordance with Metra requirements, a detailed load rating that is a representative measure of a structure's current condition shall be completed for each structure that carries rail traffic. Load rating methodology, assumptions, analysis methods, and reporting requirements, provided below, shall be followed unless otherwise directed by Metra.

7.12.1 RATING METHODOLOGY

Load rating guidelines, presented herein, supplement the general bridge load rating requirements outlined in the AREMA MRE. The following sections of the AREMA MRE provide direction on the rating of railroad structures:

- Chapter 7, Section 3, Rating Existing Wood Bridges and Trestles
- Chapter 8, Section 19, Rating of Existing Concrete Bridges

- Chapter 15, Section 7.3, Rating of Existing Steel Bridges

The load rating guidelines provided herein serve as clarification of AREMA load rating requirements and give additional direction. These guidelines shall supersede AREMA requirements where conflict exists.

7.12.2 PRE-RATING INSPECTION

Prior to load rating any structure, as-built plans shall be located, and a pre-rating bridge inspection or condition inspection shall be completed by a registered professional engineer to verify the following information, and any other conditions that could affect the load rating of the bridge:

- Actual sections and details conform to the as-built drawings. The inspection should verify that repairs, strengthening, additional section loss or other modifications have not occurred; if they have, dimensions should be recorded to determine accurate section properties and dead loads.
- An estimate of any additional dead load that has been added to the structure.
- Position of the track relative to the centerline of the structure
- Superelevation of the track across the bridge
- Degree of curvature of the track across the bridge
- Horizontal and vertical alignment of the track over the bridge
- Operating speed of the track, to accurately determine the impact factor applied to the bridge.
- Uneven settlement of piers
- Span bearing types and simple vs. continuous span supports.
- Structural condition of all members of the bridge, noting any deficiencies, defects, or deterioration that may exist that affect the load rating of the member or cause the rating of other members to be required

At a minimum, the following structural conditions should be noted:

- Timber member rot or decay
- Concrete condition (spalls, cracking, lost concrete, rust-colored efflorescence)

- Reduction in steel reinforcement area
- Steel member corrosion or section loss
- Loose rivets, bolts, or connections in any type of member
- Crooked or damaged members
- Cracked welds or live load carrying steel members

This is not a limiting list of findings that could affect the load rating. Any other findings by the rating Engineer that affect the rating shall be stated and appropriately accounted for in the rating.

The intent of the inspection is to verify that the load rating engineer has accurate information of the condition of the structure and that all factors are appropriately considered during the load rating process. The load rating engineer shall exercise engineering judgment to determine what defects, if any, found during the inspection are necessary to include in the rating.

Refer to the most current edition of the AREMA Bridge Inspection Handbook for direction on how to conduct a thorough bridge inspection of a railroad structure. Each inspection shall be coordinated with Metra and shall conform to all Metra safety and procedural requirements.

7.12.3 RATING LEVELS

Based on the member material type, the component being rated may have up to three different ratings levels – Normal, Maximum, and Fatigue. Refer to AREMA for descriptions and load rating considerations.

7.12.4 BRIDGE MATERIAL ALLOWABLE CAPACITIES

Allowable member capacities, either working stress or ultimate strength, shall be based on the materials used during construction and may vary significantly depending on the year in which the structure was constructed. As-built plans shall be used to determine the materials that were used to construct the bridge. If as-built plans are not available, the load rating Engineer shall use the age of the structure, along with historical data for typical material strengths that were predominant in that era of bridge construction, to approximate the material properties. Supplemental data shall be provided in the load rating calculations for the historically determined material properties. The assumptions made shall be clearly explained in the rating documents.

7.12.4.1 TIMBER

Allowable stresses used to determine the Normal Rating of the structure or component shall be per AREMA MRE Chapter 7, Section 3.1.14.

7.12.4.2 CONCRETE

The compressive strength of the concrete, yield strength of the mild reinforcement, or ultimate strength of the prestressing strands shall be assumed to match the design requirements listed on the as-built plans, unless field observations or construction documentation suggests that reduced values should be used. If as-built plans are unavailable and the material strengths are unknown, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the area of the bridge's construction to determine the material properties of the structure. If information specific to the area cannot be found, AREMA MRE Chapter 8, Sections 19.4.1.1 and 19.4.2.2.2, provide suggested values to use for concrete and reinforcement capacity.

7.12.4.2.1 SERVICE LEVEL METHODS

For Normal and Maximum Rating levels, the permissible stress for conventionally reinforced concrete shall be per AREMA MRE Chapter 8, Section 19.4.1.2a, and modified as appropriate using strength modification factors in the load rating equations in Section 19.5.3.1.

For the Normal Rating level, the permissible stress for mild reinforcement steel shall be the allowable levels provided in AREMA MRE Chapter 8, Section 2.26.2a. For the Fatigue Rating level, the permissible live load stress in mild reinforcement shall be limited to the allowable level per Section 2.26.2b and should only be checked using Equation 19-1. For the Maximum Rating level, the permissible stress for mild reinforcement steel shall be per Chapter 8, Section 19.4.2.1.

For Normal and Maximum rating levels, the permissible stress for prestressed concrete shall be per AREMA MRE Chapter 8, Section 17.16.2.2, and modified per Chapter 5, Section 19.4.1.2a.

7.12.4.2.2 LOAD FACTOR METHODS

The nominal strength capacity of a concrete member is calculated in the same manner for Normal and Maximum Rating levels and is described in AREMA MRE Chapter 8, Sections 2.30 through 2.39. The differences between a Normal and Maximum Rating result from the different load factors used in equations 19-7, 19-8, 19-10, and 19-11.

7.12.4.3 STEEL

The yield and/or ultimate strength of the steel used in a steel bridge or component shall be determined from as-built plans or from the standard plans used by the railroad that originally constructed the bridge. If as-built plans are unavailable and the material strength is unknown, the load rating engineer shall use the age of the structure along with historical data of typical material strengths that were predominant in the area of the bridge to determine the material properties of the structure. AREMA MRE Chapter 15, Section 7.3.4.3a, provides suggested values to use for various types of steel.

Allowable stresses to be used for the Normal Rating shall be per AREMA MRE Chapter 15, Table 15-1-11. Allowable stresses to be used for the Fatigue Rating, when considered, shall be per Chapter 15, Section 7.3.4.2. Allowable stresses to be used for the Maximum Rating shall be per Chapter 15, Table 15-7-1, as described in Chapter 15, Section 7.3.4.3.b.

7.12.5 BRIDGE MEMBER SECTION PROPERTIES

Section properties of bridge components for both dead load and geometric properties shall be based on the as-built plans and supplemented with field observations. Calculated geometric section properties shall account for section loss due to decay, corrosion, spalling, damage, or wear.

7.12.6 REQUIRED RATING CHECKS AND ANALYSIS METHODS PER BRIDGE COMPONENT

The FRA's definition of a bridge shall be used to determine whether a structure constitutes a "railroad bridge". Per 49 CFR § 237.5, "railroad bridge" means any structure with a deck, regardless of length, which supports one or more railroad tracks, or any other undergrade structure with an individual span length of 10 feet or more located at such a depth that it is affected by live loads.

7.12.7 ANALYSIS METHODS

Axial forces, shear forces, and bending moments shall be determined from an analysis that is consistent with the member support and connection conditions. Simple span support assumptions shall be used where the assumption matches the existing condition of the member, or where it would be conservative to assume a simple span condition. The following sections have suggestions for analysis methods, alternative rational analysis methods that provide the appropriate level of accuracy and detail may be used if approved by Metra.

Span deflections shall be checked using as-inspected conditions if the span is over a roadway or railroad.

Diaphragms, horizontal cross-bracing, lateral cross-bracing, and other secondary members themselves shall be checked if inspection reveals that such members are being overstressed. In all cases, the condition of secondary members used to laterally brace primary components shall be accounted for in the rating of primary members. Components subject to combined loading effects (axial and bending effects) shall use the appropriate interaction equation that combines such effects.

7.12.8 DECKS

7.12.8.1 OPEN-DECK TIMBER TIES

Timber ties resting directly on the top flanges of steel beams comprising the superstructure are structural members and shall be evaluated and rated if their current condition justifies an analysis. Open-deck ties shall be rated for bending moment, shear, and bearing (between the bottom of the tie and the supporting top flange). Timber ties supported by chorded timber stringers do not need to be rated if the stringer chords are located directly beneath each rail.

Open-deck ties shall be analyzed as continuous beams, as appropriate, and modeled as point supports at the centerline of each beam. Alternate methods may be submitted to Metra for approval.

Longitudinal distribution of axle loading shall be per AREMA MRE Chapter 15, Section 1.3.4.1.

7.12.8.2 CONCRETE DECK

Concrete decks shall be rated for the positive/negative bending moments and shear in the transverse direction. The deck shall be modeled as a continuous member with supports located at the centerline of each beam. Fatigue rating is not required to be performed for decks supported by multiple beams.

7.12.8.3 STEEL DECK

Steel decks shall be modeled to represent the as-built installed deck, simple or continuous. Steel decks shall be rated for bending moments and shear in the transverse direction of the track. Refer to AREMA MRE Chapter 15, Section 1.3.4.2.2 for distribution of axle loads.

7.12.9 TIMBER STRINGERS

Timber stringers shall be rated for bending moment, horizontal shear, and compression perpendicular to grain.

Analysis of the stringers shall account for the continuity that may exist across bent caps due to the arrangement and layout of stringers within each chord that is typical of timber trestle construction, as discussed in AREMA MRE Chapter 7, Section 3.1.5c.

7.12.10 REINFORCED CONCRETE PIPES

Analysis of a reinforced concrete pipe may be done in accordance with AREMA MRE Chapter 8, Section 10.3.

7.12.11 REINFORCED CONCRETE BOX CULVERTS

Reinforced concrete box culverts with a span(s) over 8 feet shall be rated for positive/negative bending moment and shear on all slabs adjacent to soil and for axial compression on interior walls supporting the top slab.

Analysis of a reinforced concrete box culvert may be done in accordance with AREMA MRE Chapter 8, Section 16.4.2.

7.12.12 REINFORCED CONCRETE BEAMS

Concrete beams reinforced with mild reinforcing steel shall be rated for positive bending moment and shear, negative bending moment shall be considered when appropriate. Additionally, calculations shall rate the beam at point of maximum positive bending and at a distance “d” from the face of the support for shear. Additional rating of sections shall be performed if the longitudinal steel is not continuous or where shear reinforcement changes spacing and or size.

7.12.13 PRESTRESSED/POST-TENSIONED CONCRETE BEAMS

Concrete beams with high-strength prestressing or post-tensioned strands shall be rated at service level and at strength level. Service level rating checks shall consist of a concrete compression stress rating, a concrete tension stress rating, and a prestressing/post-tensioning strand stress rating. Strength level checks shall consist of shear and positive moment ratings. At a minimum, ratings shall be completed at the section with maximum positive bending moment and at a distance “d” from the face of the support for shear; additional sections shall be rated if prestressing strands are harped/draped or where transverse shear reinforcing changes spacing or size.

Composite action between a concrete deck and the beams shall not be considered.

7.12.14 STEEL ROLLED BEAMS

Steel rolled beams shall be rated at points of maximum shear and moment. Splices shall be assumed adequate and do not require a rating unless a pre-rating inspection or the rating engineer determines that a rating of the splice joint is required.

Loads shall be appropriately distributed to each beam according to the deck conditions, bracing, and location of each beam relative to group and centerline of the load/track.

7.12.15 STEEL DECK PLATE GIRDERS

Steel deck plate girders (riveted, bolted, or welded) shall be rated for shear and bending moments. All locations for changes in beam section shall be analyzed for shear and bending moments. Splices shall be assumed adequate and do not require a rating unless a pre-rating inspection or the rating engineer determines that a rating of the splice joint is required.

Loads shall be appropriately distributed to each beam according to the deck conditions, bracing, and location of each beam relative to group and centerline of the load/track.

7.12.16 STEEL THROUGH-PLATE GIRDERS

Through-plate girder (TPG) spans are detailed and built in a variety of ways; however, they are generally comprised of a floor system that supports the track and transfers the loads to the TPG’s that are on the exterior of the track(s). The following items are rating checks that are required for TPG spans, as appropriate.

- TPG: The TPG shall be rated for shear and bending moments at points of maximum loading. The TPG is to be rated as a simple span unless detailed otherwise. All loading transferred to the TPG through the floorbeam shall be applied as a point load at the point of transfer from the floorbeam. The dead load and other loads may be modeled as appropriate for the TPG.

- Stringer: Stringers that span between floorbeams, or end stringers, shall be rated for shear and bending moments. Stringers may be rolled sections or built-up members. Span lengths for the stringers shall be taken from the centerline of floorbeam to the centerline of adjacent floorbeam or to the stringer bearing. Stringer spans shall be treated as simple spans. Refer to “Steel Rolled Beams” or “Steel Deck Plate Girders” (for built-up sections) for additional rating requirements.

- Floorbeam: Floorbeams that span between main TPGs shall be rated for shear and bending moments. Floorbeams may be rolled sections or built-up members. Span lengths for the floorbeams shall be taken from the centerline of TPG to the centerline of adjacent TPG. Floorbeam spans shall be treated as simple spans. Refer to “Steel Rolled Beams” or “Steel Deck Plate Girders” (for built-up sections) for additional rating requirements.

7.12.17 STEEL TRUSS BRIDGE

The following steel truss bridge items detail the required rating checks for a typical truss span. Secondary members, bearings and connections do not need to be load rated unless directed by the Metra.

- Stringer: Stringers that span between floorbeams, or end stringers, shall be rated for shear and bending moments. Stringers may be rolled sections or built-up members. Span lengths for the stringers shall be taken from the centerline of floorbeam to the centerline of adjacent floorbeam or to the stringer bearing. Stringer spans shall be treated as simple spans. Refer to “Steel Rolled Beams” or “Steel Deck Plate Girders” (for built-up sections) for additional rating requirements.

- Floorbeam: Floorbeams that span between main truss elements shall be rated for shear and bending moments. Floorbeams may be rolled sections or built-up members. Span lengths for the floorbeams shall be taken from the centerline of truss to the centerline of adjacent truss. Floorbeam spans shall be treated as simple spans. Refer to “Steel Rolled Beams” or “Steel Deck Plate Girders” (for built-up sections) for additional rating requirements.

- Truss: Each individual main load carrying component of the truss shall be rated for axial tension, axial compression, or both, as applicable. The maximum live load forces shall be developed based up a moving load with respect to truss configuration, location of the track, and track configuration.

7.12.18 SUBSTRUCTURE RATING

A rating (Normal, Maximum) for a substructure component is generally not required unless the field inspection indicates signs of settlement, cracking, deflection, scour, section loss, etc., that suggest the capacity of the substructure member may be compromised.

If a substructure rating is determined to be necessary, adequate as-built information for the foundation type, materials, extents, etc. is required for an accurate rating to be completed. If adequate information does not exist to rate the substructure component, a permanent repair (or temporary repair until a permanent one can be completed) may be required in lieu of a load rating calculation. Substructure rating shall be authorized by Metra.

7.12.19 EQUIVALENT DEMAND RATING

The equivalent demand rating is similar to the normal and maximum rating, except the Cooper E-80 loading is replaced with the typical train configurations used by Metra. The structures are modeled with typical trains to calculate a demand rating. The demand rating is used to determine the need for repair, strengthening, or replacement of the structure.

The additional rating will be performed at all required levels of ratings and all components for the material type and structure configuration. A representative Cooper rating will be determined by dividing the demand rating by the structure rating multiplied by 80.

Typical passenger train configurations used by Metra are discussed in Chapter 17: Vehicles. The Metra PM will provide information on the freight rail vehicles that use the corridor. Generally, the maximum locomotive weight will be 315,000 pounds for freight locomotives, and 286,000 pounds for freight cars.

7.12.20 RATING RESULTS FORMAT

The normal, maximum, and equivalent demand ratings for each member and each required check shall be listed in a tabular format. The controlling ratings for each member shall be highlighted in the table. At any point, if a member is determined to be significantly over stressed, the load rating engineer shall inform Metra.

7.13 BRIDGE REHABILITATION

Resulting from the findings of a bridge inspection, subsequent rating calculations, or other investigation, it may become necessary to perform rehabilitation to maintain normal bridge operation and service. Bridge rehabilitation involves work required to restore the structural integrity of a bridge, as well as work necessary to correct safety defects.

Bridge rehabilitation projects provide complete or nearly complete restoration of bridge elements or components. Rehabilitation work can be done on one or multiple elements and/or components of a structure. Metra may choose to combine preservation activities on several elements while a component is being rehabilitated.

Rehabilitation consists primarily of repairs and modifications. Repairs are activities that do not affect the load carrying capacity of the bridge and include remediation of damage or deterioration that affect the structural integrity of the bridge. Modifications are activities that materially affect the capacity of the bridge and may include changes to the configuration of the bridge.

Effort shall be made to repair in kind so that the structural response of the member or bridge remains consistent with the structural design. Increasing the stiffness of a member during a repair may alter the response of the structure and may detrimentally affect other members. Care shall be taken, and appropriate level of analysis performed, prior to all rehabilitation activities. When modifications are made to a structure during rehabilitation, more robust and detailed analysis and/or modeling may be required.

In all cases, the bridge rehabilitation effort shall provide an assessment for the rehabilitated existing structure to support train operations in a safe and efficient manner over the estimated life of the proposed rehabilitation, given reasonable and appropriate maintenance.

The decision to rehabilitate a structure instead of replacing it shall take into account the condition of the structure, the age of the structure, the material of construction, fatigue considerations, comparative assessment of costs, added life to be obtained from the modified bridge, and possible future uses of the track.

To reduce inventory and maintenance costs, materials shall be standardized as much as possible for consistent repair or replacement without undue cost or disruption of the rail service. The designer (or Contractor) shall investigate similar rehabilitation projects performed for Metra to maintain a consistent and cost-effective rehabilitation approach.

All rehabilitation plans shall be completed, clearly detailed, signed, and sealed by a Professional Engineer licensed in the state where the work is to be performed. The plans shall become a permanent part of the record bridge file.

7.14 RETAINING WALLS

This section is applicable to all retaining walls within Metra's ROW, as well as retaining walls adjacent to Metra's ROW that could have an impact on Metra's tracks.

7.14.1 DESIGN METHODOLOGY

The design of all retaining walls shall conform to the requirements of AREMA Chapter 8, Parts 5, 6, 7, 12, 20, and 28.

In general, concrete wall types are preferred due to minimal maintenance requirements and superior corrosion resistance. However, in selecting a retaining wall type, the designer shall consider train operations during construction, project cost, maintenance cost, the purpose of the wall, loading conditions (including seismic), geotechnical conditions, height requirements, backfill and compaction requirements, constructability, and aesthetics (where applicable). Type specified shall be clearly justified based on these criteria.

The potential for future tracks along the corridor shall be considered when developing the layout and design of retaining walls along existing tracks on Metra ROW. Retaining wall height shall consider future track raises.

Sufficient geotechnical substructure exploration shall be conducted to determine the subsurface conditions along the length of the proposed retaining wall. The boring plan shall be submitted to Metra for review prior to drilling, and all boring logs shall be submitted to Metra as part of the geotechnical report. For more information, see Section 6.5, Geotechnical (under development).

Utilities shall not be attached to any retaining wall.

Drainage shall be designed and detailed to direct all water in a direction away from the back of the wall and track roadbed. Horizontal drainpipes shall be sized for the hydraulic demand, a minimum of eight inches in diameter. Where permitted, weep holes for drainage shall be three inches or larger in diameter and spaced a maximum of 10'-0" on center. All drainage shall be directed off Metra ROW.

Retaining walls, with tracks above or tracks adjacent, shall not be placed closer than 14'-0" from the front face of wall to the centerline of the nearest track. An increase in clearance may be required to accommodate construction requirements adjacent to a live track.

7.14.2 LOADS

Loading on a retaining wall is dependent on factors including but not limited to the type of structure, the type of fill, and the location of the applied live load.

Live loads that affect retaining wall structures typically consist of railroad loading, vehicular loading (street or highway), or other transient loading in the vicinity of the wall. Cooper E-80 axle loading shall be used to determine the live load effects on the retaining wall structure. Construction loads shall also be considered and identified in the design documentation. Additional live loads, including those due to adjacent structures, shall be included as appropriate to the project.

Appropriate loading conditions and cases shall be selected and designed for as specified in AREMA MRE Chapters 8 and 15. Design loads, combinations, and calculations shall be submitted to Metra as part of the design submittal. Assumptions, codes, and approach shall be clearly detailed in loading calculations.

7.14.3 RETAINING WALL TYPES NOT PERMITTED

For permanent retaining walls, mechanically stabilized embankment (MSE) walls and soil nail walls shall not be used to retain fill subject to railroad live load surcharge.

7.14.4 USE OF TEMPORARY WALLS

See Metra's Temporary Shoring Guidelines for information on temporary retaining walls.

7.15 UNDER-TRACK CULVERTS

This section is for under track culverts conveying stormwater runoff only.

Unless otherwise noted herein, all under track culverts shall conform to the following AREMA MRE sections, as applicable:

- Chapter 1, Part 4
- Chapter 8, Parts 2, 10, and 16

7.15.1 DESIGN VALUES

All culvert structures shall be designed for Cooper E-80 live load and shall be based on a 100-year storm event.

The maximum headwater buildup for inlet control conditions shall be limited to

HW/D = 1.5

Roadbed fill shall be of sufficient height to maintain the high-water elevation below the toe of ballast, and the fill material shall be capable of resisting water infiltration for short durations.

Culverts shall be based upon the actual drainage basin. The minimum culvert size shall be 36” in diameter. The “Rational Method” shall be used for drainage areas less than 500 acres. If the drainage area exceeds 500 acres, then one of the following methods may be used with justification, provided adequate data is available:

- Soil Conservation Service (Unit Hydrograph Theory Method)
- Frequency Regression Theory
- Seven Parameter Estimating Equation

7.15.2 PERMITTED CULVERT TYPES

Concrete culverts shall be used as the basic design pipe for under track culverts and shall be used when no special conditions exist at the installation site. Other types may be used if justified by conditions.

For locations with a soil pH range of 5-8, aluminized Type 2, bituminous coated, galvanized steel pipe may be used. Test for such soils in locations with runoff from non-industrial rural areas.

In locations with high concentrations of fertilizer runoff, coal fields (acidic runoff), saltwater marsh areas, and/or high soil concentrations of heavy metals, fiber-bonded, bituminous coated pipe or plastic-coated pipe may be used. Plastic coated pipe will require special care to avoid damage during handling and installation.

Where the jack-and-bore method is required due to traffic conditions, or at locations where fill heights exceed 10 feet, smooth wall casing pipes shall be used as the basic design pipe. Liner plate installed by the tunneling method may be required when the diameter, length, presence of rock, or other unusual site conditions exist.

Cast-in-place concrete structures may be used where appropriate and if the construction can be coordinated with Metra Operations. In cases where a reinforced concrete box culvert is to replace a bridge, consideration should be given to casting as much of the box culvert as possible and using a precast element (top) for the actual change-out.

Structural plate pipes and pipe arches may be used where size and conditions dictate.

Tunnel liner may be used for retrofit of existing culverts.

All voids shall be grouted during construction.

7.15.3 INVERTS

Bituminous or asphalt-paved inverts shall be used in corrugated metal culverts where water velocities are medium to high (above 10 feet/second) or where the possibility of excessive wear from sand and gravel is likely.

Concrete or asphalt-paved inverts shall be used in structural plate, tunnel liner, and pipe arches that are field assembled. If concrete is used, the minimum concrete compressive strength shall be 4,000 psi after 28 days. The bottom 25 percent of the culvert periphery shall be covered with concrete (or asphalt) to a depth of one inch above the crest of the corrugations for circular pipes and 40 percent of the periphery for pipe arches. The concrete placement shall be reinforced with 6 x 6 (W2.9 x W2.9) welded wire fabric. This wire shall be attached to the pipe by either directly welding to the pipe or by mechanical attachment to the bolts.

7.15.4 END SECTIONS AND HEADWALLS

End sections and headwalls shall be provided at either end of the culvert and shall be designed appropriately to resist erosion and scour.

7.15.5 HANDRAILS

Box culverts shall have handrails provided at the headwalls and wingwalls. See Section 7.10.2 for handrail requirements.

7.16 HYDRAULICS AND EROSION

7.16.1 HYDRAULICS FOR OPENINGS

These requirements apply to new and replacement structures as well as modifications to existing structures. See Section 6.8 in Chapter 6 Civil and Drainage for additional drainage considerations.

Structures shall be sized such that the 100-year flood elevation does not rise above the low chord of the bridge or crown of culvert.

Information for the hydraulic opening for the existing and proposed structures shall be provided, including the energy grade line, water surface elevation, and velocity flow.

Local flood flow criteria shall be evaluated and adopted if they are more conservative than the Metra criteria.

7.16.2 EROSION AND SEDIMENT CONTROL

General plans for construction within Metra ROW shall indicate the proposed methods of erosion and sediment control. They must specifically provide means to prevent sediment accumulation in ditches and culverts, to prevent fouling track ballast and sub-ballast, and to allow free flow of runoff in drainage systems during and after construction.

Existing track ditches shall be maintained open at all times throughout the construction period. After construction is complete, all erosion and sediment control devices must be removed, all sediment deposits removed, and the entire project area restored to the pre-construction condition.

The designer shall provide a Stormwater Pollution Prevention Plan (SWPPP) and permits, if required. Bridge and roadway plans shall indicate the proposed methods of erosion control and must specifically address means to prevent silt accumulation in ditches and culverts and to prevent fouling the track ballast and sub-ballast.

Existing track ditches shall be maintained at all times throughout construction. After construction has been completed, all erosion control devices must be removed, all deposits of silt removed, and ditches must be restored.

Embankment slopes adjacent to the track must be paved for a minimum of two feet beyond the outside edge of any bridge foundation structure and, where conditions warrant, the slope paving shall be extended around the curved face of the end roll to a line opposite the abutment. The pavement shall consist of a prepared sub-base and filter fabric with a four-inch minimum thickness of Class B concrete or placed grouted rip-rap on the surface. If warranted by site specific information and contingent upon Metra approval, in select instances Metra may approve deck drainage or highway drainage to be discharged onto the embankment slopes. If the discharge of deck or highway drainage onto the embankment slopes is permitted, concrete paving must be used.

7.17 DRILLED SHAFTS

Drilled shafts for piers and abutments shall be designed in accordance with AREMA Chapter 8, Part 24. Thorough inspection of the shafts immediately prior to the placement of any reinforcement or concrete is required to ascertain that the shaft has been adequately prepared, the bearing material is compatible with design requirements, and whether additional investigation of the bottom is required.

Testing is required for every drilled shaft to evaluate the integrity of the drilled shaft and/or caissons. The plans and specifications shall include provisions for this testing.

7.18 LIGHTING

Lighting under Metra bridges shall be in accordance with the local municipality or roadway requirements.

7.19 FENCING

For fencing within station areas, refer to the Stations and Parking Design Guidelines.

7.19.1 ROW FENCING

Fencing is provided to safeguard the general public and prevent trespassers from entering Metra ROW and accessing the track or other railroad structures. The need to provide ROW fencing will be evaluated for each project.

The following requirements shall apply to ROW fencing:

- Location: Where fencing is required, fencing shall be located at the limits of Metra's ROW.
- Height: Fencing shall be a minimum height of four feet, unless the fencing is required for the purposes of limiting access, in which case it shall be a minimum of six feet.

7.19.2 FENCE TYPES

The type of fence to be used shall be decided on a per-project basis, depending on the needs of the project site. The following criteria shall apply as appropriate:

- Chain link fence: Openings shall not exceed three inches.
- Wrought iron picket fence: Openings shall not exceed three inches and may be used in locations where trespassers may cut a chain link fence.
- Architectural fencing: All architectural fencing shall require prior review and approval by Metra. Architectural fencing shall not allow an opening of more than three inches and shall be designed to prevent climbing.
- High security fencing: High security fencing may be used at locations with trespasser issues, or at locations deemed applicable by Metra. The high security fence design shall be approved by Metra.

7.20 CONSTRUCTION, ERECTION, AND DEMOLITION PROCEDURES

7.20.1 GENERAL

All work is subject to inspection at any time by Metra or its designated representative. Metra has the full authority to stop work at any time if deemed necessary to maintain the safety of railroad interests. At any time during construction activities, work may be immediately stopped due to unforeseen sight conditions, weather, or for any hazard that may interrupt or present a danger to rail operations. Metra shall not be held liable for any additional cost or schedule delays during the mitigation of such hazards.

A pre-construction meeting shall be conducted with all parties involved with the project prior to start of all activities and the railroad engineer or designated representative shall be present for the entire construction, erection, or demolition procedure, unless otherwise approved in writing by Metra.

If hoisting operations or demolition of existing structures take place on, over, or adjacent to the Metra ROW, a detailed procedure shall be submitted to Metra for review and approval. Approval of the procedure shall be granted prior to the start of any construction activities. This requirement also applies in all cases where cranes or extendable equipment will be positioned such that the maximum boom length at full extension is within 15’-0” of the centerline of any track.

Railroad tracks and other railroad property must be protected from damage during all construction, erection, or demotion procedures.

Blasting is not permitted without written authorization from Metra. If approved, additional requirements will be determined at that time.

The Contractor shall install a geotextile fabric ballast protection system to prevent contamination of the Metra ballast section from debris and fines due to construction activities over the Metra tracks. This ballast protection system shall be installed, cleaned, inspected, and otherwise maintained to the satisfaction of Metra prior to the start of all construction actives over the track. The ballast protection system shall extend a minimum of 25’-0” beyond the limits of construction activities.

No equipment or vehicle is permitted to set on or travel over the Metra rails without written authorization from Metra. No material shall be dropped on Metra ROW.

Dynamic hoisting operations are not permitted during construction activities if the equipment possesses the ability to foul any track.

All rigging components to be used in construction shall be clearly marked and tagged with their rated lifting capacities. Any component that is missing a tag or where the tag has become illegible shall not be used on Metra property. Metra reserves the right to validate any equipment and associated documentation at any time during operations. If proper documentation or tagging cannot be produced, work shall be stopped at the Contractor's expense until compliance is achieved.

All existing substructure units or existing structures to be removed during the demolition process shall be removed to a minimum of 3'-0" below existing/ proposed grade or the final invert of the ditch line. Metra may impose additional removal requirements as required by current or future site conditions or plans.

The Contractor shall assume all liability for damage to the railroad or railroad ROW or death caused by railroad traffic or by the Contractor's construction methods and equipment. Any delays to railroad operations attributed to the construction or Contractor shall be the liability of the Contractor.

After the completion of all activity to be performed by the Contractor, the Contractor shall remove all trace of work performed on the Metra ROW and it shall be left in a condition that is equal to or better than the conditions that existed prior to construction activities. The cleanup or improvements to the ROW are subject to approval by Metra or the designated engineer.

7.20.2 SUBMITTAL REQUIREMENTS

The following is a list of submittal requirements to be completed by the Contractor or other appropriate parties and submitted to Metra for approval in advance of any construction, erection, or demolition activity. Metra reserves the right to require additional information or submittals on a case-by-case basis as necessary for specific projects. All submittals shall be signed and sealed by a professional engineer licensed and in good standing in the state of the proposed work. Metra's approval of submittals does not relieve the Contractor from liability.

- Final signed and sealed plans for the proposed structure to be erected or as-built plans for the structure(s) being demolished. A detailed field investigation shall be conducted under the supervision of a Professional Engineer in the absence of as-built plans. All temporary shoring and/or stabilization proposed or required shall be based on as-built plans and/or the detailed field investigation.

- Rating sheets, including crane charts, for all equipment and rigging to be used in all construction operations. All equipment and rigging shall be capable of carrying 150 percent of the anticipated loading. Built-in safety factors listed on the rating sheets shall not be considered. Rigging and equipment substitution shall not be permitted without Metra's approval, regardless of rated capacity. Crane charts shall have the crane capacity marked based upon the boom length, operating radii, counterweight, etc. to match the proposed plan details.

Detailed design calculations and associated plans for the following:

- Temporary shoring and/or stabilization, where applicable
- Overhead or vertical debris shield design, where applicable
- Controlling lift/pick weights along with sketches of the rigging components from the equipment hook block or other lifting device to the load/element to be lifted during construction
- Bracing of the existing structure for temporary conditions during construction. Bracing or falsework shall be adequate to prevent overturning, buckling or any unanticipated failure of the existing or proposed structure. Lateral wind forces shall be considered in all cases, per AREMA MRE Chapter 8, Section 28.6.2.

Detailed drawings showing the following:

- All working positions and outrigger setup, along with the maximum operating radii, of cranes or extendable equipment both vertically and horizontally in relation to the centerline of nearest track, adjacent structures, or overhead obstructions
- Location of access, staging, delivery, disposal, and stockpiles of material in relation to the centerline of nearest track, adjacent structures, or overhead obstructions
- Lift clearances in relation to adjacent structures or overhead obstructions
- Names and associated experience of key operators or craftsman. Additionally, all required certifications (i.e., welding certifications, operator certifications, etc.) shall be submitted for review.
- A detailed procedure and schedule of all construction, erection, or demolition activities. The schedule shall include the timeline for various stages as well as an overall schedule of the entire procedure. Each

critical path subtask activity shall be outlined in detail within each of the various stages.

- As-built beam or girder seat elevations along with top of rail elevations and updated minimum vertical clearance calculations accounting for deflection and camber. These shall be submitted to Metra for review and approval prior to the erection of beams or girders over Metra ROW. Beams and girders shall not be erected until minimum vertical clearance is confirmed and approval is granted.

7.20.3 DEMOLITION DEBRIS SHIELD REQUIREMENTS

On track or ground level debris shields are not preferred and must be submitted for approval in advance of the demolition activities.

Overhead debris shields shall be installed over the track area prior to the start of demolition, for the purpose of catching errant falling debris and particles to prevent damage of the track, railroad interests, or property. While the debris shield shall be adequate to contain and protect the railroad, it shall not be the primary means for containment of the demolition.

Overhead debris shields shall be designed to support a minimum of 50 pounds per square foot in addition to self-weight, debris, equipment, personnel, and any other loads that are anticipated to be supported by the debris shield. The Contractor shall continuously monitor that the field conditions, debris size, quantity, and impact loading are within the design parameters submitted. The debris shield shall be cleaned daily, at a minimum, or as required to remain within the approved design parameters. The Contractor shall submit design calculations and details for the proposed overhead debris shield to Metra for review and approval.

The Contractor shall submit to Metra for review and approval an installation/ removal means and methods for the debris shield, in addition to the proposed demolition procedure submission.

On diesel-powered lines, a minimum temporary vertical clearance of 22’-0” shall be maintained below the overhead debris shield. On electrified districts, the clearance will be determined by Metra to account for the overhead catenary system. If the existing vertical clearance is less than 22’-0”, the existing clearance shall be maintained. Reduction of this minimum vertical clearance may be considered on a case-by-case basis with approval by Metra.

Where demolition operations are being conducted adjacent to the tracks, a vertical debris shield may be required for the protection of the railroad. The vertical debris shield shall not reduce the minimum horizontal clearance to the nearest track centerline unless approved by Metra.

Demolition plans shall be stamped by a structural engineer and submitted to Metra for approval.

7.20.4 ERECTION

See applicable sections elsewhere in this chapter for additional requirements related to erection.

Erection plans and splicing plans shall be stamped by a structural engineer and submitted to Metra for approval.

7.20.5 TRACK MONITORING

Reference the Metra Track and Ground Monitoring Guidelines.

7.21 CONSIDERATIONS FOR CONSTRUCTION

This section contains information on construction requirements related to bridges and structures. These apply to both Metra-owned projects and projects by third parties. Any and all construction activity that will take place on or with the potential to foul Metra ROW shall conform with the requirements laid out in this section, Section 7.20, and any additional requirements deemed necessary by the Metra.

7.21.1 GENERAL

All permanent or temporary construction activities or operations on, over, or adjacent to the tracks shall be subject to the inspection and approval of Metra or any designated appointed party. All construction shall be in accordance with Metra's general rules, regulations, and safety requirements. Any proposed construction staging shall be reviewed and approved by Metra at the concept stage and re-reviewed during development of detailed plans.

All construction shall be phased, staged, or otherwise coordinated such that Metra operations are not interrupted. If an interruption is required or unavoidable, detailed justification shall be submitted to Metra for review and approval. Regardless, a detailed plan and timeline of construction activities shall be submitted to Metra for review and approval.

A proposed construction sequence for all aspects of work for grade separations impacting Metra operations, including agreed-upon construction track windows, shall be incorporated into the construction documents and annotated in the contract drawings. The Contractor shall submit a final Site-Specific Work Plan incorporating the construction sequences and phasing, including track windows accepted during the design phase, for review and approval prior to procurement, manufacture, fabrication, and construction.

All construction taking place on or near Metra ROW which has the potential to affect or disturb railroad operations must be approved by Metra prior to any work being performed. Any costs arising from the failure to acquire approval prior to scheduled construction activities will be at the sole expense of the Contractor or host agency.

During all construction activities which have the potential to impact or foul the railroad ballast section, the Contractor shall install a geotextile fabric ballast protection system to prevent the contamination or damage to the ballast section. This ballast protection system shall be installed, cleaned, inspected, and otherwise maintained to the satisfaction of Metra. The ballast protection system shall extend a minimum of 25’-0” beyond the limits of construction activities. No equipment or vehicle is permitted to set on or travel over any track without written authorization from Metra.

All construction projects, regardless of scope, are subject to, but not limited to, submittal of the following where applicable:

- General construction means and methods
- Excavation and shoring
- Culvert, pipe, and tunnel installation
- Ballast protection
- All formwork and falsework, including installation procedures.
- Demolition procedure
- Erection procedure
- Debris containment
- Pipe, culvert, and tunnel installations
- Blasting

For bridges carrying Metra’s ROW, the following submittals are required where applicable:

- Complete as-built drawings

- Complete shop drawings, including structural steel, bearings, and prestressing as applicable
- Concrete mix designs
- All material testing and certifications
- Subsurface investigation report and foundation construction report

A detailed description of work to be performed, a detailed schedule broken out by task, and all anticipated equipment to be used during each activity shall be included in all submittals.

It is the responsibility of the Contractor or host agency to verify all necessary submittals have been reviewed and approved by Metra prior to construction. Metra reserves the right to require additional submittals at its discretion.

Any damage to rails, ties, structures, embankment, third party property, signal and communications equipment, or any other facilities shall be repaired, at Contractor expense, to a condition equal to or better than the condition prior to entry and as accepted by Metra.

The project sponsor or the Contractor shall reimburse Metra and/or any operating railroads for any and all costs and expenses incurred as a result of the Contractor's work which may result in a) unscheduled delay to trains or interference in any manner with the operation of trains; b) unscheduled disruption to normal train operations; c) unreasonable inconvenience to the public or private users of the system; d) loss of revenue; and/or e) alternative method of transportation for passengers.

7.21.2 SHOOFLY TRACK

A shoofly (detour) track may be used to maintain railroad operations during construction activities.

The shoofly track shall be designed to maintain railroad operations and support the maximum authorized timetable speed. The shoofly track shall account for track settlement.

Temporary structures are permitted for shoofly tracks. Temporary structures shall be designed in accordance with these criteria and AREMA requirements. If open deck structures are used over a roadway, the roadway shall be closed to traffic or protective shielding shall be in place.

Metra tracks shall remain fully operational except during scheduled pre-approved cut over operations.

7.21.3 TEMPORARY CONSTRUCTION CLEARANCES – VERTICAL & HORIZONTAL

To accommodate construction activities, the following requirements shall apply:

- The temporary vertical clearance shall be 22 feet from the top of the highest rail. Deflection of forms shall be considered in the vertical clearance measurement.
- The temporary horizontal clearance shall be 15 feet from the centerline of track plus an additional 1.5 inches for each degree of curvature. Additional clearance, as determined based on Metra operating conditions, may be required.
- The minimum temporary construction clearances shall be shown on the general plan and elevation sheet.
- Temporary construction clearances less than the minimum values listed above shall be subject to approval by Metra. Rehabilitation projects on bridges with substandard clearances shall not be reduced during construction without prior approval from Metra.
- The construction clearances shall accommodate standard drainage ditches or other means of providing drainage to the ROW.

7.21.4 TEMPORARY EARTH RETENTION & SHORING

All excavations shall comply with applicable OSHA regulations and Metra's Temporary Shoring Guidelines. In the event of conflict, the more stringent requirement shall govern. Regardless of depth, shoring shall be required for all excavations where there exists the potential to adversely affect Metra ROW, tracks, structures, personnel, or Metra operations in general.

7.21.5 EXCAVATION AND SHORING

See Chapter 6 Civil and Drainage, Section 6.7 Excavation and Shoring.

7.21.6 STRUCTURE BACKFILL

See Chapter 6 Civil and Drainage, Section 6.8 Backfill for general backfill requirements.

7.21.6.1 ABUTMENTS AND WALLS

Design of structure backfill shall adhere to the requirements of AREMA MRE Chapter 8, Sections 5.5.1 and 5.5.2, and as specified herein. Properties of backfill material shall be as specified in AREMA

MRE Table 8-5-2. Type 1 backfill shall be used where feasible. Types 2 and 3, in declining order of preference, may be used due to economic or other considerations; these considerations must be documented and approved by Metra through the design exception process. Type 4 and 5 backfill shall not be permitted without prior discussion with Metra.

The backfilled areas behind a wall or an abutment shall be designed to dissipate water pressures using free draining backfill material in conjunction with drains.

7.21.6.2 CULVERT PIPES

Backfill shall adhere to the installation requirements of AREMA MRE Table 8-10-1 as specified by AREMA Chapter 8, Section 10.4.3.

7.21.6.3 CONCRETE BOX CULVERTS

Backfill shall adhere to the installation requirements of AREMA MRE Chapter 8, Sections 16.2.3, 16.5.6, and 16.7.6.

7.21.6.4 FLEXIBLE SHEET PILE BULKHEADS

Backfill shall adhere to the installation requirements of AREMA MRE Chapter 8, Sections 20.2.5, 16.5.6, and 16.7.6.

8. STATIONS AND PARKING (UNDER DEVELOPMENT)

See Metra's Station and Parking Design Guidelines.

9. SIGNALS (UNDER DEVELOPMENT)

10. COMMUNICATIONS

10.1 OVERVIEW

This chapter describes the criteria for the design of the communications system and associated subsystems that support Metra's railroad operations. The communications system shall provide for transporting data, voice, and video to facilitate control and monitoring of train traffic, train tracking, traction electrification system, controlled interlockings, passenger station facilities, fare collection system, and the yard and shop facilities. The following subsystems and/or functions shall be considered part of the communications system and its design, including certain requirements related to expanding the subsystems to fulfill future needs:

- Radio very high frequency (VHF) and Wireless Systems
- Video Surveillance System
- Telephone System
- Public Address (PA) and Visual Information Display System
- Access Control System
- Communications Transmission System
- Supervisory Control and Data Acquisition (SCADA) System
- Ticket Vending Machine (TVM) System

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of a conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

10.2 GENERAL

10.2.1 STANDARDS, CODES, AND REGULATIONS

All equipment shall be Underwriters Laboratories, Inc. (UL) listed and shall conform to the applicable National Electric Code (NEC), National Electrical Manufacturers Association (NEMA), and Federal Standards and Specifications. Materials and components shall be new and shall conform to grades, qualities, and standards as specified herein and in the contract documents.

At the time of design, all designs shall comply with the latest versions of the local laws and ordinances referenced below. The following publications are incorporated herein by reference to the extent applicable, refer to the Technical Specifications for additional references:

- International Building Code (IBC)
- National Fire Protection Association (NFPA) Standards
- NFPA 70: National Electrical Code
- NFPA 72: National Fire Alarm and Signaling Code
- NFPA 70E: National Electrical Safety Code
- NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems
- NFPA 720: Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment
- NFPA 780: Standard for the Installation of Lightning Protection Systems.
- American National Standards Institute (ANSI) Standards:
- ANSI/EIA/TIA-472: "Generic Specification of Fiber Optic Cables"
- ANSI/EIA-472D000-A, "Sectional Specification for Fiber Optic Communication Cable for Underground and Buried Use"
- ANSI/EIA/TIA-475-AAAA, "Detail Specification for Fiber Optic Connector Set; Type SC, Singlemode, Simplex and Duplex Versions"
- ANSI/TIA-568: inclusive of all cabling standards under ANSI/TIA-568 series of documents
- ANSI/TIA-569: inclusive of all pathway and space standards under ANSI/TIA-569 series of documents
- ANSI/TIA-598: Optical Fiber Cable Color Coding
- ANSI/TIA-606: Administration Standard for Telecom Infrastructure
- ANSI/TIA-607: Grounding and Bonding Requirements for Telecom
- ANSI/TIA-758: Customer-Owned Outside Plant Telecommunications Infrastructure Standard
- ANSI/TIA-942: Telecom Infrastructure for Data Centers

- ANSI/TIA-002: Data Center Design and Installation Best Practices
- Institute of Electrical and Electronic Engineers (IEEE) Standards
- IEEE 802: inclusive of all standards under IEEE 802 LAN/MAN series of documents including 802.1 series, 802.3 series and 802.11 series
- American Society for Testing and Materials (ASTM) Standards
- National Electrical Manufacturers Association (NEMA) Standards
- National Electrical Contractors Association (NECA) Standards
- NECA 1-2015: Standard for Good Workmanship in Electrical Construction
- Americans with Disabilities Act (ADA)
- International Society of Automation (ISA) Standards
- UL Standards
- Federal Communications Commission (FCC) Rules and Regulations
- Telecordia Technologies (Bellcore) Standards
- Telcordia TR-TSY-000020, "Generic Requirement for Optical Fiber and Optical Fiber Cables".
- GR-1275: Central Office Telecommunication Installation
- International Electrotechnical Commission:
- IEC 60794-5-10, "Optical fiber cables - Part 5-10: Family specification Outdoor microduct optical fiber cables, microducts and protected microducts for installation by blowing"
- Occupational Safety and Health Administration (OSHA)

10.2.2 ABBREVIATIONS

Title	Acronym
ADA	Americans with Disabilities Act
AFF	Above Finish Floor
ANSI	American National Standards Institute
CCTV	Closed Circuit Television
EMT	Electrical Metallic Tubing
FRE	Fiberglass Reinforced Epoxy
HVAC	Heating, Ventilating, and Air Conditioning
IEEE	Institute of Electrical and Electronics Engineers
IMC	Intermediate Metal Conduit
MER	Mechanical Equipment Room
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
PAS	Public Address System
PVC	Polyvinyl Chloride
RGS	Rigid Galvanized Steel
ROW	Right-of-Way
SCADA	Supervisory Control and Data Acquisition
TRACC	Train Reporting and Customer Communication Center
TVM	Ticket Vending Machine
UL	Underwriters Laboratories, Inc.
UPS	Uninterruptible Power Supply
XHHW	XLP High Heat-Resistant Water-Resistant

10.2.3 GENERAL DESIGN REQUIREMENTS

The design documents shall include system description and interface requirements as follows:

- System description, at a minimum, shall include subsystem description, detailed design and interface information, all performance, functionality, and operational description, as well as details such as cable and equipment identification.

- Interface requirements shall identify all required interfaces with other communications and non-communications systems and subsystems. This includes, but is not limited to, the following:

  - Interfaces between new work to be performed and any other existing communications work

  - Interfaces among subsystems

- Identification and description of any required hardware and software modifications or additions to existing subsystem equipment

- Identification of all external interfaces, including service points and facilities and equipment provided by others. Interface examples include power, cable facilities, discrete signals, voice, and data.

- Equipment list (bill of materials) depicting a table or list of model and part numbers for all proposed equipment and materials to be used for individual subsystems. The table or list shall be grouped for each subsystem with functional descriptions of equipment or material included. Quantities and locations shall be included.

- Calculations and/or analysis required for each subsystem

- Phasing and staging to identify all major system cutover events or integration activities describing techniques, methods, duration, and procedures.

- System and subsystem block and functional diagrams

- Complete cable identification and equipment labels

- Grounding details

10.2.4 SAFETY AND RELIABILITY

The design shall include considerations for system safety for elements as specified in the codes and standards as well as unique elements in the Metra system that may not be comprehensively covered in the codes and standards section.

Examples of system safety considerations include, but are not limited to, the following:

- Structural design to support dynamic message signs, communication huts.
- Electrical design for earth ground, structural ground, ground isolation, lighting, and transient protection/suppression.
- Mechanical design for heating, ventilation, and cooling for communications nodes.
- Construction analysis to provide for safety of personnel and infrastructure during installation of systems.

10.2.5 ELECTROMAGNETIC INTERFERENCE (EMI)

The design shall include protection of the network and systems against EMI. The design shall employ design techniques, construction methods, and equipment required to prevent interference caused by external and internal sources from affecting the proper operation of the equipment and systems. To contain EMI emissions wherever possible, the suppression of transients shall be at the source of the transient.

Example of design requirements include, but are not limited to, the following:

- Coordinating frequencies and providing required balancing, filtering, shielding, modulating techniques, and isolation to maintain signal to noise ratio (S/N) above limits required to operate all equipment. Shielding, isolating, balancing, and grounding shall be used, as required, to reduce the undesirable effect of interference.
- Electrostatic and magnetic shielding methods shall be employed to minimize the effect of stray signals and transient voltages and interconnecting cables.
- Equipment and facilities shall be located and arranged to minimize voltage induction into circuits due to future electrification, auxiliary power, and overhead catenary system current transients.
- Equipment design and enclosures shall shield equipment from any effects resulting from the operation of cellular telephones, including when said telephones are operated in the vicinity of the equipment and on the passenger platform.

10.2.6 RELIABILITY AND MAINTAINABILITY

The design shall include consideration for the reliability and maintainability of communication system elements. Communication system design components must consider Metra's existing systems. Each design component shall be considered as part of a systems engineering plan to ensure 100 percent compatibility and interoperability with the existing systems.

Final physical placement of systems shall consider the ability for maintenance crews to service the system components. Care should be taken to avoid systems that require track outages or other impacts to revenue operations to service a system component.

All system components shall be of the latest standard and commercially available, unless otherwise noted. Warranty of systems and components shall include, at minimum, a one-year warranty to cover defective materials and workmanship. Refer to the Technical Specifications for specific reliability and maintainability requirements for each subsystem.

10.3 SYSTEMS

10.3.1 RADIO (VHF) AND WIRELESS SYSTEMS

10.3.1.1 RADIO (VHF) SYSTEM

The existing Metra VHF radio system is an above-ground radio system that consists of a conventional narrowband analog (12.5 kHz) system and a digital Next Generation Digital Narrowband (NXDN) (6.25 kHz) system which provide two-way radio coverage throughout the Chicago metropolitan area with separate channels for Metra Road Operations, Maintenance, Yard, and the Metra Police. The current system consists of 50 radio transceiver base stations and radio antenna towers.

The VHF Radio System shall have the following requirements:

- The above ground two-way VHF radio system shall be designed to conform to support the Conventional Narrowband Analog (12.5 kHz) format and the NXDN Digital (6.25 kHz) format. Other modulation formats currently under development within Metra will be added at a later date.

- The system shall provide a minimum DAQ (Delivered Audio Quality) of 3.4 with 95/95 percent reliability and a Bit Error Rate

(BER) less than or equal to 3.1 percent. DAQ tests shall be performed utilizing pre-recorded Harvard Sentences.

- The system shall be equipped with a GPS-synchronized simulcast system with seamless coverage along the entire right of way. Simulcast testing and alignment shall be completed for all adjacent radio base station sites.
- Base station antennas shall not exceed Effective Isotropically Radiated Power (EIRP) and shall not exceed levels stated on Metra's FCC radio license for the site.
- New base stations shall support the Conventional Narrowband Analog (12.5 kHz) format and the NXDN Digital (6.25 kHz) format.
- New base station antennas shall have a Voltage Standing Wave Ratio (VSWR) of 1.5:1 or better.
- Antennas shall be equipped with lightning surge arrestors in accordance with manufacturer's guidelines.
- Network equipment for base station and head end sites shall use commercial-off-the-shelf (COTS) components that meets all Metra specifications.
- All rail revenue and designated non-revenue vehicles shall be equipped with mobile radio transceivers, with radio frequencies and output power consistent with Metra's FCC radio license. All train operators, transportation and maintenance field personnel, and other key Metra employees along the ROW shall be equipped with fully compatible portable hand-held radio transceivers.
- For any expansion of the two-way system, a radio coverage study shall be conducted to indicate where any "dead" spots may be prevalent. This coverage study shall include 1,000 feet from each side of the planned alignment's right-of-way. The study shall also include inside all traction power substations, signal houses and communication houses. Based on the findings, recommendations shall be provided to enhance the coverage area as necessary. Radio simulations, coverage predictions and line-of-sight terrain mapping shall be completed for the new area.
- When adding a new radio base station site or changing the operation/ modulation/frequencies of existing sites, prepare all

required FCC documentation including applications, forms, and FCC contour analysis per FCC part 90 rules.

- Every channel shall be fully equipped to operate in Conventional Narrowband Analog (12.5 kHz) and NXDN Digital (6.25 kHz) modes so that each call can request to be handled in either mode with the channel automatically switching modes, depending on the needs of the user radios.

- The system shall be capable of Dispatcher Override, where the system ensures that calls originating from a dispatch console cannot be blocked by handheld radio users. The system shall permit a call originating from a dispatch console to interrupt a call by a handheld radio user.

- Base stations shall meet or exceed all applicable FCC requirements and fully comply with EIA standards.

- The system shall provide monitoring capability of detecting failure of all major equipment items at a base station site, including at a minimum:

- Base station operation

- Status of network line, leased landline or microwave link

- Status of antenna system (VSWR)

- Failure of direct current (DC) power

- The system shall include at least one radio system management console which provides system management of the entire system.

10.3.1.2 WIRELESS SYSTEMS

Other wireless system requirements are currently under development within Metra and will be added at a later date.

10.3.2 TELEPHONE SYSTEM

The telephone system shall be a network-based Voice over Internet Protocol (VoIP) system that utilizes Metra’s existing telecommunication infrastructure that connects the six satellite PBX locations to the main telephone PBX at Corporate headquarters. Call control and messaging servers shall be designed to fail over to a geographically diverse server.

The design shall include, but is not limited to, the following elements:

- Internet Protocol (IP) network shall be configured for Quality of Service to give voice traffic priority.
- IP telephones shall be configured to encrypt voice traffic.
- Adequate IP network security shall be provided.
- Gateways and VoIP routers geographically diverse for redundancy.

The basis of design for the system shall include, but not be limited to:

- The system shall be designed for (N+1) redundancy for either a voice gateway, appliance, or application server outage.
- The hardware and software design shall be such that incremental increases in telephone lines, and modifications of user data (adds, moves, or changes) may be easily accomplished without affecting service to any existing lines.
- The system components include an integrated router-voice gateway with an integrated ethernet module and stand-alone router for rail stations, rail yards, and other facilities. Provide analog voice gateways for analog phone lines.

Installation and Number of Telephones:

- All telephones installed in ancillary rooms shall be within 15 feet of room entrances and must have a 25 feet long handset cord. If the room is larger than 30 feet, there shall be an additional telephone. All phones must have independent lines.
- Refer to the Technical Specifications for specific requirements for furnishing, installing, and testing of the telephone system.

10.3.3 VIDEO SURVEILLANCE SYSTEM

The design of the video surveillance system shall provide real time and recorded video for use by all departments at Metra. Closed circuit television (CCTV) shall be used for video surveillance of station platforms, yards, ancillary facilities, and office spaces in operation facilities. The quantity and location of cameras will depend on the type and size of the location.

The video surveillance system shall perform multiple functions, including but not limited to:

- Provide visual surveillance facilities to improve passenger and staff safety and security of assets.
- Provide visual information for operators that allows Metra to react and respond to urgent or unforeseen events effectively, efficiently, and accurately.
- Enable emergency responders to monitor incidents and investigate unusual activities.

The design shall include, but is not limited to, the following major components:

- Video management system (VMS)
- Network equipment and servers
- Internet protocol cameras
- Video recording – network/digital (NVR/DVR)
- Viewing stations
- Network connections
- Video analytics
- Structured cabling

The basis of design for the system shall include, but not be limited to:

- Fixed view cameras
- Fixed multi-imager cameras
- Pan-Tilt-Zoom (PTZ) cameras
- Thermal cameras
- 360-degree cameras
- LPR (License Plate Recognition) cameras
- Field equipment enclosures
- Miscellaneous hardware

10.3.3.1 CAMERAS

The video surveillance system design shall use IP cameras and a combination of fixed, PTZ, fixed 360-degrees, multi-imager, and/or thermal cameras based on the contract requirements. The design, placement, and installation of cameras and associated cabling and cabling infrastructure shall be fully coordinated with key stakeholders and other disciplines. The designer shall be cognitive of existing conditions, changing conditions, movements of customers and personnel, and new construction during design. The designer shall take into consideration an appearance that is aesthetically pleasing and avoids obstructions from signs, lighting fixtures, landscaping, and other architectural and physical features. Cameras shall be installed and positioned to provide unobstructed views of the target and minimize unwanted surroundings. Cameras shall be installed in such a manner to provide for ease of maintenance.

Cameras shall provide a minimum of 30 days of storage. Cameras shall be compatible with current VMS software in use and be capable of remote maintenance functions including, but not limited to, power cycling, zoom, focus, and access to camera configuration parameters.

Cameras shall be installed, at a minimum, in an IK08 vandal resistant and IP66 rated enclosure. Cameras shall be outdoor rated except for those being installed in interior office spaces, unless otherwise specified by the contract documents. Cameras shall be Power-over-Ethernet (POE). Camera installations shall comply with the contract specifications.

Exterior cameras wired directly into communication rooms shall land on a pre-network switch surge protector.

10.3.3.2 COVERAGE

Cameras are used to monitor station conditions, monitor equipment, provide situational awareness, and provide evidentiary video of incidents.

- Cameras shall be placed in such a way to capture desired pixel density on target (pixel-per-foot or ppf) moving in both directions through the station.
- Cameras shall be placed as if the platforms are at 80 percent capacity. Line of sight shall capture the edge of the platform.

- Cameras shall be placed 10 feet AFF, unless otherwise directed, throughout the station and surrounding environment.
- Cameras shall be placed to provide views of waiting areas, entrances, and exits, and to provide situational awareness.
- Cameras shall be placed to monitor fare machines, both during normal operation and during service procedures, taking into consideration the door swing direction so as not to obstruct the camera's view.
- Cameras shall be placed to monitor movement through fare collection areas (where applicable).
- Cameras shall be placed to view the entire path and landing of all escalators.
- Cameras shall be placed in all service rooms, providing an unobstructed view of the entire door and surrounding area.
- Cameras shall be placed in service corridors and at employee entrances.
- Cameras shall be placed to view all customer intercoms and emergency call phones. The target shall encompass a minimum of 50 percent of the field of view of the image.
- Cameras shall be placed at all entrances and exits of areas of refuge.
- Cameras shall be placed along the exterior of a station to view, at minimum, entrances and exits, kiss and ride drop-off, bus loops, bike racks, crosswalks, and any area that can be viewed to enhance the safety of customers.
- Cameras shall be placed at all wayside ancillary facilities to provide views of all doors, rollup doors, and exterior walls, ramps, and walkways.
- Camera placement shall be coordinated with the lighting plans to prevent whiteouts, with vegetation plans to ensure trees do not obstruct coverage, and with signage plans to prevent coverage blockage.

10.3.4 PUBLIC ADDRESS AND VISUAL INFORMATION DISPLAY SYSTEM

The Public Access system shall perform functions including but not limited to:

- Provide audio information to the public, employees, and contractors in both the public and non-public areas.

The design shall include, but is not limited to, the following major components:

- Station IP to audio converter
- Redundant station amplifiers
- Station speakers
- Control panel with microphone
- Wireless microphone system
- Intercom
- Priority mixer
- Ambient noise sensor and processor
- Compressor / limiter
- Digital audio equalizer

10.3.4.1 CRITERIA

Metra's ACORN system makes automated broadcasts to stations. In addition, the Train Reporting and Customer Communication Center (TRACC Center) leverages Metra's ACORN system to broadcast messages to select stations, such as:

- System wide announcements to all Metra stations
- Announcements to all stations on selected lines
- Announcements to individual stations

Each passenger station shall be designed to have an independent public address (PA) system. The PA system provides for general purpose and emergency evacuation announcements throughout the passenger station.

PA coverage shall be provided to all public and nonpublic areas of the station.

Each station shall be provided with a priority mixer. The line mixer shall be used to control the level of the individual audio inputs. A single output shall be taken from the mixer and input to the power amplification. When an announcement of a higher priority is initiated, the lower priority announcement is removed from the amplifier's input until the high priority announcement is completed.

The operation of the passenger station PA system from the ticketing office shall be accomplished by simultaneously depressing the push-to-talk pushbuttons on the hand-held microphone and the kiosk PA control panel, then speaking into the hand-held microphone.

When a selection is made by a passenger operations supervisor in the operations control center, the audio path of the console shall connect to the station PA via an IP connection.

In downtown passenger stations (Millennium Station, Van Buren Street Station, Ogilvie Transportation Center, and LaSalle Street Station), non-ACORN PA speakers shall be designed to be wired in either noise-compensated or non-noise compensated circuits. Noise-compensated circuits shall be used in areas where train noise must be overcome by automatically adjusting the PA volume. The station waiting area and platform areas shall have noise compensated circuits that use automatic level control. For areas where noise compensation is required, circuits shall be wired to the loudspeaker distribution panel designated for noise-compensated circuits. Non-noise compensated circuits shall be used in all other areas. In areas where noise-compensated circuits are not required, circuits shall be wired to the loudspeaker distribution panel designated for non-noise compensated circuits. Passenger station service rooms and non-revenue passageways are examples of areas that require non-noise compensated speaker circuits. Service rooms shall be provided with a volume control circuit.

The PA amplifiers shall have a constant voltage output of 70.7 volts. Each loudspeaker shall be equipped with an audio transformer to match the 70.7-volt line with the loudspeaker. The transformers shall have various taps to allow for adjustment of the sound level in a particular area. Each transformer shall have a minimum of four taps. The power rating for each of the taps shall be determined during installation.

The design and deployment of public address speakers shall be coordinated with architectural design. The speaker quantities and locations shall be determined by the coverage requirements. A sufficient quantity of speakers shall be placed in passenger stations to give even volume distribution without objectionable loudness from any one speaker location. Non-ACORN speakers shall be fed from two different amplifiers in an alternating feed pattern so that if one amplifier fails, PA audio is provided to all coverage locations.

At Chicago Union Station, Amtrak controls the PA system.

10.3.4.2 REAL TIME TRAIN ARRIVAL DISPLAY SYSTEM (TROI-NET)

Metra currently uses the TROI-NET system to provide scheduled and real-time train arrival information as well as visual display of announcements made through Metra’s ACORN system. In many instances these displays are used to display the audio announcements being made at the station, and appropriate placement must be considered to best convey the visual message to customers.

Design shall consider the use of TROI-NET digital displays in various locations including:

- Above platforms: Perpendicular to the platform so the information is visible along the length of the platform. These installations are typically on a hangman-style pole.
- Along platforms: Digital displays may be hung from overhead structures such as a shelter. Ground mounted displays (totems) may be used in areas where there is a lack of overhead structures or where it is otherwise deemed beneficial.
- Near high-traffic access ways: At stations above street level, placing a digital display at the street level should be considered as well as placing displays at ADA entry points.
- Inside Stations: In areas that have 24/7 access

TROI-NET display options shall include:

- 42-inch Stretch liquid-crystal display (LCD) Display – lower profile display for locations with low overhangs. Can also be mounted on a wall – flat or 10-degree tilt

- 46-inch Landscape LCD Display – mounted back-to-back on a VIS pole. Can also be mounted on a wall – flat or 10-degree tilt
- 46-inch Portrait LCD Display – for flat wall mounting, typically at eye level or slightly above
- 55-inch Landscape LCD Display - mounted back-to-back on a VIS pole. Can also be mounted on a wall – flat or 10-degree tilt
- 55-inch Portrait LCD Display - for flat wall mounting, typically at eye level or slightly above
- 55-inch Portrait Totem LCD Display – for ground level mounting
- 75-inch Landscape LCD Display – for wall mounting – flat or 10-degree tilt
- 75-inch Portrait LCD Display – for flat wall mounting, typically at eye level or slightly above
- 43-inch E-Ink Portrait/Landscape Display – for flat wall mounting at eye level. Displays only 16-levels of gray and used for more static information such as full schedules.

The placement of any displays shall be coordinated with the overall station design effort, including architectural design. Placing displays in recesses should be avoided unless absolutely necessary (i.e., existing recess in a structure). In cases where installation in a recess is required, adequate ventilation on all sides must be taken into consideration. Displays that are mounted on a wall or vertical surface shall be mounted at a height that does not require structure below to meet ADA requirements (typically a minimum of seven feet from ground level to lower edge of the display). All displays are IP-65 rated and do not require additional protection from weather. Displays include built in security locks.

TROI-NET displays shall be connected to the network through WiFi or physically over copper, with the preference being a physical connection.

10.3.5 ACORN

Metra’s ACORN system includes equipment that must be installed at each station, typically within the same location as the Engineering Telecommunications equipment (i.e., comms box). The equipment shall include:

- SCU (Station Control Unit): A Windows PC that contains the Penta and Clever Devices applications that control which messages are played over the station audio system.

- The station microphone shall be wired into the SCU. The SCU shall be connected directly to the station amplifier. Any announcements made at the station through the use of the station microphone shall interrupt any messaging managed by the ACORN solution.

10.3.6 ACCESS CONTROL SYSTEM

The design of the access control system (ACS) shall be an addressable, electrically supervised, closed circuit intrusion detection system. The design shall include automatic and permanent recording of an intrusion alarm. This record shall include date, time, and location of each alarm and trouble.

The access control system shall perform functions including but not limited to:

- Limit access into service room, back of house areas, and other areas of concern to authorized Metra employees and/or contractors.

The design shall include, but is not limited to, the following major components:

- Card reader compatible with the current Metra ID badge

- Door controller

- “Request to Exit” motion sensor and/or push button

- Door contact/position switch

- Door strike of magnetic lock, gate lock, time delay crash bar, electrified lockset

- “Request to Exit” push button shall be provided if a magnetic lock is used

- Device power supply

- Access control enclosure (ACE) mounted on the secured side of the door

The basis of design for the system shall be provided in a future version.

10.3.6.1 CRITERIA

The ACS design shall include intrusion detection devices placed on building entrances, cabinet doors, windows, louvers, and other intrusion points as required. These shall be placed in substations, passenger stations, node houses, train control and communications buildings, equipment areas, ancillary buildings within the passenger station limits, and ancillary buildings or outside areas located along the right-of-way that are accessible to the public and require protection against unauthorized entry as required below. This list is non-exhaustive, and additional intrusion detection devices shall be provided as necessary to ensure controlled access.

ACS shall be provided via the use of an ID badge at the following locations:

- Parts and material storage locations
- Locations where high value items are stored
- Rooms where confidential material is stored
- Main gates and main doorways on employee buildings
- Communication service rooms (currently at KYD Yard only; other locations at the direction of Metra only)

The following locations shall be secured with physical locks, not with ACS, unless otherwise directed by Metra:

- Station Facilities
- Overhead doors and revenue storage roll up doors
- Ancillary station buildings
- Sales offices
- Elevator machinery room
- Electrical rooms
- Mechanical rooms
- Substations
- Elevator machinery rooms
- Other service rooms inaccessible to the public

- Shops and miscellaneous facilities
- Electrical service rooms
- Communication service room
- Mechanical service room
- Tool cribs
- Clerk's office
- Superintendent offices
- Employee offices

10.3.7 COMMUNICATIONS TRANSMISSION SYSTEM (CTS)

A fiber optic, wireless, and copper cable transmission system using recognized industry standard transmission methods shall be used to provide networked voice, data and video communications between specified sites. The CTS will include fiber optic and copper cable plant along with wireless technology, optical and electronic transmission equipment, media converters, digital cross-connect system, and other equipment necessary to provide communications channels at native signal level between sites. Bandwidth and quality of service shall be allocated in accordance with the specific subsystem requirements. The equipment shall be compatible with the existing Metra network equipment standards.

The system will be configured so that it continues to function under certain fault conditions. All equipment comprising the CTS shall have carrier class reliability. The backbone design must not have any single point of failure. The CTS shall be controlled by a single network management system, compatible to Metra's existing management system. Full featured CTS management tools shall be included that allow system configuration and alarms to be managed from the control centers. Maintenance and diagnostic capabilities shall be provided at each local node.

The network, fiber optic cable, and associated conduit system shall be sized to accommodate future anticipated growth, including possible commercialization. The backbone cabling system shall provide for a minimum of 100 percent spare capacity to each station and communications equipment room. Local distribution of communications channels shall be through fiber and copper cables, as required. A minimum of 50 percent spare capacity shall be provided on local distribution cables.

10.3.7.1 FIBER OPTIC BACKBONE

Fiber optic cable shall be installed along the system ROW to interconnect CTS nodes along the alignment. The fiber optic cable installed along the ROW shall have a minimum of 288 strand fiber and 100 percent spare fibers. Provisions shall be made to bring fiber connection and network connectivity to all communications rooms and huts, signal CIHs and traction power substations along the alignment.

10.3.7.2 DUCTS AND RACEWAYS

A complete raceway system shall be provided for all CTS cabling. Cabling infrastructure consisting of conduit, aerial cables, junction boxes, duct banks, man and handholes, hangers and supports, or a combination of multiple routing patterns.

All local distribution cables shall be placed in galvanized rigid steel conduit or totally enclosed raceway.

10.3.8 SCADA

The communication systems for the SCADA subsystem, as part of the Traction Power substations, shall facilitate the transmission of indications and alarms from the remote terminal units (RTUs) to the control centers and the transmission of controls from the various control centers to the RTUs themselves. All transmissions shall be through the CTS. The SCADA transmissions shall include:

- Communications systems control, status/indications, and alarms
- Traction power alarm, indication and control signals
- Building Management Systems (refer to Chapter 14, Mechanical, Electrical, Plumbing (MEP))

10.3.9 TICKET VENDING MACHINE SYSTEM

The TVM system shall provide multiple functions, including but not limited to:

- Clear and intuitive customer interfaces
- Purchase multiple tickets within a single transaction.
- Fare structure based on station-to-station travel, regardless of rail line or zone.

- Software that supports multiple languages.
- Meet all current ADA standards including alternative interfaces to accommodate customers with visual impairment.
- Produce various audio tones and beeps to aid the customer throughout the purchasing process.

The TVM design shall include, but is not limited to, the following major components:

- Safety and security
- Network and remote TVM management
- Customer interfaces
- Fare selection and ticket media
- Receipt printing
- Software and Software Management System

The quantity and types of equipment at each location shall be based on:

- Ridership analysis at each Metra station, specifically peak demand
- Fare policy to be utilized
- Transaction times for fare collection equipment.

See Chapter 8, Stations and Parking, for TVM quantity and placement criteria.

11. TRACTION POWER

11.1 OVERVIEW

This chapter sets forth criteria for the design of the traction power system used by Metra's electrified rail lines. The traction power system interfaces with other systems and equipment, mainly the train propulsion system, signal system, communication systems, passenger stations, train storage yards, as well as mechanical, electrical, civil, structural, and trackwork designs.

See Chapter 12, OCS and Chapter 13, Stray Current and Corrosion Control for additional considerations related to the traction power system.

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of any conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

11.1.1 EXISTING SYSTEM DESCRIPTION

The Metra Electric District (MED) was built in 1926. It comprises an approximately 31-mile Main Line with two branches, the South Chicago Branch Line approximately 4.7-miles and the Blue Island Branch Line approximately 4.4-miles.

The MED traction power system (TPS) provides direct current (DC) traction power to the electric trains by the means of the traction power supply system, the traction power distribution system, and the traction current return system. The electric train collects power from the positive overhead contact system (OCS) by means of pantographs and returns the negative current to the substations via running rails.

11.2 STANDARDS, CODES, AND REGULATIONS

All design work, material selection, installation, testing, and construction shall conform to, or exceed, the requirements of the latest editions of standards and codes issued by the following organizations:

Code, Standard, Reference, or Guideline
Aluminum Association of America
American Hot Dip Galvanizers Association
American Concrete Institute

Code, Standard, Reference, or Guideline
American Institute of Steel Construction
American Iron & Steel Institute
American National Standards Institute
American Public Transportation Association
American Railway Engineering and Maintenance-of-Way Association
American Society of Mechanical Engineers
American Society for Testing & Materials
American Water Works Association
American Welding Society
Association of American Railroads
Building Officials Conference of America
Concrete Reinforcing Steel Institute
Construction Specifications Institute
Illuminating Engineering Society
Industrial Fasteners Institute
Institute of Electrical & Electronics Engineers
International Society of Automation
Insulated Cable Engineers Association
National Association of Corrosion Engineers
National Board of Fire Underwriters
National Electrical Code
National Electrical Contractors Association

Code, Standard, Reference, or Guideline
National Electrical Manufacturers Association
National Electrical Testing Association
National Electrical Safety Code
National Fire Protection Association
Occupational Safety and Health Administration
Steel Structures Painting Council
Underwriters Laboratories

The system shall also meet applicable state, local, and county codes.

11.3 TRACTION POWER SUPPLY SYSTEM

The traction power supply system shall consist of all equipment between the interface points with the local electrical power utility company and the traction power distribution and return systems. The system shall include traction power substations located along the system route and traction power tie breaker stations. The substations shall receive primary power from the three-phase alternating current (AC) distribution circuits of the local electrical power utility company. The substations shall include all the equipment necessary to transform and rectify the utility AC voltage and current to DC electrification voltage and current. The DC current shall be supplied via DC feeders to the overhead distribution system. The AC feeders shall be overhead or underground, while the DC feeders shall be placed in underground ductbanks to the wayside feed points. The tie breaker stations shall include all equipment necessary to sectionalize the OCS at strategic locations such as interlockings and equalize DC current distributed from substations to improve OCS line voltage regulation at the midpoint between two substations.

The equipment shall include:

- AC cables
- AC switchgear assemblies
- Transformers
- Rectifiers
- DC switchgear assemblies

- Negative
- DC positive and negative cables
- Raceways and conduits
- 60 Hz auxiliary power supply system
- Protective devices
- Programmable logic controllers
- Instrumentation
- Indication
- Annunciation
- Supervisory control and data acquisition system
- Lighting
- Temperature control system
- Busbars and bus connections
- Control and low voltage wiring
- Equipment enclosures
- Insulation and grounding systems
- Foundations, substation housings
- Other miscellaneous equipment

The traction power substations shall house all equipment necessary to transform and rectify the utility AC voltage to the traction power system DC utilization voltage used by the electric train. To minimize the construction and installation costs, as many traction power substations as possible shall be of the prepackage-type design. In areas where the environmental impact of package-type substation is not acceptable, the substation equipment shall be installed as discrete components in a masonry building.

11.4 TRACTION POWER DISTRIBUTION SYSTEM

The traction power distribution system shall consist of all equipment between the interface point with the DC traction power supply equipment and the vehicle pantograph. The equipment shall include an OCS with foundations, poles, cantilevers, bridge arms, system conductors, feeders, hangers, jumpers, terminations, tensioning devices, sectioning equipment, disconnect switches and all other necessary equipment. Refer to Chapter 12 for OCS criteria.

11.5 NEGATIVE CURRENT RETURN SYSTEM

The electric train shall collect power from the OCS wire by means of pantographs. After the power is exerted in traction motors, negative current shall be returned to the substations via the steel running rails, cables and/or impedance bonds. The running rails shall be insulated from ground. The negative return system shall be cross-bonded at least every 1000 feet, with impedance bonds if necessary. Where a single signal rail is required the outside running rail shall be utilized as the return for traction power.

See Section 13.4: Stray Current Corrosion Control.

11.6 FUNCTIONAL REQUIREMENTS

All traction power system equipment shall be designed to account for the effects of the harmonic content of the traction load, the highly fluctuating pattern of traction current, and the system faults. The TPS shall be designed for a minimum functional life expectancy of thirty (30) years.

11.6.1 TRACTION POWER SUPPLY SYSTEM

The traction power supply system substations and tie breaker stations shall be designed and located along the system route at predetermined intervals to ensure that the following conditions are satisfied:

- The electric train voltages shall be maintained above a minimum allowable value (1200 volts), voltages below this level would cause an undue degradation of the Electric train performance under all normal operating conditions.
- The traction power supply equipment shall not be overloaded causing excessive temperature rise of equipment and premature equipment failure.
- The voltage shall remain within normal operating levels under normal operating conditions throughout the line, to maintain peak operating performance of the vehicle.

- The negative voltage rise shall not exceed the specified value under any operating condition.

11.6.2 TRACTION POWER SUBSTATION (TPSS)

Whenever site conditions permit, the traction power substations shall be of the prepackage, metal fabricated structure. Each prepackage-type substation shall be factory assembled, pre-wired and fully tested at the factory prior to shipping. All equipment shall be housed in self-supporting, transportable enclosures suitable for outdoor installation. Every package-type substation shall be completely weatherproof, self-contained, with all necessary auxiliary systems for power, heating, ventilation, and air conditioning (HVAC), communications, fire alarm, supervisory control and data acquisition (SCADA). It shall be installed on a vaulted or slab foundation and connected via suitable feeders to the utility interface point and to the traction power distribution and return systems. The prepackage substation unit shall be designed for a thirty (30) year life cycle without the requirement to refresh paint or replace exterior panels.

In locations where the environmental impact needs to be limited, the substations shall be brick and mortar type provided with an acceptable exterior to match architecture of the surrounding buildings and structures and meet any local zoning requirements. In this case, equipment shall be delivered to the site individually as discrete components and installed, connected, and tested within the building.

All TPSS shall be designed to meet state and local building codes and the minimum and maximum recorded temperatures, maximum snow loads, and maximum wind loads associated with the Chicago area.

11.6.3 TRACTION POWER TIE BREAKER STATIONS (TBS)

Traction power tie breaker stations shall be provided at interlockings to allow for power sectionalizing and switching for single track operations during emergencies and where possible or necessary, equalize DC current distributed from substations to improve OCS line voltage regulation at the midpoint between two substations. TBS facilities shall include DC switchgear and bypass switching to provide equalization and sectionalizing to match the power zones and tracks. TBS facilities shall be pre-package type structures, specified to the same requirements as traction power substations.

11.6.4 NEGATIVE CURRENT RETURN SYSTEM

The negative return system shall be designed to ensure that the rail-to-ground voltages are maintained within specified limits to prevent creation of irritating or unsafe vehicle-to-platform potentials and high level of stray currents under all operating conditions.

11.7 DESIGN REQUIREMENTS

11.7.1 SYSTEM LOAD FLOW STUDY

The design of the traction power system shall be based on load flow simulations performed in accordance with IEEE P1653.3 (Guide for Traction Power Modeling). The study shall be performed using a computer program specifically developed for simulation of transit power supply and distribution systems. The trains shall be simulated to operate at the minimum projected headway without any degradation of performance (i.e., reduced or tapered tractive effort), and with all TPSS substations and tie breaker stations in service while maintaining adequate voltage drop to the trains as stated in Section 11.7.2. For contingency outage conditions (i.e., as defined below) the trains shall be simulated to operate at the minimum projected headway with train voltage drop levels as specified in Section 11.7.2.

Systemwide analysis shall include normal operation of all substations in-service and contingency analysis defined as each substation one at a time, experience loss of rectifier transformer unit(s) (TRU) based on number of TRUs at substation, as detailed below.

- Substation with 2 and 3 TRUs, a contingency shall be loss of single TRU
- Substation with 4 and 5 TRUs, a contingency shall be loss of two TRUs

Substation TRU regulation shall be stated to minimize the effect of the system voltage drop.

Under all simulated operating conditions, the TPS design shall be shown to operate successfully within specified design parameters. The TPS design shall not be accepted until all specified parameters are met. The program must be capable of simulating multiple operating schedule offsets to demonstrate worst case conditions, such as train bunching or dispatch fluctuation.

The study input data shall include representations of the track gradients, track speed restrictions, passenger station locations, passenger loading, station dwell times as well as electrical and mechanical characteristic of electric trains. Further, the electrification system shall be represented by the electrical power utility system, the traction power substations, the power distribution system, and the current return system parameters.

The output data shall include train operational data such as speed, distance traveled, mechanical and electrical power, train voltage, negative rail voltage and energy consumption for each station-to-station run. For each substation, the results shall include power demand, energy consumption, rectifier current, DC feeder breaker currents. For each substation-to-substation section of the distribution system, the results shall include positive DC voltage profile, negative voltage profile, and OCS conductor current and temperature. Calculations shall be made to size DC feeder cables from substation to the OCS feeder point.

11.7.2 MAXIMUM VOLTAGE DROPS AND NEGATIVE RAIL POTENTIALS

To sustain high traction motor performance under normal operating condition, the design voltage drop from rated voltage output of 1500 volts shall not exceed 300 volts at any train. Normal operating condition is defined as a rail system operating maximum train consist, at minimum projected headways with all transformer-rectifier units in service at all traction power substations.

Negative rail potential shall not exceed 70 volts for normal operation, 100 volts for heavy service demand (operation under emergency conditions) and 120 volts for substation outage conditions (i.e., abnormal).

As part of the normal operating conditions, under heavy service demands (emergency conditions) such as train bunching, special event services, etc., or a substation with transformer-rectifier unit(s) outages as stated in Section 11.7.1, a voltage drop of 400 volts at the train shall be permitted.

Under abnormal traction power configuration with a total loss of AC power at any one substation, the traction power supply system shall be designed to limit the voltage drop to a maximum of 500 volts. Reduced train performance characteristics under these low voltage conditions would be allowed.

Train cut out voltage is set to 900 volts. At no time shall voltage go below this level.

11.7.3 SUBSTATION SPACING AND DISTRIBUTION SYSTEM CONDUCTOR SIZES

The traction power substation spacing and the size of the distribution system conductors shall be based on the system load flow study taking into account the following criteria:

- Voltage along the overhead distribution system shall not drop below the normal minimum value under "all substations in" condition.
- Voltage along the overhead distribution system shall not drop below the emergency minimum value under transformer/rectifier outage condition

and total substation outage condition. Substation locations shall result in uniform loading of transformer/rectifier units to permit selection of standard rating.

- System overhead conductors shall not carry excessive currents causing the conductor temperatures to rise above the limit recommended by the conductor manufacturer.

- Voltage rise along the running rails shall be within maximum permissible value under all operating conditions.

11.7.4 SUBSTATION EQUIPMENT RATING

Continuous rating of the substation equipment such as the rectifier transformers, rectifiers, circuit breakers and cables shall be based on the system load flow study. The equipment rating shall be selected to account for the following criteria:

- Substation equipment shall be capable of supplying adequate power to the distribution system to enable electric trains to operate at full rated performance under the worst-case peak period operating schedule

- Substations shall have sufficient spare capacity to enable scheduled and unscheduled outages of transformer/rectifier units

- Under transformer/rectifier outage conditions the substations shall permit operation within the overload name plate rated performance

- Substation TRU regulation shall be stated to minimize the effect of the system voltage drop

- Equipment shall be rated extra heavy-duty in accordance with IEEE 1653.2

11.7.5 TRANSFORMER/RECTIFIER UNIT QUANTITY (TRUS)

Each substation shall include the number of transformer/rectifier units (TRU) determined by the load flow study but not less than two TRUs of equal rating.

11.7.6 SUBSTATION LOCATIONS

Subject to the electrical constraints, the substation sites shall be selected in the following areas:

- Sections of system with maximum electrical loading, i.e., adjacent to passenger stations or in the middle of long track gradients

- Locations without underground utility conflicts
- In the proximity of electrical power utility substations or power supply feeders
- Within the system right-of-way or on property owned by Metra
- On the lowest cost property where Metra owned right-of-way is not available
- Locations with minimal environmental impact
- Substation location should include provisions for transformer removal

11.7.7 SUBSTATION INCOMING SERVICE

The traction power substations shall be supplied by the local power utility company AC three-phase, distribution network at a nominal voltage of 12.47 kV, 60 Hz. The designer shall, through Metra, meet with the electric utility and submit a load letter to determine the number and rating of utility feeders. Each feeder shall originate from a different bus of the utility system and shall be as independent as possible from the other feeders. Adjacent substations shall not be supplied by feeders connected to the same utility system bus and preferably not from the same utility substation.

Depending on the substation location, the input power shall be tapped at the utility system interface point from overhead lines or from underground cables. Power supply from the interface point to the substation shall be by underground cables. A Metra-owned means of disconnect shall be provided ahead of the substation at each site.

Cable ductbanks, conduits, raceways and pullboxes inside the substation property line shall be designed from the point of utility interface to the traction substation. The design shall be fully coordinated with the utility requirements and interfaced with the utility overhead or underground facilities. The feeder rating shall permit the substations to supply the specified load cycle and short circuits without exceeding the allowable temperatures of equipment.

11.7.8 SUBSTATION FEEDING CONFIGURATION

Each traction power substation shall have one or more DC main cathode breakers, depending on number of TRUs, and a DC feeder breaker for each power zone. To allow for electrical continuity between the substations under normal and contingency operations, the DC distribution system configuration shall be designed as an equalizer when the substation is offline.

To allow for maintenance on any DC feeder, one maintenance bypass DC circuit breaker shall be provided. The design shall include bypass switches on the output of each DC circuit breaker configured to allow switching for the bypass operation.

11.7.9 POWER ZONE SECTIONALIZING

The system sectioning shall be designed to enable the electrical protective devices to disconnect faulted sections of the distribution system, perform planned maintenance, and achieve flexible operation during system emergencies.

Sectioning at substations and at other locations along the system shall be performed by means of insulated overlaps where possible. Sectioning shall not be located in the middle of station platforms. Sectioning shall be located at least 200 feet from the entering end of any station platform in minimum power draw and minimum regeneration areas. Where overlaps cannot be used, section insulators shall be used. Section insulators shall also be used for sectioning at crossovers and turnouts. All mainline section insulators shall be a bridging type of section insulator.

The primary connection and isolation of the system sections shall be performed by the substation DC feeder circuit breakers. At locations along the route, connections and isolation of the system sections shall be accomplished by disconnect switches located on poles.

11.8 EQUIPMENT REQUIREMENTS

11.8.1 INCOMING AC FEEDERS

The incoming substation service from the power utility interface point shall be by underground cables. Appropriate cable conduits, ductbanks, and pullboxes shall be designed from the utility interface to the traction power substation to specific utility requirements.

The design shall be fully coordinated with the utility requirements and interfaced with the utility facilities. The feeder rating, termination and connector size shall permit the substations to supply the specified load cycle and short circuits without exceeding the allowable equipment temperatures. A means of disconnect from the utility via a pole mounted switch or pad mounted switchgear i.e., S & C Vista underground switchgear outside the substation must be provided for maintenance outages.

11.8.2 AC SWITCHGEAR ASSEMBLY

The AC switchgear assembly shall provide the means to deliver, control and measure the substation power requirements. The assembly shall be housed in dead-front enclosures containing AC draw out vacuum circuit breakers, drawout fuses, draw out potential transformers, current transformers, relaying, and auxiliary power supply equipment. Metering equipment shall be specified and installed in the substation to meet utility requirements. The switchgear lineup shall consist of a main-tie-main configuration.

The equipment shall conform to ANSI C37.20.2 “IEEE Standard for Metal Clad and Station Type Cubicle Switchgear”, and shall be UL listed and labeled, or certified by an independent testing laboratory to meet ANSI and UL standards. Working space shall be provided to access components from the front and the rear of the switchgear. The switchgear shall have bottom cable entry and top cable exit.

11.8.3 AC CIRCUIT BREAKERS

AC circuit breakers shall be vacuum break, draw-out type having specified load and fault break capabilities and shall conform to or exceed the requirements of IEEE C37.06 and IEEE C37.12.

AC circuit breakers shall be designed to roll directly from the floor into the switchgear or from the switchgear compartment onto the floor without a need for external lifting device or dolly. Circuit breakers shall be supplied with two swivel type wheels on the front and two fixed wheels on the rear.

Interrupters, operating mechanisms, and equipment cubicles shall be designed, tested, and assembled by one manufacturer.

Circuit breakers shall be mechanically and electrically interchangeable. They shall be electrically and mechanically trip free. The operating mechanism shall be non-pumping.

11.8.3.1 MINIMUM RATINGS

The following minimum ratings shall apply:

- 15 kV class
- Nominal System Voltage: 12.47 kV, three-phase
- Nominal interrupting capacity: 50 kA, minimum – final coordination by Contractor, with utility short circuit report

- Close and latch rating: 65,000 amps, symmetrical

11.8.3.2 CIRCUIT BREAKER INSULATION

Circuit breaker insulation shall be noncombustible, non-hygroscopic and track-resistant.

Mechanical strength and physical characteristics shall match the stresses imposed by the circuit breaker rated momentary current.

11.8.3.3 CIRCUIT BREAKER OPERATING MECHANISM

Circuit breaker operating mechanisms shall be of the stored energy type. The mechanism shall be designed to prevent overcharging and shall ensure that the release of stored energy for closing the circuit breaker main contacts is prevented unless the mechanism has been fully charged.

The stored energy closing mechanism shall automatically charge itself within 15 seconds after closing of the breaker.

Energy storage shall be sufficient for an open-close-open cycle at the maximum rated short circuit current. Manual cranking capability shall be provided to permit spring charging if motor power is unavailable. Provide manual trip and close buttons on front of circuit breaker.

11.8.3.4 WITHDRAWAL OF CIRCUIT BREAKER FROM ENCLOSURE

Provide an interlock to prevent withdrawal unless the mechanism is fully discharged. Alternately, provide automatic controlled discharge of the stored energy when the circuit breaker is withdrawn from or inserted into the enclosure.

11.8.3.5 OPERATION COUNTER

Operation counters shall be of the four-digit mechanical register type and shall be mounted on each removable element.

11.8.3.6 CONTACT EROSION INDICATOR

Contact erosion indicators shall not be influenced by mechanism wear and shall not require mathematical calculations to determine the amount of contact erosion. Indicators shall be provided on each breaker.

11.8.3.7 CIRCUIT BREAKER CONTROL VOLTAGE

Circuit breaker control voltage shall be 125 Vdc. The equipment shall operate correctly between 100 and 145 Vdc.

An adjustable low-voltage device shall be installed to automatically trip the breakers between 70 and 100 Vdc.

11.8.3.8 CIRCUIT BREAKER CONTROL SWITCHES

Circuit breaker control switch open/close shall be possible from:

- Local, via switch on the breaker
- Local, via supervisory control equipment (RTU) HMI touch screen, in substation control room
- Remote, via SCADA

Circuit breakers shall be configured for control using local closing switch on housing when in test position.

11.8.3.9 AUXILIARY CONTACTS

Provide a minimum of three electrically separate sets of reversible auxiliary contacts, in addition to those required for the circuit breaker control circuit, for each cubicle.

Auxiliary contacts shall be operated by the breaker mechanism in both the connected and test positions.

Spare auxiliary contacts shall be wired to the outgoing terminal blocks.

11.8.4 RECTIFIER TRANSFORMER

Rectifier transformers shall be Vacuum Pressure Impregnated (VPI) dry type transformers and shall be specified and manufactured in accordance with IEEE 1653.1 (Standard Practices and Requirements for Traction Power Rectifier Transformers).

The transformer shall be designed to withstand the system fluctuating load currents and fault currents without overheating or a decrease in life expectancy. The transformer windings shall be adequately designed, insulated, braced, and strengthened to withstand without damage the thermal, mechanical, and electrical stresses occurring during system operation and short circuits.

The overall transformer/rectifier efficiency shall be greater than 97.5 percent at its continuous rating. The displacement power factor shall be 0.95 or greater from 25 percent to full load at rated AC voltage.

11.8.4.1 TRANSFORMER TEMPERATURE LIMITS

Average winding temperature rise by resistance at a 40°C ambient shall not exceed 80°C after a two-hour, 162 percent RMS load following continuous 100 percent load-stabilized thermal conditions.

Average winding temperature rise by resistance at a 40°C ambient shall not exceed 65°C after temperature stabilizes at 100 percent full load current.

Maximum winding hot spot temperature rise shall not exceed 180°C in an ambient corrected to 40°C after running at 300 percent full load current for 36 minutes following stable thermal conditions at 100 percent full load current.

Winding insulation shall be Class H for a total temperature of 220°C or better. The transformer shall be able to withstand a 1,200 percent full load current for 12 seconds without damage.

11.8.4.2 IMPEDANCE

The rectifier transformer's impedance shall be selected to comply with specified voltage regulation requirements.

11.8.4.3 AUDIBLE SOUND LEVELS

For a dry-type transformer, audible sound levels will comply with 65 dB, maximum, at rated voltage, frequency, and no load, with excitation on the transformer, per ANSI C57.12.91.

11.8.4.4 PRIMARY ENTRANCE COMPARTMENT

The primary entrance compartment for the rectifier transformer shall include the necessary conduit termination, fittings, cable supports, and connections.

Provide cable terminators, suitable insulating material, and tape to properly insulate all exposed current carrying members.

Provide for mounting terminals in the compartment. The compartment shall be physically separated via barrier from all other areas of this transformer.

11.8.4.5 SECONDARY ENTRANCE COMPARTMENT

Secondary voltage terminals shall be located at the top of the transformer enclosure, arranged for direct bolted connection through flexible connectors to the bus duct.

11.8.5 RECTIFIER

The rectifier shall be natural, convection-cooled, with six-pulse rectification suitable for indoor service and for the extra heavy-duty cycle. Each rectifier shall be a complete self-contained unit including all bus connections and hardware from the rectifier transformer output flange to the flange for connection of the bus to the DC switchgear. Each rectifier shall be a complete operative assembly consisting of silicon diodes, heat sinks, protective fuses, enclosure, and all other necessary components, controls, and accessories. The rectifier shall be equipped with voltage surge suppressors to limit reverse voltage across diodes with the peak reverse voltage rating of the diode, irrespective of whether the voltage transient appears in the AC or DC power circuits.

11.8.5.1 SILICON DIODES

Diodes shall be hermetically sealed and rated in accordance with EIA-282 and readily replaced without use of special tools. The rectifier shall be capable of carrying the specified overloads and short-circuit loads with one parallel diode removed from each phase arm without exceeding the safe junction temperature on the active diodes. The maximum current imbalance shall not exceed plus or minus 10 percent for all load conditions with one string of diodes per phase out of service.

11.8.5.2 ACCESSIBILITY

Access for all normal maintenance and repair shall be from the front, with internal fluorescent lighting fixtures and windows to facilitate visual inspection of diodes and fuses. Access from the rear shall be provided for maintenance or repair.

11.8.5.3 RATING AND CONFIGURATION

The rectifier unit shall comply with the following:

- Continuous full load output rating: 3000 kW at 1,500 Vdc at a maximum ambient room temperature for 40°C (104°F)

- Duty Cycle: IEEE 1653.2 extra heavy traction service, guaranteed overload after constant temperature rise is reached following continuous full load
- Design for a utility supply of 500 MVA and X/R ratio of 15
- Full load overall efficiency: Not less than 97.5 percent
- Displacement power factor: Above 90 percent lagging

The voltage regulation characteristic shall be six percent to provide output voltage within the limits shown in Table 11-1, based on the following:

Table 11-1. Voltage Regulation	
Output Current	**Output Voltage DC**
0.5 percent Full Load	1,603 to 1,590
100 percent Full Load	1,525 to 1,500
150 percent Full Load	1,485 to 1,455
300 percent Full Load	1,363 to 1,323
450 percent Full Load	1,250 to 1,188

The rectifier transformer, rectifier, bus duct, and AC and DC switchgear shall be capable of withstanding a bolted short circuit on the rectifier output terminals without damage to any component, including protective fuses and rectifier elements immediately following the two-hour overload period specified above.

11.8.5.4 CONFIGURATION

Rectifier #1: IEEE 1653.2 Rectifier Circuit No. 25

Rectifier #2: IEEE 1653.2 Rectifier Circuit No. 26

11.8.6 DC SWITCHGEAR ASSEMBLY

The DC switchgear assembly shall form a lineup of dead-front metal enclosures. The DC circuit breakers shall be high speed or semi-high speed, solenoid operated, draw-out, single-pole units and have bottom feeder cable entry. The DC switchgear shall consist of a main breaker cell, feeder cells, maintenance bypass cell, internal buses, protective circuitry for each feeder, reclosing circuitry for each feeder, digital processing unit for each feeder, programmable controller for the complete DC switchgear and all other necessary components and accessories.

The assembly shall be built to either ANSI C37.20.2 or ANSI C37.20. 3, “IEEE Standard for Metal Enclosed Switchgear” as appropriate. Provide access to install, remove, and maintain cables and equipment in the rear of the cubicle. Front-access-only equipment is prohibited.

11.8.7 DC CIRCUIT BREAKERS

DC circuit breakers shall be heavy duty rated, 1600 VDC, high speed or semi-high speed, draw-out type having specified load and fault break capabilities and shall conform to or exceed the requirements of ANSI C37.14. Circuit breakers shall be withdrawable type with integral wheels and not require use of portable lift device. DC circuit breaker ampere rating shall be determined in accordance with load flow data but not less than 2500 amperes.

11.8.8 NEGATIVE RETURN ASSEMBLY

The negative return assembly shall include negative disconnect switch, negative busbar, terminations for negative return cables, provisions for measurement of bus-to-ground voltage and stray currents, termination for ground cables, and other associated equipment. All equipment shall be rated at the system maximum rated voltage.

11.8.9 DC POSITIVE FEEDERS AND NEGATIVE RETURN CABLES

All DC positive feeder and negative return cables shall be sized to carry the design load and fault currents without exceeding allowable cable temperatures.

The cables shall be suitable for installation in underground ductbanks. All cables shall be continuous from the substation circuit breaker to the distribution system feeding point and from the negative bus to the running rails or impedance bonds.

11.8.10 CABLE RACEWAYS

Cable raceways include ductbanks, conduits, cable trays and other approved methods of supporting cables. Raceways shall be of sufficient size to carry the appropriate cables. A sufficient number of spare ducts (at least 25 percent) shall be provided to enable field modification of installation.

All buried ductbanks for AC feeder cables shall consist of six-inch reinforced epoxy fiberglass conduit (REFC) pipe conduits. All buried ductbanks for DC feeder cables shall consist of concrete-encased four-inch REFC pipe conduits.

The ductbanks shall be furnished with pullboxes spaced at appropriate intervals to maintain manufacturer recommended cable pulling tensions and sized appropriately to enable cable bends not to exceed manufacturers bending radius.

Pullboxes shall be designed with sufficient space to permit proper bending and racking of cables. Cable racking devices shall be provided on walls adjacent to duct line openings.

11.8.11 SUBSTATION STATION POWER

Each substation shall be furnished with station power systems consisting of the following:

- AC auxiliary power system
- DC auxiliary power system

When required, the substations shall supply signal and/or communications system bungalow power requirements. See Chapters 9 and 10.

The auxiliary AC signal power and wayside power systems shall consist of the following:

- 12.47 kV, 60 Hz, AC feeder circuit breaker for the signal power transformer
- 12.47 kV to 2400 Volt, 60 Hz step down signal power transformer
- 2400 Volt, 60 Hz AC switchgear line up for signal power distribution system
- 12.47 kV, 60 Hz, AC feeder circuit breaker for the wayside power transformer
- 12.47 kV to 4160 Volt, 60 Hz step down wayside power transformer
- 4160 Volt, 60 Hz AC switchgear line up for wayside power distribution system

The auxiliary AC signal power and wayside power systems provide power to signal huts, signal cases, passenger stations, and other wayside systems. The power is distributed along the right-of-way suspended from the OCS support structures with separate cross arms mounted above the 1500 VDC catenary.

Service drops are provided with either pole or pad mount transformers, stepping voltage down to usable levels.

11.8.11.1 AC AUXILIARY POWER SYSTEM

The AC auxiliary power system shall consist of the following:

- Auxiliary power transformer with input compatible with the station power primary voltage
- AC panelboard
- AC power distribution system
- Conduits to all distribution system loads and the specific load devices and controls

The AC auxiliary system shall supply the following substation loads:

- Lighting
- HVAC systems
- Convenience receptacles
- Anti-condensation heaters
- Battery charger
- AC control power
- Fire alarm control panel
- Communication systems

11.8.11.2 DC AUXILIARY POWER SYSTEM

The DC auxiliary power system shall consist of the following:

- Ungrounded, 125 Voltage DC sealed substation battery and rack
- Battery charger
- DC panelboard
- DC power distribution system

- Battery disconnect switch
- Conduits to all distribution system loads and the specific load devices and controls

The DC auxiliary power system shall supply the following substation loads:

- DC control power to each device
- Substation electronic device loads
- Annunciation
- Emergency lighting and control
- Substation short circuiting device (Device 57)

11.8.12 PROTECTIVE DEVICES

A comprehensive protective scheme shall be designed based on the magnitudes of load, overload, and short circuit currents. The protective devices protect the substation equipment, the overhead distribution system, and provide back up for the electric train protective devices. The characteristics and ranges of all protective devices shall be selected to ensure satisfactory coordination of all devices and a fast fault clearance.

All protective devices shall be high quality, microprocessor utility-type devices enclosed in rustproof, dustproof, and high-impact cases with integral test switches. The protective devices shall have readily visible seal-in indications signifying specific device function operation. The protective devices shall be arranged to be visible, accessible for maintenance and logically grouped with devices of related functions located in proximity to each other.

11.8.12.1 TRACTION POWER SUBSTATION PROTECTION

Protection in traction power substations includes the following devices:

- AC switchgear protection: Device shall be microprocessor based and incorporate as many of the following functions in one unit. Electro-Mechanical relays shall not be acceptable with the exception of Device 86
- Time overcurrent function with instantaneous element, Device 50/51

- Time overcurrent function, Device 51
- Time overcurrent function with instantaneous element, Device 50/51 N
- Undervoltage function, Device 27
- Phase imbalance function, Device 47
- Overvoltage function, Device 59
- Lockout function, Device 86
- Dry type transformer protection: Device shall be solid state.
- Winding overtemperature function, two-stage, Devices 49-T1 and 49-T2
- Door position contacts, Device 33

11.8.12.2 RECTIFIER PROTECTION

Rectifier protection device(s) shall be solid state, programmable logic controller (PLC) based, and incorporate as many of the following functions as possible in one unit:

- Diode fuses
- Diode failure function, Device 98-1 & 98-2
- Overtemperature protective functions, Devices 26-R1 and 26-R2
- Surge protection
- Reverse current instantaneous function, Device 32
- Door position contacts, Device 33
- DC switchgear protection: Device(s) shall be microprocessor based, and incorporate as many of the following functions in one unit
- Direct-acting overcurrent trip function, Device 176
- Time overcurrent function, Device 151

- Rate-of-rise function, Device 150 R
- Load measuring and auto-reclosing function, Devices 182 and 183
- DC feeder breaker transfer trip function, Device 85
- Incomplete sequence function, Device 48
- Negative to Earth Potential function, Device 57/59

11.8.12.3 DC ENCLOSURE PROTECTION

Provide the following:

- Enclosure live protection function, Device 64 L
- Enclosure grounded protection function, Device 64 G

11.8.12.4 NEGATIVE DISCONNECT ENCLOSURE PROTECTION

Provide the following:

- Door position contacts, Device 33
- Negative disconnect switch position contacts, Device 33

11.8.12.5 SPECIAL PROTECTION

Provide the following:

- Negative grounding unit function, Device 57

11.8.12.6 OTHER PROTECTION

Provide the following as appropriate:

- Undervoltage function, Device 27 A
- Overvoltage protection utilizing AC and DC surge arresters
- Smoke and Fire detection
- Intrusion detection
- Auxiliary devices as required
- ETS mushroom pushbuttons

- Signal and wayside power system
- Time overcurrent function with instantaneous element, Device 50/51
- Lockout function, Device 86

11.8.12.7 SURGE ARRESTERS

AC and DC surge arresters provide overvoltage protection of the substation equipment. The arresters shall be rated to withstand the maximum system voltage. The arresters shall be capable of discharging the energy resulting from lightning strikes, switching surges and regeneration surges.

11.8.13 INSTRUMENTATION

Instrumentation shall be high quality, metal case, semi-flush, high accuracy, electronically stable microprocessor type devices. All instrumentation shall have an accuracy of one (1) percent or better. As a minimum, the following instrumentation shall be provided and incorporate as many of the following functions as possible into one unit for each AC switchgear, rectifier, and DC switchgear:

- AC feeder voltmeter
- AC feeder ammeter
- AC event and fault storage Instrumentation
- Auxiliary power voltmeter
- Rectifier output voltmeter
- Rectifier output ammeter
- Traction transformer winding temperature
- DC feeder voltmeter, one for each switchgear bus section
- DC feeder ammeter, one for each feeder
- DC Event and Fault Storage Instrumentation, one for each feeder
- DC Enclosure Voltage Instrumentation

- Substation high ambient temperature detector
- Thermostat

11.8.14 INDICATION

All indications, such as circuit breaker opened and closed positions, shall be by light emitting diodes (LEDs).

As a minimum, the following indications shall be provided:

- AC breaker opened and closed
- 86 Device operation
- DC breaker opened and closed, one for each breaker
- Negative switch opened and closed

An AC digital power monitor shall be provided to monitor and display line current per phase in amperes, line-to-line voltage and line-to-ground voltage in volts, and power demand in kW. The output of the monitor shall be suitable for connection to SCADA using an appropriate interface. The monitor shall capture and store all faults and events on the AC power system and shall be capable of downloading the data to a PC for analysis.

11.8.15 ANNUNCIATION

The substations shall be equipped with an internal annunciation system. The annunciator shall be of modular design, convection-cooled, solid-state, and programmable. The annunciator consists of LED indicating lamps, acknowledge and reset functions as well as other associated equipment.

A comprehensive annunciation "points list" shall include the following conditions:

- AC incoming power loss
- AC auxiliary power loss
- AC incoming power fault
- Transformer over-temperature
- Rectifier over-temperature

- Diode failure
- DC breaker trip (group)
- DC breaker transfer trip (group)
- Equipment door open
- DC enclosure live
- DC enclosure grounded
- DC auxiliary power loss
- Battery charger failure
- Substation lockout function operation
- Rectifier reverse current trip
- Negative to earth overvoltage
- Substation ambient temperature high
- Smoke/fire alarm
- Intrusion alarm
- Signal power fault
- Wayside power fault

The substation alarm panel shall be built to ANSI C37.21 “Standard for Control Switchboards”, and contain the substation annunciator, and SCADA interface terminal blocks. The substation alarm panel shall be the central location for emergency diagnostics.

11.8.16 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

Each substation shall be equipped with a SCADA system to enable control, status indication and telemetry to the Operation Control Center (OCC). A comprehensive SCADA "points list" shall include the following:

- Status Indication Points
- Control Points

- Measuring Points
- AC incoming power loss
- AC auxiliary power loss
- AC incoming power fault
- Transformer over-temperature
- Rectifier over-temperature
- Diode failure
- DC breaker trip (group)
- DC breaker transfer trip (group)
- Equipment door open
- DC enclosure live
- DC enclosure grounded
- DC auxiliary power loss
- Battery charger failure
- Substation lockout function operation
- Rectifier reverse current trip
- Negative to earth overvoltage
- Substation ambient temperature high
- Smoke/Fire alarm
- Intrusion alarm
- 50/51 Trip indication

11.8.17 SCADA REMOTE TERMINAL UNIT

Control and indication of each substation shall be performed by a flexible, compact, and reliable remote terminal unit (RTU). The RTU shall be the latest ePAQ-94XX and Sim 94XX manufactured by QEI, or approved equal, and shall support as a minimum the following features:

- Digital status inputs with momentary change-of-state detection and reporting
- Analog inputs with exception reporting dead bands
- Highly secure select-check back controls with programmable execute durations
- Analog set point controls
- Sequence of event (SOE) time tagging
- Programmable calculations and stand-alone control algorithms
- Support both byte and bit-oriented protocols
- Serial and/or IP communication compatible with substation electronic control, instrumentation, and metering intelligent electronic device (IED) protocols compatible with QEI IED protocols

All control and status relays in the SCADA cabinet shall have LEDs.

The remote terminal unit shall incorporate a modular architecture with maximum simplicity of expansion. All logic and communication functions required shall be supported by the hardware included in a single integrated central processor card. Field wiring termination shall be made at the RTU cabinet. Expansion of the RTU shall require only the addition the required I/O panels: status input, control output, and/or analog input.

11.8.17.1 HUMAN MACHINE INTERFACE

The SCADA RTU shall be equipped with a human machine interface (HMI). The HMI shall have the capability to view and acknowledge all alarms in the building and only view (not acknowledge) alarms in the substation. The HMI shall be mounted in a separate enclosure per Metra's instructions.

The HMI shall meet the following requirements:

- Not less than 1920 x 1080 pixels
- Size: Minimum 32-inches diagonal

- Microsoft Windows®-based user interface on touch screen
- Provide connection options for external periphery units (keyboard, mouse, and laptop), e.g., via a USB interface
- Minimum 64-bit RISC CPU
- Minimum configuration memory: 16 gigabytes
- HMI shall be wall-mounted, in the area adjacent to the RTU. Final location height shall be decided by Metra based upon the manufacturer's recommendation.
- Final listing of substation alarms and status shall be approved by Metra
- HMI touchscreen software shall be fully graphical

11.8.17.2 HMI SCREENS

Color coding shall be used on HMI screens, and shall conform to the following:

- Provide different colors to indicate the energization or operational status of traction power system equipment on the touch screen
- There are no exceptions to the following color codes for equipment symbols on the single line diagram and no other colors are permitted
- Energization: Color shall indicate the energized, de-energized, or uncertain state of each component, including the busbar and feeder cables
- Energized equipment: Red
- De-energized equipment: Green
- Uncertain equipment state: Grey
- Display flashing red color text "Energized" beside each piece of equipment when it is first energized and solid Red after 10 seconds.

- Color shall indicate the good, bad, or uncertain operational status of the Master Controller, HMI, and IEDs:
- Good Condition: Green
- Bad Condition: Red
- Uncertain Condition: Grey

The following HMI screens shall be provided, with the specified capabilities:

- Control Screen
- This view shall show a simplified one-line diagram, showing the major substation components
- The status (including the color) of the traction power equipment on the touch screen shall be displayed in real time and updated at least every two seconds
- This view shall provide open/close operation of the equipment in accordance with the HMI user management system
- If a protection function is triggered, the related equipment and alarm field shall flash until it is acknowledged
- The alarm shall be acknowledged only once on either the control view or alarm view
- The screen shall display the manufacturer’s logo, Metra’s logo, the substation name, and the current time and date
- Alarms Screen
- This view shall indicate which alarm has been triggered in the traction power system. Alarms shall include those from the master controller, HMI, rectifiers, auxiliary equipment and IEDs.
- Provide each alarm message with an individual acknowledge button on the touch screen
- The alarm message shall continue to flash until it is acknowledged
- Alarms shall be user-definable to add additional alarm items

- Alarms from each rectifier HMI as well as all AC switchgear and PSE building alarms shall be displayed
- Events Screen
- This view shall display operating statuses and fault messages concerning the traction power system and master controller, HMI, and IEDs
- It shall display a log of in/out, and record of values measured and stored periodically, such as current and voltage
- Events shall be user definable to add additional event items. Any event item shall be able to convert to an alarm item.
- Network Status Screen
- This view shall display the communication and health status of the entire network, including master controller, HMI, IEDs, and SCADA workstation
- The 125 Vdc control power system status shall be displayed on this view
- Communication status to Metra's central server and active fiber line shall be displayed
- If a device fault occurs, the related icon shall flash until it is acknowledged
- Settings Screen
- Provide a settings screen application for adjusting time, editing user management/password settings, editing alarm screen windows, and viewing PAC I/O Status
- Time setting: Provide both manual adjustment options and automatic SNTP synchronization with an NTP server
- Viewing permissions: No password required
- Editing permissions: Password required
- Help Screen

- Provide a help screen containing operational instructions and descriptions for the SAS HMI applications described above
- Organize and display help topics in an outline format with individual topics that expand to display information when selected
- Provide a legend defining the symbols and abbreviations used on the HMI screens

11.8.18 LIGHTING

Substation lighting design shall provide for a minimum lighting level of 50 footcandles at the floor level.

Two LED lights shall provide outdoor security lighting located above each substation doorway. The security lighting shall be controlled by a photoelectric cell and shall not overflow into surrounding residential communities and must meet the Metra lighting standards with a minimum of five (5) footcandles at ground level.

Substations shall be provided with the following emergency lighting:

- Emergency lighting supplied from the DC panelboard shall be energized using a switch located near each door. This lighting shall utilize the 125-volt DC battery bank used for battery backup. The emergency lighting shall be incandescent and provide for a minimum lighting level of five (5) footcandles at the floor level.
- A self-contained emergency lighting circuit to include exit indication located above each egress shall energize the lamps on failure of the AC power. The emergency lighting shall be incandescent and provide for a minimum lighting level of five (5) footcandles at the floor level for a minimum of four hours.

11.8.19 TEMPERATURE CONTROL SYSTEM

The substation temperature control system shall control the substation ambient temperature. HVAC heat pump units shall be furnished for this purpose. The HVAC system shall be fully redundant to allow for a single HVAC unit failure without exceeding operating temperature limits of all installed equipment. The substation HVAC requirement shall be determined from the worst-case loading of the load flow simulation study and solar loading. The noise level generated from the HVAC units operating together shall not exceed 65 dB inside the substation. The external noise level generated from the HVAC units operating together shall not exceed City of Chicago requirements. The replacement of filters shall be able to be performed without the use of tools from inside the substation. All HVAC units shall be cycled to operate fully on when the ambient air within the substation exceeds 90 degrees.

11.8.20 BUSBARS AND BUSS CONNECTORS

The busbars and buss connections shall be designed to withstand, without damage to the busbars or enclosures, the thermal and mechanical stresses occurring during the specified load cycle and the rated short circuit currents.

Busbars shall be made of rigid, high electrical conductivity copper and shall be adequately insulated and braced with high strength insulators. Buss connections shall be bolted and furnished with silver-plated surfaces. Each joint shall have conductivity at least equal to that of the busbar.

Busbars and termination points for metal clad switchgear shall be insulated per ANSI C37.20.2.

11.8.21 CONTROL AND LOW VOLTAGE WIRING AND CABLES

Substation control and low voltage power wiring and cables use insulated stranded copper conductors sized based on voltage drop, rated ampere, and short circuit duty. The conductors shall be of sufficient gauge to withstand repeated handling during maintenance. Multi-conductor cables are not acceptable for control wiring within the substation.

11.8.22 EQUIPMENT ENCLOSURES

All equipment shall be housed in enclosures fabricated out of steel. The equipment enclosures shall have structural strength to support equipment during transportation and installation, and to endure mechanical stresses under normal operation and short circuit conditions.

11.8.23 EQUIPMENT ARRANGEMENT

Substations shall have adequate space to accommodate all electrical equipment and ancillary components while providing adequate drawout and working space around drawout equipment. Relative spacing and positioning of each item of equipment shall permit maintenance, removal, and replacement of any equipment unit without the necessity of moving other units.

The arrangements of the equipment shall permit doors to be opened, panels to be removed, and switchgear to be withdrawn without interference of other units. Ceiling heights, aisle clearances, and structural openings shall permit entry and removal of the largest components installed in the substation. Access shall be provided to maintain cables, fuses, and equipment in the rear of cubicles without necessitating entry through the cubicle.

Minimum working clearances that meet or exceed NEC requirements shall be provided.

11.8.24 GROUNDING

11.8.24.1 SUBSTATION GROUNDING

Each traction power substation shall be furnished with a ground grid and provisions for equipment grounding. The ground grid shall be contained within the substation property lines and shall be designed so that the step and touch potentials at rated short circuit current do not exceed the recommended safety limits of IEEE Standard 80.

All grounding connections shall be capable of carrying the rated short circuit current.

11.8.24.2 HIGH RESISTANCE GROUNDING FOR DC EQUIPMENT

All DC equipment enclosures shall be electrically and suitably insulated from the substation floor with an insulating compound, and from walls and AC enclosures with sheets of insulating material. The insulating materials, when exposed to flames or electrical arcing, shall not produce gases harmful to personnel and have self-extinguishing properties.

11.8.25 SUBSTATION FOUNDATIONS

The substation foundations shall be designed by the project civil/structural engineers to withstand all live and dead loads of the substation building and equipment. Substation foundations shall be designed in accordance with BOCA standards as well as the Local Building Code. An appropriate factor of safety according to the standards shall be applied at each site.

Each foundation shall be provided with necessary elements to connect the substation equipment to the local power supply system, to the overhead distribution and return circuits, to the communications interface point, to an electrical drainage interface point, and to the auxiliary power interface point. The civil utility design shall provide appropriate ductbanks and pullboxes at each site to facilitate the substation design. Substation foundations shall be a slab or vaulted design. Any required steps or entrance ramps must meet local building codes and OSHA standards. Traction power substation floor, grid, components, and foundation base slab shall be located a minimum of one foot above the one hundred (100) year flood elevation.

11.8.26 SUBSTATION HOUSING AND SITE REQUIREMENTS

Substation housings shall be weatherproof, manufactured of steel, and designed to withstand stresses caused during transportation and the maximum specified wind speed and equipment loading. Substation housings shall be galvannealed and painted with a color approved by Metra.

The housing shall be of double wall and double roof construction to accommodate insulation material to reduce heat transfer. Sufficient insulation material shall be provided under the building to the floor to reduce heat transfer. Two exit doors with panic hardware shall be provided at opposite ends of the building. A roll up door shall be provided to remove equipment. Removeable panels or exterior doors shall be provided to access the rear of all equipment cells for connection and maintenance and permit removal of interior equipment.

Substation shall be equipped with personnel entry staircases, landings, and railings in accordance with code requirements. When a substation is accessible from the street, sufficient parking and turn around capabilities shall be provided for work vehicles and large delivery trucks as well as security fencing and vehicle entry gates. Substation rollup door access shall be designed with a roadway ramp to allow typical 10-ton flatbed truck loading. All walkways and driveways shall be designed for rated loads and in accordance with applicable local standards.

The substation site shall be equipped with outdoor lighting for personnel safety. All exterior lighting shall be on a photocell and be IEC 62262, IPX3 and IK10 rated. Illumination shall be designed for five (5) footcandles at 4’-0” above finish floor. All walkways and driveways shall be illuminated.

Surrounding site landscape, if available, shall be designed with a minimal-maintenance covering using ballasted granite rock, asphalt, or other material as approved by Metra.

11.8.27 ADDITIONAL EQUIPMENT

Substations shall be provided with auxiliary equipment and devices necessary for reliable and safe operation of the units as well as to enable preventive and corrective maintenance of the substations. These shall include anti-condensation heaters, spare contacts, test points, handling equipment, fire extinguishers, telephones, receptacles, document cabinets, spare parts cabinets, worktable, first aid kit, and other miscellaneous items. Fire extinguishers and automatic fire detection system shall conform to local fire code requirements. Ventilation fans shall be provided for battery installations in accordance with building and fire codes.

Substations shall be environmentally controlled and ventilated to maintain temperature between 68°F and 85°F throughout the year. Redundancy shall be designed into the environmental system to provide N+1 units should any one unit fail. The use of large removeable filters shall be designed to allow ease of service and maintenance access.

11.9 SERVICE AND INSPECTION YARDS

Metra's service and inspection (S&I) yards provide storage of rail cars during non-revenue hours, provide for the inspection and maintenance of the cars, and replacement and repair of bulky car equipment in major repair shops. The power for the movement of rail cars to and from the yard and for the support of stored cards in the yard is provided by the traction power facilities located within the yard area.

11.9.1 TRACTION POWER DESIGN

The steel running rails in the yard shall be insulated from the ground in the same manner as the running rails for mainline revenue tracks. Because of its overall lower resistance to ground, due to track lengths and configuration, yard tracks shall be isolated from the mainline track using insulated joints.

At the junction of the mainline tracks and yard track isolation point, the yard contact OCS shall also be electrically isolated from the main line OCS, therefore effectively isolating the yard traction power system from the main line traction power system. Physical separation between the mainline OCS and yard OCS shall be from a non-bridgeable section insulator. However, means shall be provided to defeat electrical isolation of the mainline and yard traction system, should the rectifiers supplying the yard traction power fail.

The shop running rails shall be isolated from the yard running rails using an insulated joint outside the apron of the shop entry tracks. The shop 1500 VDC power shall also be electrically isolated from the yard OCS and powered from its own rectifier unit. For running rail isolations, all insulated joints (IJ), insulated join bars, and jumper cables shall be located three (3) feet away from the edge of the shop apron. All jumper cables shall be installed in approved conduits for traction power cables.

Yard traction power facilities shall be sized to accommodate up to four, three-megawatt, transformer rectifier units. For reliability reasons, a minimum of two units shall be installed in the traction power substation regardless of the load calculations. The yard load calculations shall include the following:

- Auxiliary load of maximum number of cars/trains that can be accommodated on the yard and storage tracks

- Load of the switch heaters (if applicable)
- Load to support 60 Hz and DC power for the S&I shop in the event the shop rectifier is offline
- Loads to support movement of one 8-car train moving in and one moving out of the yard simultaneously.

Yard traction power substation(s) shall be strategically located to avoid negative return currents from the storage tracks to magnetize train control switch points.

A yard TBS or TPSS shall be installed at the yard entry to allow for isolation of yard DC power from mainline DC power. The TBS or TPSS shall be designed for equalization of power across non bridgeable section insulators coincident with the yard-to-mainline IJs. The TBS or TPSS shall have positive and negative DC circuit breakers and shall allow local remote-control operation from the yard tower to “tie” or “isolate” the two systems.

Yard rectifiers shall support 100 percent of the calculated loads without utilizing overload capabilities of the rectifiers. The overload capabilities of the yard rectifiers shall be considered only during the movement of the eight-car train in and out of the yard in addition to supplying 100 percent of the designed loads or for single rectifier outage conditions. Under these conditions the overload duration shall never exceed the equipment ratings.

DC feeder circuit breakers shall be provided to supply power to each yard power zone.

Storage track power zones shall be logically grouped to be fed from different DC feeder circuit breakers based on projected load and to allow for outages or emergency operations.

Each yard lead track OCS power zone shall be fed from dedicated DC feeder breakers.

TBS shall support double crossovers installed at critical locations, based upon the yard's failure mode analysis, to maintain yard operations during an emergency.

S&I shop entry track OCS power zones shall be fed from dedicated DC feeder breakers to allow continuous, limited shop operations in the event of outages or emergencies.

Yard bypass and loop track OCS power zones shall be fed from dedicated DC feeder breakers to allow for limited yard operations in the event of other power outages and emergencies.

The power zones supplying car storage tracks and other tracks where cars can be stored shall have either double end power supply or the means to be supplied by another OCS power zone through a manual disconnect switch.

Electrically interlocked, positive and negative bus tie breakers shall provide mainline/yard isolation as well as DC power to the S&I shop where applicable.

The power rails in the yard shall be cross bonded to equalize traction power return current. Additional cross bonding cable shall be installed to compensate loss for cross bonding cable as a backup means for the traction current return.

At special track work, where the power rail and the signal rail reverse sides, adequate quantity of power bond cable shall be installed to maintain electrical resistance of the power rail.

Negative return cable connections to the running rails shall be distributed throughout the yard to allow for rated current equalization. Negative rail connections and bonding shall be fully coordinated with the Automatic Train Control (ATC) system design.

11.9.2 TRACTION POWER EQUIPMENT

Technical requirements of the traction power equipment shall be the same as those for the mainline as specified in Section 11.8, with the following exceptions:

- The remote control of the yard traction power equipment shall be from the yard control panel through the yard SCADA System. HMI installed in the yard control tower shall display equipment arrangement, status, and alarms, and provide control of each DC feeder breaker supplying power to the yard OCS power zones.
- The multi-function protection relay (MPR) providing protection to the DC feeder breakers shall be inhibited for the load measuring and automatic reclosing of the circuit breakers.
- The setting of the protection relay shall be based upon an approved short circuit/coordination study.
- Provision shall be made to supply S&I house power from the traction power substation DC distribution system, in case the transformer rectifier unit

supplying the S&I house power fails. Key interlocks shall be provided to avoid dual supply to the S&I shop.

- The traction power equipment shall communicate with the yard control tower through the SCADA equipment for control, alarm, and status indications. Yard control tower shall be equipped with means to de-energize the entire yard with one command (emergency off)

- Where the yard OCS has a dual end feed, a trip command from the yard control tower shall trip both DC feeder breakers supplying the same tracks simultaneously. The closing of the DC feeder breakers shall be independent of this requirement.

11.9.3 YARD STORAGE TRACKS

Adequately sized no load make/break isolation switches with a minimum rating of 2500A shall be installed for each storage track to isolate the storage track for maintenance and repair purposes. Each yard isolation switch shall be provided with a voltage sensing device and position switch connected to SCADA for monitoring.

The isolation switches shall be bolted pressure design and enclosed in a fiberglass enclosure suitable for pad mounting in a vertical position. The isolation switches shall have sufficient auxiliary contacts to transmit their status to the yard control tower and provide means to isolate both power buses of the heater cable installed on the storage tracks.

11.9.4 SERVICE AND INSPECTION SHOP

1500 VDC power required for the movement of the cars in and out of the S&I shop and during testing and inspection of the rail cars shall be provided through a dedicated TPSS rectifier unit located in the S&I. This TPSS design shall have provisions to receive backup power from the yard traction power distribution system in case of failure of its transformer rectifier unit. A key interlock scheme shall inhibit simultaneous dual feed to the shop traction system. This house power is isolated from the yard traction power distribution system.

The transformer-rectifier unit shall be designed for an extra heavy duty loading cycle per IEEE P1653.2 (standard for uncontrolled traction power rectifiers).

The DC switchboard located in the S&I TPSS shall supply power to the S&I shop's overhead contact wire system. Sectionalization within the S&I shop shall be provided to allow de-energization of individual work areas and tracks. Wall mounted push button stations and isolation disconnect switches shall be provided for each power section, to allow local operation of power by shop personnel.

The S&I shop and the car wash tracks shall be electrically isolated from the yard tracks and shall be encased in an insulating epoxy to provide isolation from the S&I shop floor's reinforcement.

The S&I shop and car wash tracks shall be firmly grounded to the substation grounding system.

11.9.5 YARD CONTROL TOWER

An HMI master yard control panel shall be installed in the tower to control OCS power within the yard limits. The design shall include an HMI SCADA workstation that shall communicate to the TPSS equipment through its Digital Input-Output (DIO) for control and status. The equipment status and yard OCS power zones, isolation switches, and DC feeder breaker graphics shall be displayed continuously on a large screen monitor in the tower.

The yard traction power equipment and SCADA design shall provide for the de-energization of the entire yard traction system with a single command from the yard control tower.

12. OVERHEAD CONTACT SYSTEM

12.1 OVERVIEW

This section provides the criteria for the overhead contact system (OCS), also referred to as the traction power distribution system or catenary system. The section includes technical, operational, maintenance, local climatic, and economic considerations.

The traction electrification system shall provide electrical power to the electric multiple unit (EMU) by means of the traction power supply system (TPSS), the OCS, and the traction current return system. The EMU will collect power from the positive overhead contact wires by means of pantographs and return the negative current to the substations via the running rails.

The traction electrification system will interface and be coordinated with other systems and equipment on the project, including the EMU, the corrosion control, signal, and communications systems, as well as mechanical, utility, electrical, civil, structural, and trackwork designs.

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of any conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

12.1.1 OVERHEAD CONTACT SYSTEM TYPES

Five distinct types or styles of OCS are used on the Metra system:

- Simple catenary auto tensioned system
- Simple catenary fixed termination system
- Single contact wire auto tensioned system
- Single contact wire fixed termination system
- Overhead conductor rail system

A **simple catenary auto tensioned (SCAT)** system shall consist of a messenger wire supporting a contact wire by the means of hangers. The contact wire shall not sag over the operating design temperature range. Auto tensioning shall be accomplished by means of counterweights or spring tension devices, which shall be mounted to anchor poles located at the ends of each tension length. As the conductors contract and expand with temperature variation, the counterweights rise and fall thus maintaining a constant conductor tension throughout the specified temperature range. Suitable midpoint anchor arrangements shall be used in the center of each tension length to prevent along-track movement of the OCS at that point. The system shall be designed to meet current carrying capacity and power requirements without the use of supplementary along-track feeders.

The catenary system shall be supported and registered by means of hinged cantilevers, head spans, k-frame portal structures, lattice portal structures, and pull-offs attached to steel poles. Wherever possible, poles shall be located between the tracks. At special locations, such as crossovers, turnouts, and stations, the OCS may be supported by cantilevers mounted on poles located on the outer sides of the track or attached to head span arrangements or portal structures.

Contact and messenger wires shall be offset from the track centerline (staggered) at registration points to provide for even wear over the width of the pantograph carbon strips.

A **simple catenary fixed termination (SCFT)** system consists of a messenger wire supporting the contact wire by means of hangers. This system shall use fixed conductor termination assemblies that do not compensate for conductor elongation, and therefore the tension is variable. The system shall be supported from insulated bracket assemblies.

A **single contact wire auto tensioned (SWAT)** system with parallel feeders consists of a contact wire strung with sag over the tracks and electrically supplemented with feeder cables outside the track ROW. Feeders shall be insulated cables installed in raceways or aerial bare conductors supported from insulated bracket assemblies. Feeders shall be connected to the contact wire, as appropriate, at approximately equal intervals. The contact wire shall be staggered. Auto tensioning and support of the system shall be accomplished like the auto tensioned simple catenary system.

A **single contact wire fixed termination (SWFT)** system shall be supported from insulated bracket assemblies. Where required, along-track paralleling feeders shall supplement the single contact wire system.

An **overhead conductor rail (OCR)** system shall consist of a contact wire inserted at the bottom of an extruded aluminum profile rail section. A reduced height aluminum profile rail section may be used in areas that restrict the use of standard OCR. Supports shall be sliding or pivoting type and provide double insulation between the OCS and any grounded structure. The conductor rail design shall include staggering of the OCR, provisions for a smooth transition in overlaps (especially in the upward direction of track slopes), and between the flexible OCS and the OCR. The section lengths shall be properly sized to account for track alignment and shall include the use of mid-points with overlap sections where applicable.

12.1.2 EXISTING SYSTEM DESCRIPTION

The Metra Electric District (MED) OCS was built in 1926. It comprises approximately 41 miles (a 31-mile Main Line with two branches, the 4.7-mile South Chicago Branch Line and the 4.4-mile Blue Island Branch Line).

The existing OCS is a compound catenary fixed termination system that is comprised of a stranded composite messenger wire supporting a copper auxiliary wire and a grooved contact wire vertically through hangers. The contact wire heights range from approximately 16 to 21 feet.

The Main Line OCS underwent some support structure replacement in 1967 and 1990. The system generally utilizes steel lattice portal structures. Most portals span two to three tracks with some conjoined with an adjacent portal to support the wire for additional tracks. The catenary structures also typically support signaling equipment and conductors.

The South Chicago Branch Line OCS was replaced in 1967. This is a double tracked line with single steel poles between the tracks or steel portals that span both tracks. From these poles, steel arms cantilever over the tracks and support the catenary wires. Like the Main Line, some of these poles support signaling equipment. Above the OCS, additional support assemblies carry ancillary wires the length of the branch line. The poles are supported by concrete foundations and some masts are incorporated into stations.

Blue Island Branch Line OCS is generally comprised of a single steel I-beam pole with a cantilever, supporting compound catenary over a single track. There are additional ancillary wire supports typically installed above the OCS cantilevers. In locations where the line is double tracked, the poles are located between the tracks.

12.1.3 PROPOSED SYSTEM DESCRIPTION

The OCS consists of all equipment between the interface point with the 1,500 volts direct current (DC) traction power supply wayside equipment and the vehicle pantograph. The interface point between the OCS and the TPSS feeders is the feeder tap pole or the feeding disconnect switch pole. The OCS equipment shall include foundations, poles, cantilevers, bridge arms, system conductors, feeders, hangers (droppers), jumpers, terminations, tensioning devices, sectioning equipment, disconnect switches, and all other necessary equipment.

The mainline OCS shall consist of a SCAT system. The electrification system shall include a single contact wire supported by a messenger wire via hangers per track. The tension of the mainline conductors shall be held constant by the means of counterweights or constant tension spring devices. The overhead conductors shall be supported typically by freestanding poles, although other means of supports, and overhead bridge attachments, may be used with approval by Metra. A SCFT system may be used in areas where a SCAT system cannot be applied. The use of fixed termination requires approval by Metra.

Storage yards shall primarily utilize a SCFT or SWFT system with parallel feeders if needed. A SCAT or SWAT system with parallel feeders may be used as an alternative with the approval of Metra. (See Chapter 15: Shops and Yards for additional requirements for OCS in storage yards.)

Shop areas shall utilize a SWFT system or an OCR system. The SWFT system shall be supported from insulated bracket assemblies attached to building structures. Where required, along-track paralleling feeders shall supplement the SWFT system. If an OCR system is used, it may be stationary or movable. The use of an OCR system requires approval by Metra. (See Chapter 15: Shops and Yards for additional requirements for OCS in shops.)

For tunnel or underground areas or in other locations where a bridge or building restricts the use of standard OCS and where fixed termination catenary wires would create problems, an OCR support system may be used. The OCR system, if used as the OCS, shall consist of a contact wire inserted at the bottom of an extruded aluminum profile rail section, which in turn shall be mounted to the underside of the structure. Double insulation shall be provided between the OCR and structure. The conductor rail design shall include provisions for a smooth transition between the flexible OCS and the OCR system. The use of an OCR system requires approval by Metra.

The OCS shall be designed to be environmentally acceptable. Within the mechanical and structural design constraints, the system structures and associated equipment shall be as lightweight as possible and use visually unobtrusive fittings. The OCS shall be double insulated with each level of insulation compatible with the system insulation class.

12.1.4 FUNCTIONAL REQUIREMENTS

The OCS shall be designed to ensure that the following conditions are satisfied:

- The overhead contact system shall allow the trains to operate with pantographs in contact with the contact wire at up to the maximum allowable speed without excessive oscillations of the system

- The design shall avoid sudden changes in contact wire height to avoid bouncing or arcing during current collection
- The maximum temperature of the overhead contact system conductors shall remain within the permissible value given by the conductor manufacturer to prevent copper annealing even under the most onerous operating scenarios
- Stagger requirements shall be maintained throughout the system
- The OCS style shall be suited to the power demand and application along the alignment and within yards

12.2 STANDARDS, CODES, AND REGULATIONS

All design work, material selection, installation, testing, and construction shall conform to, or exceed, the applicable requirements of the latest editions of standards and codes issued by the following organizations, along with all applicable industry codes and standards.

Code, Standard, Reference, or Guideline
Aluminum Association of America
American Hot Dip Galvanizers Association
American Concrete Institute, ACI 318
American Institute of Steel Construction
American Iron & Steel Institute
American National Standards Institute
American Public Transportation Association
American Railway Engineering and Maintenance-of-Way Association, Manual for Railway Engineering, Chapter 33
American Society of Mechanical Engineers
American Society of Testing and Materials
American Welding Society
Minimum Design Loads for Buildings and Other Structures

Code, Standard, Reference, or Guideline
Association of American Railroads
Concrete Reinforcing Steel Institute
Construction Specifications Institute
Institute of Electrical and Electronics Engineer, IEEE C2
International Building Code
IEC 60913, Railway applications – Fixed installations – Electric traction overhead contact lines
IEC 62128-1, Protective provisions relating to electrical safety and earthing
Insulated Cable Engineers Association
National Association of Corrosion Engineers
National Electrical Code
National Electrical Contractors Association
National Electrical Manufacturers Association
National Electrical Testing Association
National Electrical Safety Code
National Fire Protection Association
Occupational Safety and Health Administration
Steel Structures Painting Council
Underwriters Laboratories

The system shall also meet all applicable state, local, and county codes.

12.3 DESIGN REQUIREMENTS

The design of the OCS shall be based on appropriate engineering studies. These studies shall include calculations of the OCS design parameters and shall include all factors that contribute to the displacement of the contact wire with respect to the pantograph, including:

- Climatic conditions such as wind, temperature, and ice loading
- Conductor data
- Allowable auto tensioning equipment movement
- Pantograph sway
- Pantograph width
- Conductor stagger
- Stagger changes
- Stagger effect
- Vehicle roll and lateral displacement
- Sway of the pantograph
- Track maintenance tolerances
- Restraining forces of along-track cantilever movement
- Pole deflection due to loads imposed

The results of these studies shall include:

- Pantograph security
- OCS erection tolerances
- Maximum structure spacing as a function of track curvature
- Conductor blow-off, stagger effect, and allowable static offset
- Conductor rise and fall (at mid-span)
- Conductor along-track movement, stagger variation, and wire elongation

- Conductor tensions, sags, and factors of safety under various climatic conditions
- Contact wire deviation due to movement of hinged cantilevers
- Conductor profile, hanger lengths, and spacing
- Equipment vertical and radial loads
- Maximum tension section length and percentage conductor tension variation along the system

12.3.1 OPERATION REQUIREMENTS

The OCS shall be comprised of the following major items:

- Catenary wires: messenger and contact/trolley
- Feeder cables: feeders from substation to catenary
- Supports: cantilever, head span or cross-span, pull-off, overhead conductor rail
- In-span materials: hangers, jumpers, splices, etc.
- Midpoint anchors: tie wire and down guy assemblies
- Poles: poles both center and wayside
- Foundations: drilled shaft and ground connections
- Lightning arresters: surge protection
- Structure guying: termination, anchors
- Tensioning systems: concentric wheel or pulley type with balance weight assemblies or spring type tensioning systems
- Insulated overlaps: sectionalizing
- Section insulators: isolation
- Disconnect switches: isolation

OCS configuration and tension systems shall be designed to meet:

- Line speed

- Clearance
- Mandatory national standards
- Climatic and environmental constraints
- Vehicle power consumption and ampacity, determined by the operational performance requirements and traction power load flow simulation

Conversion of an OCS existing fixed termination system to an auto tensioned system shall meet the following requirements:

- Existing OCS structures shall be examined by an engineer licensed in the State of Illinois and approved by Metra for possible reuse by verifying their condition, elevation, and location. New OCS support structures shall be designed to replace existing supports where existing structures have exceeded their useful life.
- Where there is a requirement for the transition between auto tensioned catenary and fixed termination catenary, it shall be accomplished by installing a catenary parallel wire overlap. The overlap catenary cantilever spacing should take in to account the different along-track movement and sags between auto tensioned and fixed termination catenary.

12.3.2 OCS STRUCTURE SPACING AND STAGGER

OCS structure spacing for the distribution system shall be as long as possible and shall be based on the system design study. Structure spacing shall be maximized so that the contact wire remains within the limits of the pantograph head in accordance with the specified pantograph security analysis and to maintain fault free current collection and uniform wear of the pantograph carbon collector.

The contact and messenger wires shall be staggered on both tangent and curved tracks, relative to the track centerline. The amount of stagger shall be based on the various class of track allowances, vehicle body and pantograph tilt, sway, and other dynamic movements, and construction tolerance.

To minimize the possibility of harmonic oscillation in the catenary system, adjacent spans shall not have a length difference of more than 60 feet or increased by more than 50 percent of the previous span, and not more than five equal spans shall be located successively in areas where the vehicle speed is expected to exceed 55 miles per hour (mph). A span that is at least 10 percent shorter shall be inserted to minimize the possibility of any sympathetic oscillation.

12.3.3 TENSION LENGTH DESIGN

The OCS consists of several overlapping tension length sections. Each tension length shall be designed to be as long as possible considering the mechanical constraints of the system design characteristics, such as displacement of contact wire due to swinging cantilevers, tension loss along the system, auto tensioned equipment travel, and manufacturing limits of conductor length. Further, the tension length design shall consider the sectioning requirements.

Full tension lengths on an auto tensioned system shall be terminated at each end by auto tensioning devices. The auto tensioning devices shall operate with a 1:3 ratio. The center portion of the full auto tensioned length shall be stabilized by means of a mid-point anchor assembly to limit along-track movement of the OCS. Half tension lengths, where one end of the length utilizes a fixed termination and the other end a counterweight or spring tensioner, shall be used where sections are not divisible into complete tension lengths or on steeply graded sections of track. For locations where one end of the half tension length is at a higher elevation than the other end, the fixed termination shall be placed at the higher elevation.

12.3.4 OVERLAPS, CROSSOVERS, AND TURNOUTS

Overlaps shall be used between adjacent tension lengths and shall provide for continuity of current collection at the pantograph as well as provide smooth passage of the pantographs from one tension length to another.

Crossover and turnout catenary arrangements shall be used at special trackwork locations, where trains change tracks, and where they leave or enter the mainline. The OCS design objective shall be to provide a smooth transition between adjacent contact wires on the same or crossover tracks by suitable profiling of the contact wire heights.

The overlap, crossover, and turnout catenary arrangements shall be designed considering the electrical and mechanical properties of the catenary conductors. The designs shall enable a uniform uplift of the contact wires of each system with no hard spots. A safe, reliable, and smooth pantograph passage, together with an acceptable current collection with minimal arcing, shall be the objective under all operating conditions. Recommended electrical and mechanical clearances shall be provided between adjacent cantilevers and between the cantilever frames and adjacent conductors at all temperatures. This shall be particularly important for the auto tensioned system where the cantilevers of adjacent tension lengths move in opposite directions as the temperature changes and can cause misalignment of the system.

The overlap, crossover and turnout arrangements shall be designed using single poles with twin cantilevers. If this arrangement is not possible, two poles with one cantilever each may be used. The reason why the standard configuration cannot be used shall be documented as a design exception. In areas where center poles are used, the overlaps shall be staggered along the track to reduce pole loading and accommodate the balance weight assemblies. Overlaps shall not be located in station platforms. Overlaps shall be located no closer than 30 feet from either end of any station platform.

12.3.5 SYSTEM SECTIONING

The OCS shall be electrically sectionalized, consistent with the location of the TPSSs, track layout, signaling scheme, and proposed operations. The primary connection and isolation of the system sections shall be performed by the substation DC feeder circuit breaker. System sectionalizing shall be designed to provide a current path from substation to substation, enable electrical protective devices to isolate faulted sections of the OCS, enable the performance of maintenance, and achieve flexible operation during system emergencies. As near as feasible to each TPSS, the OCS shall be sectionalized to provide isolation of each electrical section. An arrangement providing continuity and flexibility for the sectioning of the OCS while any TPSS is undergoing repair or maintenance shall be incorporated. This arrangement shall be accomplished through the application of disconnect switches or load break switches for operations and maintenance.

Sectionalizing at TPSSs and elsewhere shall be performed by means of insulated overlaps where possible. Where overlaps cannot be used for sectionalizing on mainline, crossovers, and in yards, high-speed section insulators (bridging type) may be used. Non-bridging type section insulators shall be installed in maintenance building entrances.

Sectioning shall not be located in the middle of station platforms. Sectioning shall be located at least 200 feet from either end of any station platform and placed in minimum power draw and minimum regeneration areas. Connections and isolations of the system sections shall be accomplished by disconnect switches. Jumper arrangements shall maintain electrical continuity at special trackwork locations where it is necessary to have physical separation in the OCS such as in uninsulated overlaps. Uninsulated overlaps shall be located outside of any station platform. At locations where jumpers are used to provide full-feeding electrical continuity, they shall equal the electrical capacity of the OCS circuit capacity.

12.3.6 SAFETY ASSURANCE

As a minimum, the following items shall be provided in the design, specification, construction, and functionality of the OCS:

- Double insulation from any type of grounded pole, structure, building, etc. shall be provided to eliminate the possibility of bridging or spanning from neutral or grounded parts to live wires.

- Warning signs shall be attached to OCS or the supporting structures to warn personnel of the proximity of high voltage wires. Signs shall be attached to the OCS to denote the end of the electrified wires over the tracks. The signs shall state “High Voltage”, “Danger”, “Danger Live Wire”, and “Electric Train Stop” as appropriate in red and black with white background.

12.3.7 PROTECTIVE SCREENING

When the OCS is to be constructed below or adjacent to a bridge, retaining wall, building or other structure, protective screening shall be provided to isolate the poles, fittings and wires from potential human contact or interference. In addition to providing an effective barrier, design of the protective screening shall address any applicable urban design, architectural, or aesthetic objectives and related standards.

12.3.8 OCS POLE GROUNDING AND BONDING

Each pole or structure shall be grounded by a 4/0 American Wire Gauge (AWG) copper stranded wire by exothermic weld connections to two reinforcing bars in the foundation and to a ground rod adjacent to or embedded in the foundation. The use of an appropriately sized copper-weld ground wire shall be permitted at locations with public access or in areas susceptible to vandalism and wire theft. All OCS support structures shall be grounded to a total ground resistance not exceeding 25 ohms.

Ground connections to disconnect switches shall have a maximum ground resistance of five ohms. Ground rods and ground grids (mat) shall be utilized to obtain the required ground resistance. Where the tested resistance exceeds the specified value, additional ground rods shall be driven and interconnected with a suitable conductor and the test repeated. All test results shall be provided to Metra for review and approval.

12.3.9 OVER-VOLTAGE PROTECTION

Over-voltage protection for the OCS shall be provided by surge arresters. The arresters shall be rated to withstand the maximum system voltage and anticipated voltages induced from any paralleling high-voltage transmission lines onto the system conductors. The arresters shall be appropriately chosen based on the expected peak system voltage including regenerative braking. In addition, the surge arresters shall be capable of equalizing and/or discharging the energy resulting from lightning strikes to the system. At a minimum, surge arresters shall be located at each substation disconnect switch and negative bus, each feeder pole, midway between feed points if needed, and in all areas of reduced clearances, such as at overhead bridges and at tunnel portals.

A connection from the OCS to a surge arrester will be connected directly to a ground rod(s) or mat, with a total ground resistance of not more than five ohms. Surge arrester connection may not be combined with the pole/structure ground connection. For poles on aerial structures having an arrester, an independent ground wire and ground rod shall be utilized. The complete discharge voltage shall be sufficiently low to prevent damage to connected system elements.

12.3.10 OCS STRUCTURE NUMBERING AND CHAINAGE

The design shall coordinate the OCS pole numbering and system stationing with existing lines to produce a logical sequence between new and existing systems. Pole identification shall use the same numbering scheme implemented on the existing line. The numbering system and stationing shall continue in tunnels at the support location. The pole numbering scheme shall be provided to Metra for review and approval.

12.3.11 OCS POLE DEFLECTION

Pole deflection under all vehicle operating conditions shall not exceed two inches at contact wire height. Pole deflection at the top of the pole under heavy loading conditions shall not exceed 3 percent of pole length.

In addition, poles shall be raked to compensate for deflection due to dead weight loading and loads resulting from conductor tensions at the normal design temperature. Overload factors shall not be applied in the calculation of pole deflection. All pole deflection values shall take into account the effects of foundation translation and rotation for the applied loading condition.

12.3.12 OCS SUPPORT STRUCTURE DESIGN

OCS structures shall be designed in accordance with the requirements of AREMA, NESC, AISC, ACI, and other local and state codes. Design loads shall include the dead load of the system itself combined with certain live loads, including wind load, other dynamic loads, wire tension, and seismic load (where required by codes or regulations).

Dead loads are defined as the actual weight of poles, cantilevers, assemblies, and conductors as determined from the AISC and as obtained from manufacturer data, conductor sizes, and material.

Live loads consist of loads imposed by wind, dynamic, and seismic conditions. The load from conductor tensions shall be calculated based on all anticipated climatic conditions and applied to the total live load on the support structure. Design analysis shall also consider the combination of climatic conditions for operating and non-operating wind and temperature factors in accordance with NESC and AREMA Chapter 33.

Loading combinations shall be based on both operating and non-operating conditions. The structures shall be designed to sustain the worst non-operating condition combination and maximum allowable deflection.

12.3.13 OCS POLE FOUNDATION DESIGN

Foundation design shall be coordinated with OCS design, track design, and underground utilities. Design and construction of pole foundations and guy anchor foundations shall conform to established civil and structural engineering practices and ASTM, AREMA, NESC, and ACI 318 standards.

Foundations shall be reinforced concrete and shall be capable of withstanding the design loads imposed during installation, operation, and maintenance. The supporting structure foundations shall be designed to accept bolted base poles and have provision for feeder conduits (where necessary) and structure grounding.

The design shall be prepared for varying ground conditions with allowable lateral bearing values based on soil borings to be drilled throughout the alignment. The number and locations of borings shall be in accordance with AREMA, Chapter 8, Section 22.4.2. In determining the level at which the effective depth commences for foundation resistance, allowances shall be made for non-effective ground in accordance with the soil boring results and ground configuration (i.e., cutting an embankment, slope, or level ground).

Where soil conditions require a moment-resisting non-side bearing foundation, spread footings shall be used with a safety factor of 1.5 applied against overturning. Uplift at edges or corners of spread footings shall not be permitted and the allowable bearing value shall be determined by geotechnical analysis. In areas where rock is encountered close to the surface, suitable rock type foundations may be used. Such foundations may be rock sockets or grouted rock anchors. Rock foundations shall have a minimum factor of 1.5 against overturning.

Existing geotechnical conditions shall be established by local field testing, sampling, and soil investigations in accordance with the appropriate sections of the AREMA Standards and Chapter 4: Civil and Drainage, of this manual. Information suitable for satisfactory foundation design shall be obtained regarding the soil strata conditions, states, uniformities, water contents, weights, and densities, and these shall be used in foundation design.

12.4 EQUIPMENT REQUIREMENTS

The OCS equipment shall be designed to meet the following requirements.

12.4.1 POLES AND SUPPORTING HARDWARE

All poles shall be designed as freestanding except for termination poles. All poles shall have a baseplate drilled to fit the foundation bolt pattern and have provisions for grounding and bonding conductors. OCS poles shall be tubular, tapered tubular, or wide flange shapes with steel baseplates, as approved by Metra. In areas where aesthetics are important, other types of poles may be used.

Supporting structures shall be designed to restrict cross-track movement of the contact wire due to wind based on normal operating conditions. All poles will be hot-dipped galvanized. Architectural coatings and shapes may be used in aesthetically sensitive areas at the discretion of Metra.

12.4.2 CANTILEVERS

Cantilevers shall be designed for a range of loads, pole-to-center track distances, and for a range of system heights, considering the system installation tolerances. The cantilever members shall be designed for easy installation and adjustment. All pipes associated with the cantilevers shall be galvanized steel or aluminum alloy.

12.4.3 MULTI-TRACK SUPPORTS

Multi-track supports shall be required at certain locations, typically where poles are difficult to place adjacent to tracks, at passenger stations, and at overlaps. Portal structures, head-span and cross-span support arrangements may be used upon approval by Metra.

12.4.4 BRIDGE SUPPORTS

Bridge supports shall be used where sufficient clearance to accommodate a cantilever-type assembly is not available. The supports shall be designed to restrict the uplift of the contact wire when subjected to pantograph pressure and shall be capable of providing vertical and across-track adjustment. The bridge supports shall permit longitudinal movement of the contact wire.

12.4.5 INSULATORS

Insulators shall provide electrical insulation in accordance with the system insulation class and have the mechanical safety factors specified in Section 0. The insulators shall have resistance against deterioration from exposure to sunlight and airborne chemical pollution. The insulators shall have a life expectancy compatible with that of the rest of the OCS equipment.

12.4.6 CONDUCTORS AND ASSOCIATED ITEMS

Contact wire shall be solid, grooved, hard-drawn copper conductor conforming to ASTM specifications. Messenger wire shall be a concentric-lay-stranded copper conductor, conforming to ASTM specifications. All feeders and connecting cables shall be insulated or bare stranded copper conductors with enough flexibility to prevent fatigue failure of the cable due to vibration. All exposed insulated cables shall be ultraviolet (UV) resistant.

All conductor connections, attachments, hangers, and clamps shall be copper or bronze fittings and shall be designed for ease of replacement and maintenance.

Continuity and equalizing jumpers shall be bare flexible copper conductors. The spacing of the jumpers shall be determined based on the required current conductivity of the system, with a minimum of one jumper per span.

12.4.7 TERMINATIONS AND MIDPOINT ANCHORS

Strain-type termination assemblies shall be lightweight and of an aesthetically pleasing appearance. Wire wrap, straight line, cone, or wedge type designs are acceptable. Turnbuckles, in-line insulators, wire terminations, high strength steel cable, parallel clamps, steel links, and pole bands shall be used as appropriate and shall have an adequate adjustable length. A mid-point anchor arrangement shall be used at or near the mid-point of each tension length of auto tensioned equipment to restrict the movement of the conductors at that point.

12.4.8 TENSIONING DEVICES

The auto tensioned system conductors shall be tensioned using cast iron or steel counterweights. The auto tensioning devices shall operate with a 1:3 ratio. The auto tensioning devices shall accommodate conductor expansion and contraction and shall have a broken wire arrest assembly. All operating cables shall be manufactured of flexible stainless-steel non-twisting wire. Spring tension devices may be used upon approval by Metra.

12.4.9 SECTIONING AND FEEDING ASSEMBLIES

The mainline electrical sectioning shall be achieved by means of insulated overlaps. Where physical constraints do not allow the use of insulated overlaps, such as at crossovers and turnouts, high-speed type section insulators shall be used. Non-bridging type section insulators shall be installed in the entrances of maintenance buildings.

Disconnect switches shall be used to electrically connect and disconnect line sections. The disconnect switches shall be rated to withstand the system worst-case overload and short circuit conditions without overheating. The switches shall be capable of breaking the maximum load current under emergency conditions. Either manual or motorized switches may be used, the designer shall work with Metra to identify which type to use.

The switch assembly usually consists of a blade style switch mounted in a weatherproof box, full feeding jumpers positioned on either side of the switch, and insulated cables from the switch to the individual sets of catenary wires. For motorized switches, an electrical interlock circuit shall be provided to prevent operation with voltage on either side of the contact. The interlock shall prevent local and remote electrical operation of the switch motor. The interlock shall not prevent emergency manual operation.

12.5 DESIGN PARAMETERS

The OCS shall be designed in accordance with the following design parameters.

12.5.1 PROJECT CLIMATIC CONDITIONS

Table 12-1. Climatic Conditions

Output Current	Output Voltage DC
Maximum Ambient Temperature	105° F
Minimum Ambient Temperature	-15° F
Radial Ice Loading	0.5 inch
Max. Operational Wind Speed, Pantograph Security	60 mph
Max. Non-Operational Wind Speed, Structural Design	90 mph

12.5.2 CONTACT WIRE GRADIENTS

Contact wire gradient relative to the rail shall be designed according to the maximum acceptable wire slopes and gradients for various speeds as shown in . The change of grade from one span to the next shall not exceed one half the value shown below. The below table is per AREMA Table 33-4-7.

Table 12-2. Contact Wire Gradients (from AREMA Table 33-4-7)

Description	Percent
Yard Conditions	2.3
30 mph	1.3
45 mph	0.8
60 mph	0.6
80 mph	0.5

12.5.3 PANTOGRAPH SECURITY

The minimum pantograph security, i.e., the distance between the contact wire and the tip of the pantograph, shall be six inches under the worst operating conditions.

12.5.4 MINIMUM ELECTRICAL CLEARANCES

Electrical (air) clearances from energized parts of the OCS or vehicle to grounded structures or grounded parts of the vehicle and from ancillary conductors to grounded structures will be 12 inches except where otherwise approved by Metra.

For vehicle dynamic envelope, pantograph, and horizontal clearances see Chapter 5, Clearances.

12.5.5 NORMAL CONTACT WIRE HEIGHT

Table 12-3. Normal Contact Wire Height

Locations	Contact Wire Height Above Top-of-Rail (feet)
Minimum contact wire in tunnels or bridges, except where otherwise approved	16.5
On main tracks	21
In passenger car yards, except where otherwise approved	21

12.5.6 SYSTEM HEIGHT

The system height (also referred to as system depth) is defined as the height or vertical distance between the messenger and contact wires at the point of support. The nominal system height is given in .

Table 12-4. System Height by Location

Locations	System Height, Nominal (inches)
Open Route Alignments	48
Underneath Overhead Bridges	6

These heights may vary at specific locations for the profile transitioning from tunnel structures or underneath overhead structures.

12.5.7 FACTORS OF SAFETY

Table 12-5. Factors of Safety	
Equipment	**Factors of Safety**
Conductors and Wires	
Operating Conditions	2
Non-operating Conditions	1.6
Hardware	
Operating Conditions	2.5
Non-operating Conditions	2

The factors of safety for the contact wire shall be calculated taking into account the wire wear specified for mechanical design.

12.5.8 MECHANICAL PARAMETERS

Table 12-6. Mechanical Parameters	
Contact Wire Wear	**Maximum Wear (percent)**
Mechanical Design	30
Electrical Design	15

13. STRAY CURRENT AND CORROSION CONTROL

13.1 OVERVIEW

This chapter sets forth criteria governing the corrosion control design for underground metallic structures and pipes, storage facilities, tunnels, bridges, and any other facilities where corrosive conditions may occur. The different types of corrosion control include stray current mitigation, soil and groundwater corrosion (cathodic protection), atmospheric corrosion (protective coatings), microbiologically induced corrosion (MIC; firewater piping), and corrosion at hydraulic elevator cylinders.

The general service environments that are considered in this chapter include: station environments; reinforcement within concrete structures, particularly walls, slabs, and roofs regarding tunnel construction; reinforcement or structural steel partially cast into concrete with exposed surfaces; exposed structural steel; and utility and service piping, both existing and new, in the vicinity of the Metra alignment.

These criteria describe design requirements necessary to accomplish corrosion control measures for Metra interfaces with existing infrastructure, and for any third party underground metallic structures.

The design factors to be considered for each environment are:

- Evaluation of the risk of corrosion
- Assessment of appropriate methods of corrosion control/prevention for that environment
- Design and specification of corrosion control methods for each situation

For each environment, the design must consider and assess the risk of corrosion due to exposure to the prevailing environment; potential changes to that environment, with time, that may influence the corrosion risk; and the risk of stray current corrosion.

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of any conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

13.2 STANDARDS, CODES, AND REGULATIONS

The design and construction of corrosion control work shall comply with the criteria contained in this document. Applicable standards, policies, local/federal regulations, guidelines, or practices include but are not limited to the latest revision of the reference documents identified below.

In the event of a conflict between criteria, commitments, or requirements contained within one document when compared with another, the more stringent shall apply.

- Con Edison Specification No. EO-2034 Electric and Gas Service to D.C. Railroad Properties
- NYCT Standard Drawing E-2020 Typical Grounding of Electrical Equipment Subways and Elevated Lines

Code, Standard, Reference, or Guideline
American Concrete Institute
• ACI Publication SP-77 Sulphate Resistance of Concrete • ACI Publication 201.2R Guide to Durable Concrete • ACI Publication 222R Protection of Metals in Concrete Against Corrosion • ACI Publication 506.2 Below Grade Shotcrete Used as Permanent Support
American Railway Engineering and Maintenance-of-Way Association
• AREMA Manual for Railway Engineering
American Society for Testing and Materials International
• ASTM A536 Standard Specification for Ductile Iron Castings • ASTM A716 Standard Specification for Ductile Iron Culvert Pipe • ASTM A746 Standard Specification for Ductile Iron Gravity Sewer Pipe • ASTM B418 Standard Specification for Cast and Wrought Galvanic Zinc Anodes • ASTM B843 Standard Specification for Magnesium Alloy Anodes for Cathodic Protection • ASTM C452 Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate • ASTM D256 Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics • ASTM D516 Standard Test Method for Sulfate Ion in Water

Code, Standard, Reference, or Guideline
• ASTM D570 Standard Test Method for Water Absorption of Plastics • ASTM D638 Standard Test Method for Tensile Properties of Plastic • ASTM D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable • ASTM D2216 10 Standard Test Methods for Lab Determination of Water Content of Soil • ASTM D4327 Standard Test Method for Anions in Water by Suppressed Ion Chromatography • ASTM D4658 Standard Test Method for Sulfide Ion in Water • ASTM G16 Standard Guide for Applying Statistics to Analysis of Corrosion Data • ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing • ASTM G57 Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method • ASTM G165, Standard Practice for Determining Rail-to-Earth Resistance, American Society for Testing and Materials
American Water Works Association
• AWWA C104/A21.4 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings • AWWA C105/A21.5, AWWA Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems • AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings • AWWA C116 Protective Fusion-Bonded Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings • AWWA C151/A21.5 Ductile-Iron Pipe, Centrifugally Cast • AWWA C200 Steel Water Pipe 6 Inch (150mm) and Larger

Code, Standard, Reference, or Guideline
• AWWA C203 Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied • AWWA C207 Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 In. Through 144 In. (100mm Through 3,600mm) for Potable Water and Other Liquids • AWWA C209 Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines • AWWA C210 Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines • AWWA C213 Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines • AWWA C214 Tape Coating Systems for the Exterior of Steel Water Pipelines • AWWA C215 Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines • AWWA C216 Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines • AWWA C302 Reinforced Concrete Pressure Pipe, Non-cylinder Type
Electronic Industry Association
• EIA RS-169 Thermoplastic Insulated and Jacketed Hook-Up Wire • EIA 214 Method for Calculation of Current Ratings on Hook-Up Wire
International Electrotechnical Commission
• IEC 62128-1 Part 1: Protective Provisions Relating to Electrical Safety and Earthing
International Union of Railways
• UIC605OR Protection from Corrosion
Institute of Electrical and Electronics, Inc.
• IEEE C2 National Electrical Safety Code (NESC) • IEEE 80 IEEE Guide for Safety in AC Substation Grounding

Code, Standard, Reference, or Guideline
• IEEE 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements • IEEE 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems • IEEE 316 Standard Requirements for Direct Current Instrument Shunts • IEEE 837 Qualifying Permanent Connections Used in Substation Grounding
Association of Material Protection and Performance
• AMPP Report 10B189 Direct Current Operated Rail Transit Stray Current Mitigation (24255-SG) • AMPP SP 0104 Recommended Practice the Use of Coupons for Cathodic Protection Monitoring Applications • AMPP SP 0109 Standard Practice Field Application of Bonded Tape Coatings for External Repair Rehabilitation and Weld Joints on Buried Metallic Pipelines • AMPP SP 0169 Standard Practice Control of External Corrosion on Underground or Submerged Metallic Piping Systems • AMPP SP 0177 Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems • AMPP SP0187 Design Considerations for Corrosion Control of Reinforcing Steel in Concrete • AMPP SP 0207 Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Surveys on Buried or Submerged Metallic Pipelines • AMPP SP 0285 Standard Practice Corrosion Control of Underground Storage Tank Systems by Cathodic Protection • AMPP SP0290 Design Considerations for Corrosion Control of Reinforcing Steel in Atmospherically Exposed Concrete Structures • AMPP TM 0101 Standard Test Method Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems

Code, Standard, Reference, or Guideline
• AMPP TM 0497 Standard Test Method Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
National Electrical Manufacturers Association
• NEMA AB 1 Molded Case Circuit Breakers and Molded Case Switches • NEMA ICS 6 Industrial Controls and Systems: Enclosures • NEMA MR 20 Cathodic Protection Units • NEMA ST 1 Specialty Transformers (except General Purpose Type)
Transit Cooperative Research Program
• TCRP Report 155 Track Design Handbook for Light Rail Transit Chapter 8 Corrosion Control • TCRP Report 212 Stray Current Control of Direct Current-Powered Rail Transit Systems: A Guidebook
Underwriters Laboratories, Inc.
• UL 83 UL Standard for Safety Thermoplastic-Insulated Wires and Cables • UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
National Fire Protection Association
• NFPA 70 National Electric Code • NFPA 130 Standard for Fixed Guideway Transit and passenger Rail Systems

13.3 GENERAL REQUIREMENTS

This chapter is divided into five (5) areas: stray current corrosion control, soil/groundwater corrosion control, atmospheric corrosion control, MIC, and hydraulic elevator cylinder protection.

The design criteria for each of these categories and its implementation shall meet the following objectives:

- Realize the design life of Metra infrastructure and facilities by avoiding premature failure caused by corrosion
- Optimize annual operating and maintenance costs associated with material deterioration
- Provide continuity of operations by reducing or eliminating corrosion related failures of Metra facilities and subsystems
- Reduce detrimental effects to facilities belonging to others as may be caused by stray currents from transit operations

The designer shall design and provide a complete stray current mitigation solution with bonding and stray current monitoring capabilities. Application of these procedures may result in a unique stray current mitigation solution for each site. Each site shall be studied before a specific solution is applied. The study shall apply to all building structures within approximately 150 feet of the train tracks.

The designer shall provide a professional Corrosion Control Engineer with experience in the rapid transit electrification industry. The Corrosion Control Engineer shall lead the corrosion control effort and make all necessary decisions required to design, integrate, and deliver the corrosion control, bonding, and stray current monitoring systems.

13.3.1 STRAY CURRENT CORROSION CONTROL

The design intention for stray current corrosion control is to limit or minimize the risk of stray current corrosion by controlling this risk at the source. If it is determined during design or construction that this cannot be achieved, secondary methods of mitigation will be implemented.

The design shall control stray current using the following principles:

- Increasing the electrical resistance of rail-to-earth between running rails and underground metallic structures
- Increasing the resistance to ground of underground metallic structures.
- Decreasing the resistance of running rail by way of continuously welded rail (CWR)
- Providing a stray current collection system in first pour invert

Specific design criteria for stray current corrosion control are included in Section 13.4.

13.3.2 SOIL AND GROUNDWATER CORROSION CONTROL

As part of the site investigation on the tunnel route, soil and groundwater samples shall be analyzed for parameters that may influence corrosion and corrosion rates on buried materials. This data and any supplementary information will form the basis for corrosion control of buried metallic components.

Where corrosion protection is required for buried components, it shall be provided by use of sacrificial corrosion, protective coatings, corrosion resistant alloys, and/or impressed cathodic protection as appropriate.

Specific design criteria for soil corrosion control shall be established on an individual basis per structure requirements. See Section 13.5.

13.3.3 CATHODIC PROTECTION

Corrosion control measures shall be applied to all relocated and new metallic and reinforced concrete underground utilities. These measures shall include protective exterior coating, electrical continuity of pipes, electrical isolation of new and existing pipes, cathodic protection, and test facilities as appropriate. Soil and groundwater corrosive characteristics shall be determined and documented during the baseline corrosion survey.

In addition, to minimize the possibility that utility pipelines become part of the traction power return system, insulated joints or couplings shall be installed at or adjacent to the shut-off valves or at a similar location if shut-off valves are not required.

Specific design criteria for cathodic protection are included in Section 13.6.

13.3.4 ATMOSPHERIC CORROSION CONTROL

Atmospheric corrosion control shall account for the service and ambient environment in particular areas and the degree of environmental control applied within each area (i.e., station areas, tunnels etc.).

For tunnel environments, consideration shall also be given to the risk of exposure to water ingress from the ground side of the tunnels.

Material selection and equipment design shall account for the environment in which the equipment operates to minimize corrosion control requirements where possible.

Where corrosion control is considered necessary, it shall be provided by either sacrificial corrosion allowance to carbon steel, application of protective coatings, or the use of corrosion resistant alloys (e.g., stainless steels, aluminum, etc.).

Specific design criteria for atmospheric corrosion control are included in Section 13.7.

13.3.5 GROUNDING

Due to the natural difference between safety grounding and corrosion control requirements, the guidelines provided in these criteria shall be followed.

Additional design criteria relating to grounding are included in Section 13.8.

13.3.6 MICROBIOLOGICALLY INDUCED CORROSION CONTROL

The designer shall design a complete MIC solution. Application of these procedures may result in a unique MIC solution for each site. Each site shall be studied before a specific solution is applied.

Design solutions for safety and preventative measures for MIC typically include, but are not limited to, the following:

- Monitoring and mitigation
- Injection systems
- Valve, vent, and fitting design
- Inhibitors

The Corrosion Control Engineer shall lead the corrosion control effort and make all the necessary decisions required to design, integrate, and deliver the corrosion control of the MIC system.

Additional design criteria pertaining to MIC are included in Section 13.9.

13.3.7 HYDRAULIC ELEVATOR CYLINDERS

The designer, working with an elevator consultant if applicable, shall design and provide a complete hydraulic elevator cylinder corrosion control plan. This corrosion control plan includes but is not limited to the following design solutions:

- fiber reinforced polymer (FRP) casings
- Specific sand-fill requirements

- Cathodic protection through the sand-fill
- Moisture proof sealing

Additional design criteria pertaining to hydraulic elevator cylinder are included in Section 13.10.

13.4 STRAY CURRENT CORROSION CONTROL

The purpose of these requirements is to provide criteria for designs to minimize the corrosion impact of stray currents from the Metra traction power system that would impact Metra structures and adjacent structures. By the application of the appropriate design criteria, the magnitude of stray currents can be reduced to low levels thereby minimizing the risk to buried structures.

13.4.1 STRUCTURES – GENERAL

Metallic and reinforced concrete structures in contact with soil require special detailing to ensure appropriate electrical continuity. This detailing shall include mechanically connecting reinforcement, particularly on the external face exposed to soil and groundwater, and the provision of bonding cables and insulation.

A ground system and related test stations shall be provided at each end of the structure and at intermediate points as required.

Structures in contact with soil and groundwater shall have specific corrosion protection systems to mitigate the potential effects of stray current and corrosion. These structures include but are not limited to:

- Retaining walls
- Roof slabs
- Base slabs
- Slurry walls
- SPTC walls
- Steel sets
- Rock anchors
- Tiebacks

13.4.2 STRAY CURRENT CONTROL REQUIREMENTS

The traction power system and trackwork construction shall be designed such that maximum stray earth currents, during normal revenue operations, do not exceed 0.20 amperes/1000 feet. Stray current levels are general values only, based on typical utility configurations, transit structures, and soil characteristics. Values are subject to change based on project specifics. This value is considered the uniformly distributed, maximum instantaneous level during normal operations. These criteria shall also apply to special trackwork and ancillary systems.

Ancillary systems and equipment connected to either the positive or negative traction power distribution circuits shall contribute no more than five percent of the system earth conductance.

Water infiltration into the trackway area for below grade structures shall not come into direct contact with the rails, fasteners and/or conductive rail appurtenances during normal system operations.

Track washing operations and deluge fire protection systems are not required to meet this criterion.

As required by Metra, baseline studies shall be performed within two months after commencement of revenue service for a new rail line to determine and document compliance with these stray current corrosion control criteria. As a minimum, this shall include track-to-earth resistance measurements, track-to-earth potential monitoring over a minimum one-week period, representative structure monitoring, and a report with the data and related calculations, and statements acknowledging criteria compliance. Out-of-compliance conditions shall be corrected prior to report submission.

13.4.3 TRACTION POWER SYSTEM

See Chapter 11: Traction Power for criteria relating to the traction power system.

Direct current (DC) traction power circuits for the mainline and yards shall be electrically isolated from electrical grounds. DC traction power for shops shall include provisions that the negative circuit (rails) be interconnected to electrical grounds.

Transformer/rectifier units and other equipment may be housed in the same room, with common alternating current (AC) power inputs, grounding facilities and other ancillary systems, provided the DC power circuits are electrically segregated.

13.4.4 TRACTION POWER SUBSTATIONS - GENERAL

See Chapter 11: Traction Power for criteria relating to traction power substations.

The grounding methodology for Metra's traction power substations is detailed in Standard Drawing No. P-414-2646, "Grounding Details" from the latest Con Edison Specification No. EO-2034 "Electric and Gas Service to DC Railroad Properties".

In general, all metallic equipment enclosures, raceways, and conduits within traction power substations shall be electrically isolated from substation structural steel. Metallic equipment enclosures shall be bonded to the substation perimeter AC ground bus.

The substation ground bus shall be isolated from the substation structural steel.

The substation ground bus shall be bonded to the incoming water service line and supplementary grounding system on the street side of an insulating coupling.

Provide insulated joints in any metallic piping or ducts that enter or exit the substation, and which are electrically continuous with the substation structural steel.

Utilize non-metallic ducts for the low-tension and high-tension service cables.

The neutral of the Con Edison low tension service shall be left to float within the substation and shall be isolated from the substation structural steel.

A shield break shall be installed in Metra's side of the high-tension cable splice in the manhole or service end box where the Con Ed and Metra's cables meet.

In medium voltage property line manholes where disconnect switches are installed, Metra's phase cables shall have no shield connection to ground.

13.4.5 TRACTION POWER SUBSTATIONS - MAINLINE

Traction power substations shall be spaced at intervals such that maximum track-to-earth stray current discharge is less than 0.20 amperes/1000 feet. Substations shall be provided with access to the negative bus for stray current monitoring and testing. Access shall be provided either inside, utilizing dedicated wall space, or outside, utilizing a weathertight enclosure with an open conduit between the enclosure and the negative bus. Access shall be such that stray current testing can be performed by utility operators under supervision by Metra. Automated provisions shall be included for monitoring track-to-earth potentials at traction power substations. Automated equipment shall be installed at each traction power substation to measure track to earth resistance using rail-to-earth potential techniques.

13.4.6 POSITIVE DISTRIBUTION SYSTEM

Each individual and separate positive distribution system shall be normally operated as an electrically continuous bus, with no electrical separation discontinuities, except during emergency or fault conditions.

13.4.7 MAINLINE NEGATIVE RETURN SYSTEM

The mainline running rails, including special trackwork, embedded track, grade crossings, and all ancillary system connections, shall be designed to have the minimum in-service resistances per 1,000 feet of track (two rails) cited in Section 13.4.8.

The criteria cited in Section 13.4.8 shall be met by using an appropriately designed insulating track fastening device such as insulated tie plates, insulated rail clips, direct fixation fasteners, rail boots, or other approved methods. Methods for constructing rails in embedded sections, at grade crossings, and at high-rail vehicle access locations must provide for suitable isolation measures to comply with the stated minimum resistance criteria.

Individual mainline rail fixation fasteners (insulated) shall have a minimum resistance of 10 megohms dry. Embedded and exposed track systems shall be designed so that the minimum criteria in Section 13.4.8 are achieved within two hours after a rain event.

13.4.8 DESIGN CRITERIA FOR MAINLINE TRACK-TO-EARTH RESISTANCE LEVELS

The resistance measurements for track-to-earth resistance levels are measured in ohms per 1,000 track feet (Ω/1000 TF). The minimum criteria for each type of track construction are as follows:

- At-grade stations, tunnels and portals: 500 Ω/1000 TF
- Grade-separated and aerial: 500 Ω/1000 TF
- Embedded segments (at-grade crossings/city streets): 300 Ω/1000 TF

Special trackwork and ancillary systems shall meet the criteria for the segment in which they are located.

Minimum resistance levels are general values only, based on typical trackwork designs, utility configurations, transit structures, and soil characteristics. Metra may provide different criteria based on the specifics of a project. Trackwork designs with track-to-earth resistance lower than the minimum criteria shall require an engineering study and approval by Metra.

13.4.9 CROSS BONDS

Track cross bonds shall be provided between inbound and outbound tracks at the following locations for stray current control:

- At each mainline traction power substation
- Within 500 feet of passenger station platforms, if not covered by the previous requirement

Additional cross bonding shall be provided, as required, to meet criteria for traction power, signaling, and other considerations.

Cross bonding negative feeder cables shall utilize a main cable run (possibly several cables) with taps to negative power rail(s) as opposed to long runs of individual cables connected to single negative power rails.

All dead-ended track shall have the negative power rail cross bonded to other negative power rails within 10 feet of the end of the track.

13.4.10 ELECTRICAL ISOLATION

Ancillary systems such as switch machines, signaling devices, automatic train controls, train communication systems, and other devices or systems which may contact the mainline rails shall be electrically isolated such that the criteria given in Section 13.4.8 are satisfied.

Electrically grounded devices or systems that contact the rails (directly or indirectly) shall be electrically isolated from contacts with the rails. The criteria for electrical isolation shall be met through the use of dielectric insulating materials that will electrically isolate the device or system from contact with the rails. The grounding system for the device or system shall not be common with the rails.

Devices or systems that do not require an electrical ground and which may contact the rails (directly or indirectly) shall be electrically isolated from contacts with earth. The criteria for electrical isolation shall be met through the use of dielectric insulating material that will electrically isolate the device or system from contacts with earth.

13.4.11 ELECTRICAL CONTINUITY

The running rails shall be constructed as an electrically continuous power distribution circuit through use of rail joint bonds, CWR, or a combination of the two.

13.4.12 WATER DRAINAGE

Tunnel or below grade sections shall be designed to prevent water from dropping or running onto contact rails, negative rails, and rail appurtenances, as well as to prevent the accumulation of freestanding water. Mainline water drainage systems shall be designed to prevent water accumulation from contacting the rails and rail appurtenances.

13.4.13 INVERT REINFORCEMENT

Reinforcing steel in the inverts of tunnels, portals, and underground stations shall be made electrically continuous. Reinforcing steel in plinths are not required to be made electrically continuous. Reinforcement in floating slabs insulated from the below track slab is not required to be electrically continuous. Minimum requirements shall include the following:

- Welding of all longitudinal lap splices in the top layer of first pour reinforcing steel in inverts

- Welding of all longitudinal top layer members in the first pour reinforcing steel in inverts to a transverse (collector) bar at each end of the structure, at intervals along the structure not exceeding 500 feet and at each side of electrical (physical) breaks in the longitudinal reinforcing steel, such as at expansion joints. Transverse (collector) bars located on each side of breaks in the longitudinal reinforcing steel shall be interconnected electrically with copper bond cables. Electrical continuity in top layer invert reinforcing steel shall be maintained across bridging beams located at the interfaces between structures. Top-layer longitudinal steel reinforcement or dowels for bridging beams shall be welded at lap splices and interconnected through welded connections or copper bond cables to adjacent top-layer steel reinforcement in structures located on each side of the bridging beam.

- Test facilities shall be installed on first pour reinforcing steel at each end of the structure and at transverse collector bars located at intervals along the structure not exceeding 1,000 feet. Test facilities shall consist of insulated copper wires, conduits, and enclosures terminated at an accessible location. Test facilities shall also be capable of providing testing on second pour reinforcing steel for trackwork at locations, if any, where second pour reinforcing steel is electrically interconnected to first pour reinforcing steel.

- Stray current monitoring assemblies, including a permanent silver-silver chloride reference electrode and two isolated rebar probes shall be tack welded to the collector bar at each test facility, at intervals not to exceed 1,000 feet. Coupon and reference electrode cables shall be routed in conduit common with the collector bar test wires and terminated in the test station box.

13.4.14 TUNNEL LINERS

Stray current control requirements for tunnel liners will vary depending on the material and method of construction and must be determined on an individual basis. Minimum requirements shall include the following:

- Test reference electrodes shall be installed through tunnel liner walls at maximum intervals of 1,000 feet and shall be located close to the tunnel exterior wall and remotely from the adjacent tunnel. This criterion does not apply to exterior walls of passenger stations.

- Segmented steel tunnel liners shall have electrical continuity within and between segments installed below the concrete invert.

Electrical test facilities shall be installed, in pairs, on fabricated steel tunnel liners. Minimum requirements shall include the following:

- A maximum of three-hundred feet (300') between individual test points within a pair

- A maximum of one-thousand feet (1,000') between test station pairs

Precast segmented concrete tunnel liners shall have permanent access to a section of steel reinforcing within the segment. This access point shall be located adjacent to the test reference electrodes described above. No special provisions are required for electrical continuity of steel reinforcement within the precast segmented liners.

Cast in place tunnel liners shall have test reference electrodes as described in above. There are no special provisions required for providing electrical continuity in steel reinforcement within the cast in place liner.

Prestressed concrete pipe with a steel cylinder used for tunnel liners shall meet the following minimum requirements:

- Electrical continuity bonds across all pipe joints

- A minimum of four evenly spaced longitudinal shorting straps between each layer of prestressing wire with electrical interconnections to bell and spigot rings

- Electrical interconnections between prestressing wire anchors and bell and spigot rings

Provisions for electrically interconnecting the steel pipe cylinder through bond cables to the invert collector grid at maximum intervals of 500 feet along the tunnel. The bond cable from the steel pipe cylinder and the bond cable from the collector grid at interconnection shall terminate in an accessible enclosure with a removable bus bar.

13.4.15 EXISTING BOX OR U-SHAPED STRUCTURES

This paragraph applies to existing box or U-shaped structures with a reinforced concrete invert such as retaining walls along the mainline used for ballasted track construction. In this type of track construction, the rails shall be provided with insulating track fastening devices. This type of construction precludes the installation of electrical continuity in existing invert reinforcement steel. Minimum requirements shall include the following:

- A waterproofing, electrically insulating membrane is to be provided over the entire surface of the existing concrete invert that will be in contact with the ballast. The membrane system shall be multi-ply reinforced sheet material with a minimum volume resistivity of 10 ohm-centimeter and a minimum thickness of 60 mils. The membrane system shall be provided with a protective board where it is in contact with ballast material.

- The need for an electrically continuous collector grid over the membrane and a stray current ground electrode system must be determined on an individual structure basis.

13.4.16 NEW BOX OR U-SHAPED STRUCTURES

This paragraph applies to new construction for box or U-shaped structures such as portals or retaining walls along the mainline with a cast-in-place concrete invert for timber-tie or concrete-tie, direct-fixation or ballasted track construction. In this type of track construction, the rails shall be provided with insulating track fastening devices. Reinforcing steel in the invert shall be made electrically continuous. Minimum requirements shall include the following:

- Welding of all longitudinal lap splices in the top layer of first pour reinforcing steel in inverts for electrical continuity.

- Welding of all longitudinal top layer members in the first pour reinforcing steel in inverts to a transverse collector bar at each end of the structure, at intervals along the structure not exceeding 500 feet and at each side of electrical (physical) breaks in the longitudinal reinforcing steel, such as at expansion joints. Transverse (collector) bars located on each side of breaks in the longitudinal reinforcing steel shall be interconnected electrically with copper bond cables.

13.4.17 TRACK INVERT

Reinforcing steel in underground trackway structure inverts shall be made electrically continuous. Minimum requirements for the reinforcing steel from the top of rail down shall include the following:

- Welding of all longitudinal lap splices in the top layer of first pour reinforcing steel.

- Welding of all longitudinal members to a transverse (collector) member at intervals not exceeding 500 feet, and at electrical (physical) breaks in the longitudinal reinforcing steel, such as at expansion joints.

- Electrical interconnection of first pour reinforcing steel to second pour reinforcing steel at all collector bars through use of insulated copper cables or steel straps. Longitudinal steel in the second pour shall be made electrically continuous by tack welding all lap splices.

- Test facilities shall be installed at each end of the structure and at every collector bar. Facilities shall consist of insulated copper wires, conduits, and enclosures terminated at an accessible location.

- Embedded steel reinforcing members shall be constructed without special provisions for establishing electrical continuity.

- Connecting hardware between adjacent rings and ring segments should be constructed without provisions for establishing electrical continuity between segments.

- Any metallic components that will be exposed to soil and/or groundwater shall be coated with a fluidized bed epoxy resin system or coal tar epoxy system.

A coal tar epoxy coating system shall be applied to the external surfaces of each precast panel.

A waterproofing, electrically insulating membrane shall be provided over the entire surface of the concrete invert that will be in contact with the ballast. The membrane shall be multi-ply reinforced sheet material with a minimum volume resistivity of 10 ohm-centimeter and a minimum thickness of 60 millimeters. The membrane system shall be provided with a protective board where it is in contact with ballast material.

13.4.18 STRAY CURRENT MONITORING ASSEMBLIES

Test facilities shall be installed at each end of the structure and at transverse collector bars located at intervals along the structure not exceeding 500 feet. Test facilities shall consist of insulated copper test wires for the transverse collector bars, conduits, and enclosures terminated at an accessible location.

13.4.19 UTILITY SYSTEMS

All piping and conduit shall be non-metallic unless metallic facilities are required for specific engineering purposes. There are no special provisions required if non-metallic materials are used.

To reduce the stray current effects on underground utilities, non-metallic materials, jackets, or high-quality coatings shall be used.

Metra-owned utility systems using metallic pipes and conduits shall be provided with electrical continuity within discrete zones. Pressure piping that penetrates structural walls shall be electrically insulated from the outside service piping and from watering wall sleeves. Dielectric insulation shall be provided on the interior of the structural wall.

Replaced, relocated, and maintained in place utility systems shall be provided with corrosion measures required by individual master agreements.

13.4.20 QUALITY CONTROL

Corrosion control designs shall be coordinated with all other engineering disciplines to ensure that they do not conflict with other installations. Shop drawings, material catalog cuts, and additional information related to the corrosion control designs shall be required for review and approval. Testing of materials prior to their delivery from a manufacturer or during construction shall be required, as appropriate, to ensure compliance to corrosion control designs.

13.5 SOIL AND GROUNDWATER CORROSION CONTROL

This subsection provides criteria for the design of systems and measures to prevent corrosion from soils and groundwater on Metra fixed facilities. Designs shall be based on achieving a 100-year design life for buried structures.

Protection of metal structures shall include, but not be limited to, sacrificial corrosion allowance, protective coating, electrical isolation, electrical continuity, and cathodic protection as appropriate.

The designs shall be coordinated to identify reinforced concrete structures at risk of corrosion to the reinforcement, and to specify appropriate methods to improve the durability of the structure by reducing the risk of corrosion.

13.5.1 SCOPE

Structures that may be affected by soil and water corrosion shall be identified. Typically, these include, but are not limited to:

- Ferrous pressure piping (water, fire water, gas, sewage ejectors, etc.)
- Buried and on-grade reinforced concrete structures including hydraulic elevator cylinders
- Support pilings
- Other underground structures

Corrosion control measures for non-Metra structures shall be coordinated with the structure’s owner. This coordination shall be required to resolve design conflicts and to minimize impact of other designs, such as interference with or from cathodic protection. All contacts with owners of other structures shall be coordinated through Metra.

13.5.2 SAFETY AND CONTINUITY OF OPERATIONS

Corrosion control provisions shall be required for all facilities, regardless of location or material, when failure of such facilities caused by corrosion will affect safety or interrupt continuity of operations.

13.5.3 METALLIC MATERIALS

All piping (pressure and non-pressure) and conduit shall be non-metallic unless metallic materials are required for specific engineering purposes.

Aluminum and its alloys shall not be used for direct burial purposes.

If the use of ferrous (buried cast iron, ductile iron, or steel) pressure piping is supported based on engineering requirements, then it shall be cathodically protected, including piping at the affected interface with Metra.

Designs shall include:

- Application of a protective coating to the external surfaces of the pipe
- Electrical insulation from interconnecting piping, other structures, and segregation into discrete electrically insulated sections depending upon the total length of the piping
- Electrical continuity through installation of insulated copper wires, across all mechanical joints other than intended insulators
- Permanent test/access facilities, to allow for verification of continuity, effectiveness of insulators and coating, and evaluation of protection levels. These shall be installed at all insulated connections and at intervals not greater than 200 feet.
- Impressed current anodes and rectifier units or sacrificial anodes. The number of anodes and size of rectifier shall be determined on an individual structure basis.

13.5.4 NON-METALLIC MATERIALS

Plastics, fiberglass, and other non-metallic materials for pressurized piping may be appropriate to aid in corrosion control. The use of these materials for corrosion control shall consider the following characteristics of the proposed materials:

- Manufacturer's recommendations
- Mechanical strength and internal pressure limitations
- Elasticity/expansion characteristics
- Comparative costs
- Expected life
- Failure modes
- Local codes

- Prior experiences with the proposed non-metallic material in similar applications

13.5.5 REINFORCED/PRESTRESSED CONCRETE PRESSURE PIPE

Design and fabrication of reinforced concrete pipe and steel cylinder pre-stressed concrete pipe shall meet the following requirements:

- Establish a low permeability concrete by controlling the water/cement ratio. Ratios of 0.3 for core concrete and 0.25 for mortar are preferred. Industry practices may result in significant increases and wide variations to these levels.

- Allow a maximum of 200 parts per million (ppm) chloride concentration in mixing water for concrete.

- Use Type I Portland cement generally. Type II Portland Cement should be used in selected locations.

13.5.6 CONCRETE/REINFORCED CONCRETE

Design shall be based on the following for concrete in contact with soils:

- Use Type I Portland Cement or Type II Portland Cement as appropriate based on location

- Allow a maximum water/cement ratio of 0.45 by weight

- Allow a maximum 200 ppm chloride concentration in mixing water and admixtures combined

- Allow a minimum two-inch concrete cover on the soil side of all steel reinforcement when the concrete is poured within a form, or a minimum three-inch cover when the concrete is poured directly against soils

13.5.7 COATINGS

Buried metal structures requiring coating shall be provided with an appropriate coating of proven performance in buried conditions such as glass flake epoxy or fusion bonded epoxy. Mill-applied coatings shall be specified whenever possible with use of compatible tape coatings for joints and field touch-up. The corrosion control design shall specify surface preparation, application procedure, primer, number of coats, minimum dry film thickness, and integrity testing for each coating system.

Design based on the use of metallic supports exposed to the soil, such as H-beams, shall consider the use of protective coatings, and possibly cathodic protection. The need for special measures shall be based on the type of structures, analysis of soil borings for the corrosive characteristics of soils, and the degree of anticipated structural deterioration caused by corrosion.

13.5.8 ELECTRICAL CONDUITS

Buried metallic conduits shall include the following minimum provisions:

- Galvanized steel with a polyvinylchloride (PVC) topcoat or other coating acceptable for direct burial, including coupling and fittings
- Galvanized steel with a minimum of three inches concrete cover on soil sides within duct banks
- Electrical continuity through use of standard threaded joints or bond wires installed across non-threaded joints

13.5.9 ELECTRICAL INSULATION

Devices used for electrical insulators for corrosion control shall include non-metallic inserts, insulating flanges, coupling, unions, and concentric support spacers. Devices shall meet the following minimum criteria:

- Devices shall have a minimum of 10 megohms resistance prior to installation and shall have mechanical and temperature rating equivalent to the structure in which they are installed.
- Devices shall have sufficient electrical resistance after insertion into the operating piping system such that no more than two percent (2%) of a test current applied across the device flows through the insulator, including flow through conductive fluids if present.
- Devices installed in chambers or otherwise exposed to partial immersion or high humidity shall have a protective coating applied over all components.
- Design shall specify the need for, and location of, insulating devices. All devices shall be equipped with permanent test facilities when they are not accessible or when specialized equipment is necessary for access.
- Wherever possible, a minimum clearance of six inches shall be provided between new and existing structures. When field conditions prohibit a six-inch clearance, the design shall include special provisions to prevent electrical contact with the existing structure(s).

13.5.10 ELECTRICAL CONTINUITY

Electrical continuity shall be provided for all underground non-welded pipe joints within discrete zones and shall meet the following minimum criteria:

- Direct burial insulated, stranded copper wires with the minimum length necessary to span the device being bonded shall be used
- Wire size shall be based on the electrical characteristics of the structure and resulting network to minimize attenuation and allow for cathodic protection
- A minimum of two wires shall be used per joint for redundancy

13.6 CATHODIC PROTECTION

Cathodic protection systems may be required for some buried metallic structures consistent with the structure life objectives. This shall be used as a last resort, where other corrosion control measures are found to be infeasible and must be approved by Metra prior to detailed design.

When required and wherever feasible, cathodic protection shall be accomplished by sacrificial galvanic anodes to minimize corrosion interaction with other underground utilities. Impressed current systems shall be used only when use of sacrificial systems is not technically and economically feasible. Cathodic protection schemes using forced drainage of transit induced stray DC currents that require connections to the negative system shall not be used.

13.6.1 MINIMUM PARAMETERS

Cathodic protection system design shall be based on theoretical calculations for each system including the following minimum parameters:

- Cathodic current density (minimum 20 milliamps/square feet of bare area)
- Current requirements
- Anticipated current output/anode
- Assumed percentage bare surface area (minimum one percent (1%))
- Indicated total number of anodes, size, spacing
- Anticipated anode life
- Anticipated anode bed resistance

The sum of the anticipated anode life and time to failure based on corrosion rates anticipated at 90 percent cumulative probability level shall not be less than 100 years.

13.6.2 RECTIFIERS

Impressed current rectifier systems shall be completely designed using variable voltage and current output rectifiers. Rectifiers shall be rated a minimum 50 percent above calculated operating levels to overcome a higher than anticipated ground bed resistance, lower than anticipated coating resistance, or presence of interference bonds. Other conditions that may result in increased voltage and current requirements shall be considered.

13.6.3 TEST FACILITIES AND TESTING

Test stations consisting of two structure cables, one reference electrode, conduits, and termination boxes shall be designed to permit initial and periodic tests of cathodic protection levels, interference currents, and system components (anodes, insulated fittings, and continuity bonds). The corrosion control design shall specify the locations and types of test facilities for each cathodic protection system.

13.6.4 WATER TREATMENT

For air conditioning systems, chemical treatment of chiller, condenser, and boiler supply and return system shall be designed to minimize internal corrosion and to prevent component fouling. Water treatment systems shall be designed to prevent corrosion rates in excess of 2.0 millimeters per year for steel and 0.1 millimeters per year for copper. Provisions for corrosion rate measurements shall be made in the return lines. All chemical treatment systems shall comply with environmental protection requirements. The corrosion control design shall include appropriate measures and provide space requirements for treatment equipment.

13.7 ATMOSPHERIC CORROSION PREVENTION

This subsection provides criteria for designs that will ensure the necessary function and appearance of Metra structures and equipment exposed to the environment. Criteria for atmospheric corrosion control are based on prevention of appearance and reduction of maintenance costs. Systemwide criteria for all areas shall include the following:

- Materials shall have established performance records for the intended service
- Sealants shall be used in crevices to prevent the accumulation of moisture
- Barrier or sacrificial coatings shall be used on steel

- Use of dissimilar metals and recesses or crevices that might trap moisture shall be avoided

13.7.1 SCOPE

The structures that may be affected by atmospheric corrosion shall be identified. Typically, these include, but are not limited to:

- Exposed metal surfaces and structures
- Exposed metal at passenger stations
- Wayside enclosures
- Electrical, mechanical, signal and communication devices and equipment and traction power substation housings

13.7.2 MATERIALS

Metals exposed to atmospheric environments shall be selected and provided as follows:

- Steels and ferrous alloys
- Aluminum alloys
- Copper alloys
- Magnesium alloys
- Zinc alloys

13.7.3 STEELS AND FERROUS ALLOYS

Carbon steel and cast iron exposed to the atmosphere shall have a coating applied to all external surfaces. Rail and rail fasteners do not require coatings.

High strength low alloy steels shall be protected similarly to carbon steels except where used as weathering steel exposed to the outside environment. Coating of metallic contacting surfaces, crevice sealing, and surface drainage shall be addressed in the designs. Staining of adjacent structures shall be considered.

Series 200 and 300 stainless steels are suitable for use in any exposed situation without future protection. Series 400 stainless steels are acceptable but must be evaluated due to possible staining.

Stainless steel surfaces shall be cleaned and passivated after fabrication including after any on-site welding process or where a component has been affected by weld splatter.

13.7.4 ALUMINUM ALLOYS

For aluminum alloys, an anodized finish shall be used to provide the best corrosion resistant surface.

13.7.5 COPPER ALLOYS

Copper and its alloys may be used where exposed to the weather without additional protection. Bimetallic couplings shall be avoided.

13.7.6 MAGNESIUM ALLOYS

Magnesium alloys shall have a barrier coating applied when long term appearance is critical. Bimetallic coupling shall be avoided.

13.7.7 ZINC ALLOYS

Zinc alloys may be used without additional protection. Bimetallic coupling shall be avoided.

13.7.8 COATINGS

Coatings shall have a proven past performance of providing corrosion protection in comparable operating environments, and be compatible with the metallic surface to be coated. Resistance to chalking, and color and gloss retention shall be satisfactorily established for the life of the coating where visual appearance is important.

Coating systems shall consist of a wash primer (if substrate requires), a primer, intermediate coat(s), and a finish coat.

13.8 GROUNDING

The purpose of this subsection is to ensure that grounding and corrosion control requirements do not conflict and render either system ineffective. The key to accomplishing complementary systems is proper location of insulation points and proper means of grounding systems.

13.8.1 STRUCTURES

Structures such as handrails, cable trough components, and other metal components shall be electrically isolated from the top layer of reinforcing steel. At each end of the structure, insulated cables shall be exothermically welded to the reinforcing steel and terminated in an appropriately sized and conveniently located weatherproof junction box or manhole.

13.8.2 GROUNDING OF AC ELECTRICAL NEUTRAL

All building facilities physically associated with Metra and supplied with a low voltage three phase four wire electrical service shall have equipment "grounding" only. This grounding shall be accomplished by connecting the equipment "electrode grounding conductor" to the building steel only. No earth ground shall be provided. The electric service neutral shall not be connected to any ground or building steel. The neutral shall be allowed to float. An isolated neutral bus installed in the service distribution equipment shall receive circuit neutrals. These facilities include but are not limited to:

- Passenger stations
- Fan plants
- Pump rooms
- Air compressor rooms
- Crew quarters
- Escalators and elevators

13.8.3 COORDINATION REQUIREMENTS

To provide compatible grounding systems and corrosion control systems, the following items shall be coordinated:

- Ground electrode component materials
- Ground electrode locations
- Pier support/insulation detail

13.9 MICROBIOLOGICALLY INFLUENCED CORROSION CONTROL

A MIC monitoring and mitigation system shall be provided for all fire protection piping systems. A MIC monitoring station shall be located in each valve room. The monitoring stations shall include corrosion coupons and corrosion monitoring probe(s) that actuate a pressure switch when the test area has corroded. A supervisory alarm shall also be reported at the station fire panel upon detection of corrosion.

Pipe fittings shall be installed in all system risers in valve rooms, and in tunnel cross passages, to facilitate the injection of MIC mitigation products.

Each individual sprinkler and wet standpipe riser shall have an automatic air release valve installed in the high point of the system. These valves shall be UL listed and FM Global approved for fire sprinkler piping. The fire sprinkler designer shall determine the location of the air vents during layout of the fire sprinkler piping to assure evacuation of trapped air in the fire sprinkler system. Each vent shall have a fitting and valve to facilitate MIC end of sprinkler line testing. These vents and fittings must be accessible for maintenance.

All deluge and pre-action piping shall be treated with an environmentally friendly corrosion inhibitor such as Potter Pipe-Shield, or approved equal, upon installation and before commissioning of the system.

Pre-action systems shall be protected with a nitrogen generator system installed in the valve rooms. The system should be capable of producing 98 percent pure nitrogen designed for use in fire protection sprinkler systems.

13.10 HYDRAULIC ELEVATOR CYLINDERS

Steel hydraulic elevator cylinders shall be designed, fabricated, and installed to meet the following requirements:

- External protective coating resistant to deterioration by petroleum products.
- Outer concentric FRP casing. Casing thickness, diameter and resistivity shall be designed to prevent moisture intrusion (including the bottom) and to maximize electrical insulation between the cylinder and earth.
- Sand fill between the cylinder and FRP casing with a minimum resistivity of 100,000 ohm-centimeters, a pH of between six and eight and a maximum chloride content of 250 ppm.
- Cathodic protection through the use of impressed current with the anodes installed in the sand fill.
- Permanent test facilities installed on the cylinder, anodes, and earth reference to permit evaluation, activation, and periodic retesting of the protection system.
- Removable moisture-proof sealing lid installed on the top of the casing prior to installation of the cylinder. The top of the casing shall be permanently sealed against moisture intrusion after installation of the cylinder.

- Alternative protective measures in lieu of cathodic protection shall be Union Gard 160 or equal which fills the space between high-density polyethylene (HDPE) casing and cylinder.

14. MECHANICAL, ELECTRICAL, AND PLUMBING

14.1 OVERVIEW

The primary function of this chapter is to establish criteria to be used in the design of Metra facilities. In all cases, the design shall comply with local, state, and federal law.

The guidelines in this chapter are not intended to address all design issues encountered during a typical design development. They will, however, provide the criteria and guidance necessary to resolve these issues. Where it is either impossible, extremely expensive, or impractical to adhere to these guidelines, alternatives may be presented to Metra and other authorities for approval on a case-by-case basis through the design variance process (Section 2.3.7).

14.2 MECHANICAL

14.2.1 GENERAL

14.2.1.1 DESIGN CODES AND STANDARDS

Code, Standard, Reference, or Guideline
International Energy Conservation Code
Americans with Disabilities Act
American National Standards Institute
American Gas Association
Occupational Safety and Health Administration
American Society of Heating, Refrigerating, & Air Conditioning Engineers
American Society of Mechanical Engineers
Air Conditioning & Refrigeration Institute
National Fire Protection Association
Sheet Metal and Air Conditioning Contractors National Association
Underwriters Laboratories
Chicago Building Code

Code, Standard, Reference, or Guideline
International Building Code
American Society of Testing & Materials

14.2.1.2 ENERGY CONSERVATION

Comply with the standards set forth by the more stringent of ASHRAE Standard 90.1, Energy Conservation in New Building Design or the International Energy Conservation Code (IECC), latest enforced version, while meeting safety and health requirements. To maintain system uniformity, these guidelines require that a standard specification approach, rather than a performance approach, be taken for energy conservation measures.

14.2.1.3 TESTING

All testing and balancing of equipment shall be documented on industry-approved forms and submitted to Metra and design team to verify all testing has passed the required capacities before the project is complete. This should become part of any maintenance submittal for this facility. All testing shall be witnessed by Metra or the Metra representative.

14.2.1.4 COMMISSIONING

Commissioning of all mechanical equipment is to be performed by certified personnel. This work is to be certified by the manufacturer's representative and authorized Metra personnel, and commissioning forms are to be submitted and added to the maintenance binder for this facility. All commissioning shall be witnessed by Metra or the Metra representative.

14.2.2 OFFICES

14.2.2.1 DESIGN CONSIDERATIONS

The heating, ventilation, and air conditioning (HVAC) design for each building shall be unique in layout for the given location, however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and conform to the typical approach that Metra has historically found to be suitable.

Use passive heating, cooling, ventilation, and daylighting strategies where feasible to reduce energy consumption. All heating and cooling equipment shall be designed to maintain the indoor air temperatures listed below based on ASHRAE 99.6 percent heating and cooling design conditions for the nearest weather station to project location and local energy code parameters.

14.2.2.2 HEATING

Provide a heating system with the capability to raise and maintain the temperature at 70 degrees F.

INDIVIDUAL OFFICES OR SPACES (guard shack, single offices, field offices, etc.): Primary heating shall come from the ductless split heat pump system; these rooms shall be provided with a secondary heating system. Secondary heat source to be used when outdoor ambient temperature does not allow for proper heating from the heat pump. Supplemental electric heating equipment is preferred for this application, but other means of heating the office may be considered – if more economical. This equipment shall be UL and FM approved.

In individual offices, the heating controls shall maintain a temperature of 70 degrees F when room is occupied. In unoccupied rooms, maintain a set-back temperature of 55 degrees F.

GROUPED OFFICES (Larger office buildings or groups of offices within a larger facility like repair shops etc., those spaces can be lobbies, waiting rooms, conference rooms and break rooms): built up combination heating/cooling systems typical of rooftop air conditioning, air handlers with heating/cooling capabilities, or ducted split systems.

In grouped offices, thermostats to maintain occupied and unoccupied times. Will be designed with programmable thermostats that must be able to communicate with Building Automation System (BAS)/Building Management System (BMS) system capable of cloud/web based headend if required in the scope of work of the specific project.

Wall mounted heating controls shall be located inside the office. The heating controls should include an on/off switch and programmable thermostat.

14.2.2.3 AIR CONDITIONING

Provide an air conditioning system with the capability to lower and maintain the temperature at 75 degrees F dry bulb, 50% RH.

INDIVIDUAL OFFICES OR SPACES (guard shack, single offices, field offices, etc.): Provide a ductless split-system consisting of a single indoor wall mounted unit and an outdoor condensing unit. Equipment sizing shall be based on cooling 25 percent outside air and 75 percent recirculated air.

GROUPED OFFICES (larger office buildings or groups of offices within a larger facility like repair shops etc., those spaces can be lobbies, waiting rooms, conference rooms and break rooms): built up combination heating/cooling systems typical of rooftop air conditioning, air handlers with heating/cooling capabilities, or ducted split systems. Equipment sizing shall be based on cooling 25 percent outside air and 75 percent recirculated air minimum, ASHRAE 62.1, or local code requirement, whichever is greatest.

Wall mounted air conditioning controls shall be located inside the office. The air conditioning controls should include an on/off switch and programmable thermostat that must be able to communicate with building BAS/BMS system capable of cloud/web based headend if required in the scope of work of the specific project.

14.2.2.4 VENTILATION

Indoor air ventilation rates shall be 25 percent of total system air flow, or meet the requirements of ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality or local code requirement, whichever is greater.

All outside air shall be filtered before being introduced to mechanical equipment. The minimum efficiency of these filters shall be MERV-8 or equivalent.

14.2.3 SUBSTATIONS

14.2.3.1 DESIGN CONSIDERATIONS

The HVAC design for each building shall be unique in layout for the given location; however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and conform to the typical approach that Metra has historically found to be suitable.

HVAC equipment shall maintain proper clearances from electrical equipment.

14.2.3.2 HEATING

Substation facilities shall be provided with a heating system with the capability to raise and maintain the temperature to 65 degrees F. Electric unit heaters or similar types of equipment are preferred for this application. This equipment shall be UL and FM approved.

Wall mounted heating controls should include an on/off fan switch and programmable thermostat.

Heating controls shall maintain a temperature of 65 degrees F when space is occupied. When space is unoccupied, maintain a set-back temperature of 55 degrees F.

Refer to the Offices section of this chapter for heating requirements for individual offices located within substations.

For toilet rooms, install electric wall heater to maintain 72 degrees F.

14.2.3.3 AIR CONDITIONING

Air conditioning is not typically provided for substations, unless there is an office area located within the substation. Refer to the Offices section of this chapter for more information.

14.2.3.4 VENTILATION

Mechanical ventilation to be provided to maintain space temperature below 95 degrees F. Exhaust fans are to be positioned on one end of substation, while the intake louver(s) shall be positioned on the opposite end. Exhaust fans are to be thermostatically controlled to maintain space temperature and linked with intake louver(s) with low leakage type motor operated damper. Intake louver to have rack for two-inch pleated MERV-8 air filters with velocity less than 500 feet/minute through the filter media.

Intake louvers are to be an extruded aluminum drainable type, sized to not exceed 60 percent of the free area velocity at the beginning point of water penetration.

Exhaust louvers are to be extruded aluminum and a maximum leaving air velocity of 1000 feet/minute through the actual free area of the louver.

Dampers to be extruded aluminum opposed blade low leakage type with actuators that open the dampers when any of the large exhaust fans activate. And close when all fans are off.

14.2.4 MAINTENANCE FACILITIES

14.2.4.1 DESIGN CONSIDERATIONS

The HVAC design for each building shall be unique in layout for the given location, however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and conform to the typical approach that Metra has historically found to be suitable. See Section 15.11.5 for further requirements for Metra maintenance facilities.

14.2.4.2 HEATING

Maintenance facilities shall be provided with a heating system with the capability to raise and maintain the temperature at 65 degrees F. Gas fired unit heaters or roof mounted heaters are preferred for this application.

Heating controls shall maintain a temperature of 65 degrees F when space is occupied. When space is unoccupied, maintain a set-back temperature of 55 degrees F. If building is large enough, install BAS to control all HVAC equipment.

Refer to the Offices section of this chapter for heating requirements for offices located within maintenance facilities.

For toilet rooms, install wall heater to maintain 72 degrees F.

14.2.4.3 AIR CONDITIONING

Air conditioning is not typically provided for maintenance facilities, unless there is an office area located within the facility. Refer to the Offices section of this chapter for more information.

14.2.4.4 VENTILATION

Indoor air ventilation rates shall meet the requirements of ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality or local code requirement, whichever is greater.

14.2.5 YARDS

14.2.5.1 DESIGN CONSIDERATIONS

N/A

14.2.5.2 HEATING

N/A

14.2.5.3 AIR CONDITIONING

N/A

14.2.5.4 VENTILATION

N/A

14.2.6 COMMUNICATION HOUSES ON RIGHT OF WAY

14.2.6.1 DESIGN CONSIDERATIONS

The HVAC design for each building shall be unique in layout for the given location; however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and conform to the typical approach that Metra has historically found to be suitable.

HVAC equipment shall maintain proper clearances from communications equipment.

14.2.6.2 HEATING

Communications houses shall be provided with a heating system with the capability to raise and maintain the temperature to 65 degrees F. Electric unit heaters are preferred for this application. This equipment shall be UL and FM approved.

Wall mounted heating controls should include an on/off switch and programmable thermostat.

Heating controls shall maintain a temperature of 65 degrees F when space is occupied. When space is unoccupied, maintain a set-back temperature of 55 degrees F.

14.2.6.3 AIR CONDITIONING

Air conditioning shall be provided to maintain a space temperature at, or below, 75 degrees F. A ductless split-system consisting of a single indoor wall mounted unit and an outdoor condensing unit. or a wall mounted packaged system can be used.

Wall mounted controls shall be located inside the room to be air conditioned. The air conditioning controls should include an on/off switch and programmable thermostat.

14.2.6.4 VENTILATION

Ventilation is not required in an unoccupied communications house.

14.2.7 SIGNAL HOUSES ON RIGHT-OF-WAY

14.2.7.1 DESIGN CONSIDERATIONS

The HVAC design for each building shall be unique in layout for the given location. however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and conform to the typical approach that Metra has historically found to be suitable.

HVAC equipment shall maintain proper clearances from signal equipment.

14.2.7.2 HEATING

Signal houses shall be provided with a heating system with the capability to raise and maintain the temperature at 65 degrees F. Electric unit heaters are preferred for this application. This equipment shall be UL and FM approved.

Wall mounted heating controls should include an on/off switch and programmable thermostat.

Heating controls shall maintain a temperature of 65 degrees F when space is occupied. When space is unoccupied, maintain a set-back temperature of 55 degrees F.

14.2.7.3 AIR CONDITIONING

Air conditioning shall be provided to maintain a space temperature at, or below, 75 degrees F. A ductless split-system consisting of a single indoor wall mounted unit and an outdoor condensing unit can be used.

Wall mounted controls shall be located inside the room to be air conditioned. The air conditioning controls should include an on/off switch and programmable thermostat.

14.2.7.4 VENTILATION

Ventilation is not required in an unoccupied signal house.

14.3 PLUMBING

14.3.1 GENERAL

14.3.1.1 DESIGN CODES AND STANDARDS

Code, Standard, Reference, or Guideline
International Plumbing Code
State of Illinois Plumbing Code
Americans with Disabilities Act
State of Illinois Accessibility Standards
American National Standards Institute
American Society of Plumbing Engineers
Occupational Safety and Health Administration
Underwriters Laboratories
Chicago Building Code
American Society of Mechanical Engineers

14.3.1.2 TESTING

All pressure and leakage testing of fixtures and piping shall be documented on industry-approved forms and submitted to Metra and design team to verify all testing has passed before the project is complete. This should become part of any maintenance submittal for this facility. All testing shall be witnessed by Metra or the Metra representative.

14.3.1.3 COMMISSIONING

Commissioning of all plumbing equipment is to be performed by certified personnel. This work is to be certified by the manufacturer's representative, and commissioning forms are to be submitted and added to the maintenance binder for this facility. All commissioning shall be witnessed by Metra or the Metra representative.

14.3.1.4 FIXTURES

Location, type, and quantity of plumbing fixtures shall be shown on the plumbing drawings using defined abbreviations via plans, isometric diagrams, and schedules. Where required by local or state regulations, ADA accessibility guidelines, or when reasonably feasible, ADA accessible type fixtures shall be provided. Where required by local or state regulations, or when reasonably feasible, unisex toilet rooms shall be provided.

All water closets, urinals, and lavatories are to be wall mounted when possible. In office building environments the water closets, urinals, and lavatories are to have hard wired flush valves and hand free electronic eye faucets. In stations, smaller out buildings and utility locations manual flush valves and manual faucets will be required unless water service to location prohibits use of flush valve type of fixture then a wall mounted flush tank type will be acceptable. All supply fixtures are to be commercial grade and meet the WaterSense requirements. Fixture supports to be heavy-duty type.

14.3.1.5 PIPING SYSTEMS, PIPE AND FITTINGS

All piping systems shall meet local requirements for sizing and installations. If ferrous to non-ferrous metal piping is required install dielectric unions or flanges between different types to avoid oxidation and current transfer.

All plumbing pipes and fittings shall be shown on the construction drawings using plans, isometric diagrams, riser diagrams and sectional views. Expansion loops, elbows, caps, tees, cleanout plugs, traps, vacuum breakers, etc., shall be labeled as needed to indicate the complete assemblage of the various piping lines including but not limited to the following plumbing components:

- Domestic hot- and cold-water supply piping systems
- Domestic hot water return piping system and pump
- Soil, waste, and vent piping systems
- Drainage piping (including stormwater and subsoil drainage piping)
- Specialized waste pretreatment drainage and system for battery electrolyte spills
- Systems for hydronics system glycol retention/collection
- Systems for locomotive engine coolant retention/collection

The plumbing drawings shall indicate elevations of all significant sections of waste and storm pipes with an invert elevation note. All significant sections of hot and cold-water piping shall be indicated with a bottom-of-piping note. All piping shall be designed to run directly as possible and parallel, or at right angles to walls and partitions. Multiple pipes shall be grouped in parallel lines with an appropriate section showing how the pipes are hung together.

Label all pipes with permanent plastic pipe markers to identify the content of the pipe and the direction of the fluid flow. Provide markers at no greater than ten-foot centers.

14.3.1.6 PUMPS

14.3.1.6.1 SEWAGE EJECTOR PUMPS

Electric-driven duplex sewage ejector with electronic alternator and level control devices shall be provided for all facilities where gravity flow to a sanitary sewer is not possible. Consolidate waste pipes into a single sewage ejector when possible, versus providing multiple sewage ejectors. Sewage ejector sizing shall be based on fixture unit data obtained from design calculations per the applicable plumbing code/Illinois plumbing code, and in accordance with the manufacturer's recommendations. Account for discharge pipe volume and ejector cycle time.

Provide illuminated indicator lights for power available, motor overload, high-water and low-water situations. This shall be provided for with local audible alarm and remote indicating alarm in the building engineer office and as otherwise directed by Metra. Corrosion control shall be incorporated in the design of sewage ejector systems. The sewage ejector basin shall be constructed of a non-corrosive material (i.e., fiberglass). Drainage pumps should be powered by a dedicated power source from emergency power panel.

14.3.1.6.2 SUMP PUMPS

Electric-driven duplex sump pumps with electronic alternators and floats shall be provided for storm water only (non-sanitary) for all facilities where gravity flow to a storm main is not possible. Sump pump sizing shall be based on data obtained from the applicable building code/Illinois Plumbing code and applied in conjunction with sound engineering judgment. Provide illuminated indicator lights for power available, motor overload, high-water (pump failure) and low-water situations (possible float failure or hang up). This shall be provided with local audible alarm and remote indicating alarm.

For sump pumps located in elevator pits, transformer vaults, and any other location that may collect oily substances, a control system shall be provided to prevent the pump from operating when oil is detected in the settling basin.

If a settling basin is not used with sump pump system, a sewage ejector pump with the same rating may be used, to keep any foreign object in drain water from damaging sump pumps.

Corrosion control shall be incorporated in the design of sump pump systems. See Chapter 13. The sump pump basin shall be constructed of a non-corrosive material such as fiberglass.

14.3.1.6.3 FLOOD CONTROL PUMPS

Flood control pumps to be provided at projects that are located in areas which are under the water line or in flood plains.

Electric-driven duplex flood control pumps with electronic alternators and floats shall be provided for non-sanitary water only. Flood control pump sizing shall be based on data obtained from the applicable building code/Illinois Plumbing Code and applied in conjunction with sound engineering judgment. Provide illuminated indicator lights for power available, motor overload, high-water and low-water situations. This shall be provided with local audible alarm and remote indicating alarm.

14.3.1.7 CLEANOUTS

Provide pipe-sized cleanouts at maximum 50-foot intervals in all drain or sanitary pipes and for each change in direction.

14.3.1.8 CORROSION CONTROL

In buildings where stray currents could be present, all piping passing from a building related structure into the ground or into a structure shall be non-metallic pipe. All metallic piping passing from a building related structure into the ground or into a structure that is grounded shall be fitted with two-stage dielectric isolation couplings to prevent possible stray currents. Any underground metallic piping shall have cathodic protection. All piping subject to corrosion shall be weatherproof epoxy coated.

14.3.1.9 INSULATION

Provide jacketing at all above-grade insulated piping. All-service Jacketing (ASJ) is preferred for general applications. Piping exposed to high humidity or moisture, or exposed piping within eight feet of the ground shall be jacketed with PVC. Aluminum jacketing shall be used where piping is installed outdoors, or exposed to abuse, significant temperature fluctuations, or UV.

All piping shall be permanently labeled with plastic pipe markers or adhesive labels (labels will be acceptable if not exposed to exterior or humid environments), at no greater than 10-foot centers, which will indicate the content of the pipe and the direction of the fluid flow. The following shall be insulated:

- Domestic hot water supply and return piping
- All cold-water piping subject to condensation
- All heat traced piping
- Drainage, waste, and cold-water piping subject to sweating
- Below grade sleeved piping
- Heating steam, condensate, and hot water piping
- All valves and other appurtenances to make this a complete operational system

14.3.1.10 HEAT TRACING

Piping routes shall be designed in such a manner as to minimize requirements for heat tracing. Provide self-limiting type heat tracing tape with thermostatic control for freeze protection only where absolutely needed, with a complete system of heaters, components, and controls to prevent freezing of the water, sanitary drainpipes, and gutters and downspouts. Also, protect any piping run intended to drain a location where blockage (complete or partial) could result in significant damage to the physical structure or equipment.

Design temperature conditions shall be -25 degrees F outside ambient. Liquid temperatures shall be maintained to prevent a change of phase in the liquid at any point in the pipe, under all foreseeable conditions of installations.

Provide two ambient sensing thermostats, one of which is for a parallel backup, such that either will alarm to indicate the failure of a thermostat. The air-temperature-sensing thermostat shall shut off the self-regulating heat trace cable circuit(s) when the ambient temperature rises to above 35 degrees F.

Provide a heat trace control panel to show the status of the system, including failures. Devices on the panel are to include, but not necessarily be limited to, an on/off selector switch, push-to-test 120-volt LED lights, silence switch, current and voltage sensing relays.

Provide an alarm buzzer and indicating push-to-test LED light wired from the heat trace control panel. Provide wiring to the interface cabinet from the heat trace control panel. Alarms shall indicate actual operation of the heat trace cables, via current and voltage. Thermostats shall be placed in safe and accessible locations for maintenance.

All piping that requires freeze protection shall be insulated.

14.3.1.11 DOMESTIC HOT AND COLD WATER

Hot and cold-water piping shall be pitched to a low point to facilitate draining. Drain valves are to be provided. Avoid designs which have pipes embedded in the structure. However, all pipes which pass through structural walls and/or floors shall be sleeved. Include water hammer arrestors in plumbing systems to avoid water hammer.

In areas where code requirements require backflow devices, all devices shall be installed per the AWWA “M14 Backflow Prevention and Cross-Connection Control”, as well as all locally acceptable codes, and shall protect all installed domestic water systems from contamination.

14.3.1.12 SOIL, WASTE, AND VENT

All waste and vent piping shall be designed in an efficient manner. Redundant runs and risers shall not be employed. Piping shall be sized to meet code requirements, as a minimum.

DRAINAGE: Whenever possible, drainage shall be by gravity flow. Where drainage sections are below points of gravity outfall, pumps shall be provided. All drainage piping shall be a minimum of two-inch outlet size and shall be connected to laterals no less than that size. Underground drainage piping shall not be less than four-inches in diameter. Underground piping and joint materials shall be chemical and petroleum resistant.

If sewer flooding is an issue or flood level is above inverts of drains, install a backwater valve to prevent sewage from backflowing into Metra properties.

FLOOR DRAINAGE: Floor drainage shall be vented per applicable code and shall be provided in the following areas:

- Elevator pit (Sump pumps will be allowed if required)

- Mechanical equipment rooms
- Washbays
- Kitchens
- Shower rooms
- Janitor's rooms, toilet rooms and other utility spaces
- Any oil/grease laden areas (grease interceptor to be provided)

Floor drains not regularly receiving drainage and prone to evaporation of the trap fluids will be provided with a trap primer if available water supply is nearby, or the trap shall be filled with light oil to reduce evaporation.

ROOF DRAINAGE: Types of roof drainage include roof drains, gutters, downspouts, and scuppers. Roof drainage shall be connected to storm drainage system of building.

If area of roof drainage does not have a storm drainage system, or it is not feasible to install one on a specific project site, then approval of any other proposed solution must be granted from Metra before completion of design.

14.3.1.13 PLUMBING EQUIPMENT

Hot water shall be supplied to all toilet rooms, shower rooms, sinks, kitchens, break rooms, washing bays, and janitor's closets. A hot water recirculation system shall be employed if required by the energy code. Minimum heater tank storage capacity shall be based on 100 degrees F recovery delta temperature and shall comfortably accommodate the size and use of fixtures served by the water heater.

Natural gas tankless/tank water heaters are to be installed where the property/location has natural gas service. Electric tank water heaters are to be installed where the property/location does not have any natural gas service. Minimum temperature rise in tankless water heaters shall be 65 degrees F. The capacity of the tankless water heater shall be coordinated with the demand of the fixtures to be provided with hot water. In cases where the hot water demand is beyond capacities of the tankless heaters, conventional tank type water heaters can be installed. In larger, non-station facilities, larger tank type gas hot water and hybrid electric heat pump domestic water heaters would be acceptable per Metra directive.

14.3.1.14 FIRE PROTECTION

When required by applicable codes, a sprinkler system shall be provided. Fire protection systems shall be connected to Metra and local police and fire departments using an automatic dialer system.

In spaces where discharge of water-based fire protection could damage energized electronics, data servers, security, radio equipment, signals, or comms. Spaces to use an approved clean agent fire suppressant type system.

Jockey pumps to be provided alongside fire pumps to maintain pressure inside the fire-protection sprinkler system. Jockey pump sizing shall be based on data obtained from the applicable NFPA code and applied in conjunction with sound engineering judgment.

14.3.2 OFFICES

14.3.2.1 DESIGN CONSIDERATIONS

The plumbing design for each building and/or structure shall be unique in layout for the requirements and constraints of the given location, however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and shall conform to the typical approach that Metra has historically found to be suitable.

14.3.2.2 FIRE PROTECTION

When required by applicable codes, a sprinkler system shall be provided in office areas. Fire protection systems shall be connected to Metra and local police and fire departments using an automatic dialer system.

14.3.3 SUBSTATIONS

14.3.3.1 DESIGN CONSIDERATIONS

The plumbing design for each building and/or structure shall be unique in layout for the requirements and constraints of the given location; however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and shall conform to the typical approach that Metra has historically found to be suitable.

14.3.4 MAINTENANCE FACILITIES

14.3.4.1 DESIGN CONSIDERATIONS

The plumbing design for each building and/or structure shall be unique in layout for the requirements and constraints of the given location, however, the design shall be conceptually congruent with the requirements established herein. The basic design shall be compatible with the structural and architectural design and shall conform to the typical approach that Metra has historically found to be suitable.

Provisions should be made for an oil/water separator connected to all industrial waste lines.

See Section 15.11.7 for further requirements for Metra maintenance facilities.

14.3.5 YARDS

N/A

14.3.6 COMMUNICATION HOUSES ON RIGHT-OF-WAY

N/A

14.3.7 SIGNAL HOUSES ON RIGHT-OF-WAY

N/A

14.4 ELECTRICAL

14.4.1 GENERAL

14.4.1.1 DESIGN CODES AND STANDARDS

The codes and standards that the design should follow, such as IEEE, NFPA, National Electrical Code, Local Codes, etc. are listed below:

Code, Standard, Reference, or Guideline
Chicago Electrical Code

Code, Standard, Reference, or Guideline
American National Standards Institute
Institute of Electrical and Electronic Engineers
National Fire Protection Association
Insulated Power Cable Engineers Association
National Electrical Code
National Electrical Manufacturers Association
National Electric Safety Code
Occupational Safety and Health Administration
Underwriters Laboratories
American National Standards Institute

14.4.1.2 DESIGN CONSIDERATIONS

- Determine the power source and lengths of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine the amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.

14.4.1.3 POWER SOURCE

- Power sources shall come from the utility
- Coordinate with the utility on power, service agreement, and contracts, breakdown of the cost and service entrance location sketched
- Coordinate with the utility on available fault current

- A standby generator with an automatic transfer switch (ATS) or a generator receptacle box shall be provided to back up the utility power.

- Services shall be sized to handle all projected loads by the City of Chicago Electrical Code load calculations.

14.4.1.4 SERVICE EQUIPMENT

- Where ComEd metering transformers are installed in switchboards, ComEd shall review and approve the switchboard shop drawings before drawings are submitted for approval. Each rented concession shall be metered separately.

- The service shall be protected by a molded case circuit breaker or metal-clad draw out breakers equipped with LSIG trip elements and have interrupting capacity sufficient to interrupt maximum available short circuit current at its load terminals.

- Service equipment and distribution breakers shall be molded case with a minimum of 65KAIC rating and shall be provided with transient voltage surge suppressor (TVSS) protection.

- A typical facility shall have one electrical room at a location reviewed and approved by the Metra.

- Ground fault protection shall be coordinated with branch circuits such that the least number of circuits are tripped should a ground fault occur.

14.4.1.5 DISTRIBUTION EQUIPMENT

- The minimum Kilo Ampere Interrupting Capacity (KAIC) rating for the electrical equipment shall be 65KAIC.

- Services shall utilize a switchboard with group mounted industrial grade feeder circuit breakers.

- Provide National Electrical Manufacturers Association (NEMA) 1A enclosure for general purpose use in dry switchboard rooms not exposed to combustible gases but gasketed against dust. Use NEMA 4 enclosures at outdoors and where water tightness is required.

- Panelboards shall be of the safety dead front type.

- A separate panel shall feed communication equipment. Panelboards shall be provided with TVSS protection. Panelboards shall be sized for 250 percent increased capacity.

- All panelboards shall be lockable with a CAT 60 lock. Panelboards and breakers shall have a minimum of a 65KAIC rating. Each panelboard shall be sized to contain circuit breakers for connected loads and 25 percent capacity for future expansion. This expansion capacity shall include at least 20 percent spare single pole circuit breakers (four minimum). Each panelboard shall be fully equipped with full bus work and terminations to readily accept the future breakers. Each panelboard shall be equipped with a ground bus.

- Distribution branch circuit breakers shall be heavy duty, industrial type molded case, bolted type, front removable, and rated to interrupt maximum available short circuit current at their load terminals, based on rated voltage.

- Dry–Type Distribution Transformers (600 volts and below) Transformers step up or step down shall be UL listed, dry type suitable for indoor/outdoor application. The transformer enclosure shall be compatible with the installation environment. Transformer winding shall be copper.

- Automatic Transfer Switch shall be used maintain service to the loads by changing the source of supply between the two incoming services when the source feeding the load fails.

14.4.1.6 EMERGENCY SYSTEMS

The emergency power systems shall consist of battery-supported UPS, standby generators with ATS or generator receptacle box as required to provide emergency power to the following loads, as a minimum:

- Egress and stair lighting

- Drainage pump system

- Fire protection pumps

- Communications, supervisory control, data acquisition, and fire detection and alarm systems

- Signal Systems

- Selected building lighting
- Selected receptacles in switchboard rooms, generator rooms, mechanical rooms, restrooms, stairways, and offices.

System design shall be based upon ANSI/IEEE Standard and the criteria defined herein.

Uninterruptible power supply (UPS) units shall be connected to supply power if normal power fails. The UPS units shall be designed to operate "online" such that when normal power fails, the batteries will provide power for a designated period through the inverter output. If a UPS malfunctions, a static switch shall automatically connect the load directly to the normal supply while simultaneously opening the inverter-output circuit breaker. A maintenance bypass shall be provided to manually transfer the load to the normal supply for routine service or maintenance.

A standby generator can be used to power emergency loads and full loads at the location. Standby generators shall be gas fired. Diesel engine driven generators will not be allowed. Generator output shall be the same as the facility power, and kW capacity as determined by the design calculations. An automatic transfer shall be used to power the load from the generator on the loss of utility power

Either emergency backup system used shall be able to back up the loads for a minimum period time of four hours.

14.4.1.7 TESTING

All testing shall be in accordance with the manufacturer’s recommendations and industry standards. All testing shall be documented on industry-approved forms and submitted to Metra and the design team to verify all testing has passed the required capacities before the project is complete. This should become part of any maintenance submittal for this facility. All testing shall be witnessed by Metra or Metra representatives.

14.4.1.8 COMMISSIONING

Commissioning of all equipment is to be performed by certified personnel. This work is to be certified by the manufacturer's representative and authorized Metra personnel, and commissioning forms are to be submitted and added to the maintenance binder for this facility. All commissioning shall be witnessed by Metra or a Metra representative.

14.4.1.9 WIRING DEVICES

All wiring devices shall comply with NFPA 70.

Switches shall be UL listed and to be mounted at man-doors in suitable outlet boxes in the wall or partitions unless otherwise noted. Switches to be rated 20 amperes, 120/240 volts alternating current (AC), surface mounted, and premium specification grade. Wall switches to be two poles are indicated on drawings for heater and ventilation control.

Buildings shall be provided with sufficient convenience type receptacles spaced around the perimeter of the interior walls, mounted on columns, or otherwise located in such a manner as to meet the power requirements of portable equipment such as small hand tools, drop lights, vacuum cleaners, small blowers, small pumps, supervisory equipment, etc., connected to a 50-foot maximum length portable cord. The receptacle shall be tamper proof.

Grounded 120-volt, single phase, 20-ampere duplex convenience receptacles shall be installed throughout the building as required by applicable codes.

Each receptacle circuit in the public areas shall feed not more than eight duplex outlets. Outlets shall be circuited alternately.

In service (non-public) areas, no more than six duplex outlets shall be wired into each circuit.

Outlets shall not be connected to lighting circuits. Outlets shall have an Underwriters Laboratories label for use in wet locations. Outlet receptacles shall be heavy grade with stainless steel covers.

Ground fault circuit interrupters shall be heavy duty, feed through, duplex type rated 20 amperes, 125 volts, incorporating solid state ground fault sensing and signaling, 5 mA trip level. Receptacles exposed to the public shall have weatherproof vandal proof lockable covers.

Weatherproof, gasketed, vandal-proof lockable spring type covers shall be provided for weatherproof receptacles.

Facilities shall be provided with a motion control occupancy sensor in nonpublic spaces. Each occupancy sensor shall include an integral ON/OFF disconnect switch. Multiple sensors are required for spaces with multiple entry doors. Each occupancy sensor shall bear the Underwriters Laboratories label.

14.4.1.10 MATERIALS AND STANDARDS

The facilities shall be provided with an access panel for ceilings or walls to permit adjustment or service of the concealed item such as pull boxes, junction boxes, other specialties, or any piece of equipment or device requiring adjustment or service. Panels shall be a flangeless hinged type with vandal-proof fasteners.

Concrete pads shall be minimum of four inches high, unless otherwise noted complete with steel reinforcing and necessary bolts, anchors, etc.

Expansion fittings and bonding jumpers shall be installed for the metallic conduit system where the conduit crosses each building expansion joint.

Expansion fittings shall provide for eight-inch movement and to include bonding jumpers.

Sleeves shall be provided where conduits pass through walls, floors, partitions as required by the Drawings, and/or field conditions. Spare sleeves shall be provided and capped with a suitable fire rated material and identified on the drawings.

Sleeves shall be 18-gauge galvanized sheet metal or plastic, as approved by Code. Floor sleeves shall be RTRC. Sleeves through walls, ceilings, and floors, will have the net openings packed with fiberglass insulation.

14.4.1.11 RACEWAY AND WIRING METHODS

The basic raceway system shall be of conduit, either exposed or embedded.

For new installations all conduits shall be concealed in public areas. A rigid galvanized steel conduit shall be used for all runs for exposed conduit runs, indoor and outdoor, where there is a potential for physical damage. Intermediate metal conduit (IMC) shall be used indoors in conditioned areas and where not exposed. Screw type connections should not be used

Liquid-tight flexible metal conduit shall be provided for final connections to recessed lighting fixtures and equipment subject to vibration, noise transmission, or movement.

Polyvinyl chloride (PVC) conduit shall be used for installations below grade, below the ground floor slab, embedded in floor or ceiling slab. Conduit below grade and below floor slab shall be encased in a minimum of two inches of concrete. RTRC shall be used for encasements in duct banks for all applications.

Cable trays may be provided in lieu of conduit for the installation of multi-conductor control cables. Cable trays shall not be used for installation of medium voltage wires and cables in any location, nor shall they be used for installation of 600-volt wires and cables.

All conduit exposed or unheated areas shall be rigid steel heavy wall type and minimum size shall be 3/4-inch conduit. The minimum raceway size shall be 3/4-inch. Aluminum conduit shall not be used.

At least 18 inches of flexible metallic conduit shall be used for connections to motors to limit the transmission of vibration.

Pull boxes, junction boxes and outlet boxes, and associated fittings shall be fabricated of material compatible with that used for the conduit terminating at the boxes.

Fittings for rigid conduit shall be of the threaded type. The use of set screws or crimp-type fittings is prohibited.

Wire shall be the copper conductor and shall have thermoplastic insulation Type THWN/AWM. Service entrance conductors shall have High heat-resistant water-resistant (XHHW) insulation.

Power conductor runs shall be not less than 12 American Wire Gauge (AWG) copper wire size.

Outdoor lighting (poles-roadways, yards, and parking areas) shall use Type RHW consisting of ethylene propylene rubber (EPR) insulation with a Hypalon jacket.

Branch conduits shall contain no more than one multiwire branch circuit, or one three-phase, four-wire feeder, plus ground-messenger.

Home runs shall contain a maximum of nine wires.

14.4.1.12 EQUIPMENT

14.4.1.12.1 ELEVATOR

Determine the location of the elevator.

Electrical feeders shall be routed to each elevator machine room and terminated in a disconnect switch. Elevator power and control disconnect shall be located in the elevator machine room. Elevators should be properly grounded using appropriate size grounding conductors connected to the ground bus. Elevators shall be sized to accommodate an emergency stretcher. The elevator lobby should also be designed to accommodate the movement of a stretcher. Elevator lobbies shall be heated and enclosed from the weather. The lower floor position shall be the resting position of the elevator. All elevator alarms shall be reported to Supervisory Control and Data Acquisition (SCADA).

Install fire heat sensors in the shaft and smoke detectors in the landing of elevators. Upon loss of normal power, adequate standby power shall be supplied to automatically return the car nonstop to the designated floor.

Hoistway and car design shall utilize materials/ construction to promote transparency and maximum visibility. Hoistway size will be determined by the product manufacturer's specifications.

Provide HVAC to control rooms to maintain room between 60 degrees F and 90 degrees F as per code. Elevator lobby finish materials should be resistant to salt, weather conditions, and vandalism. All elevators shall be based on American Public Transportation Association (APTA) standards.

Elevators must be connected to an interface with the fire alarm system.

14.4.1.12.2 ESCALATOR

Determine the location of the escalator.

Electrical feeders shall be routed to each escalator machine drive area and shall be terminated in a disconnect switch. The electric service shall be from the general services panelboard. Escalator should be properly grounded using appropriate size grounding conductors connected to the ground bus. A "stop" button shall be provided at each landing.

The stations whose depth from the surface is substantial, movement upwards and downwards is primarily served by escalators and elevators. All escalators shall be based on APTA standards.

Escalators must be connected to an interface with the fire alarm system.

14.4.2 OFFICES

14.4.2.1 DESIGN CONSIDERATIONS

- Determine the power source and lengths of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.

14.4.2.2 POWER SOURCE

- Power sources shall come from the utility.
- Coordinate with the utility on power, service agreement, and contracts, breakdown of the cost and service entrance location sketched.
- Coordinate with the utility on available fault current.

14.4.2.3 SERVICE EQUIPMENT

Where ComEd metering transformers are installed in switchboards, ComEd shall review and approve the switchboard shop drawings before drawings are submitted for approval. Meter enclosure panels shall have vandal-resistant transparent viewing panels for reading.

The service shall be protected by a molded case circuit breaker or metal-clad draw out breakers equipped with LSIG trip elements and have interrupting capacity sufficient to interrupt maximum available short circuit current at its load terminals.

Service equipment and distribution breakers shall be molded case with a minimum of 65KAIC rating and shall be provided with TVSS protection.

A typical office facility shall have one electrical room at a location reviewed and approved by Metra.

Ground fault protection shall be coordinated with branch circuits such that the least number of circuits are tripped should a ground fault occur

14.4.2.4 EMERGENCY SYSTEMS

The emergency power systems shall consist of battery-supported UPS, standby generators with ATS, or a generator receptacle box as required to provide emergency power to the following loads, as a minimum:

- Egress and stair lighting
- Drainage pump system
- Fire protection pumps
- Communications, supervisory control, data acquisition, and fire detection and alarm systems
- Signal systems
- Selected building lighting
- Selected receptacles in switchboard rooms, generator rooms, mechanical rooms, restrooms, stairways, and offices.

System design shall be based upon ANSI/IEEE Standard and the criteria defined herein.

UPS units shall be connected to draw power from if normal power fails. The UPS units shall be designed to operate "online" such that when normal power fails, the batteries will provide power for a designated period through the inverter output. If a UPS malfunctions, a static switch shall automatically connect the load directly to the normal supply while simultaneously opening the inverter-output circuit breaker. A maintenance by-pass shall be provided to manually transfer the load to the normal supply for routine service or maintenance.

A standby generator can be used to power emergency loads and full loads at the location. Standby generators shall be gas fired. Diesel Engine Driven Generators will not be allowed. Generator output shall be the same as the facility power, and kW capacity as determined by the design calculations. An automatic transfer shall be used to power the load from the generator on the loss of utility power.

Either emergency backup system used shall be able to back up the loads for a minimum period time of four hours.

14.4.2.5 CONTROL SYSTEMS

Install an open-source building management system to control all lighting and HVAC equipment in offices, data centers, and maintenance facilities.

14.4.2.6 GROUNDING AND LIGHTNING PROTECTION

Each electrical load center shall be grounded to provide safety for personnel and to provide fast, reliable relaying. Grounding shall consist of a main grounding junction box (GJB) which shall be comprised of a copper bus bar. The incoming water line shall be connected to GJB using a ground cable.

Ground rods shall be located adjacent to the outside building. The number of rods and interconnections among rods shall be adequate to provide a ground resistance is not to exceed five ohms. Each ground rod shall be not less than 10 feet in length and shall consist of solid stainless steel material type 304. The maximum resistance of a driven rod shall not exceed 10 ohms. Total Ground Grid resistance shall not exceed five ohms.

The building and surrounding area shall be evaluated to determine if lightning protection shall be provided. Lightning protection shall be provided for all feeders subjected to lightning exposure.

Lightning protection systems and equipment shall be installed, where required, to provide protection of persons, equipment, and facilities against the hazards posed by lightning. The lightning protection system shall comply with the requirements of a UL “Master Label System” and NFPA 78, “Lightning Protection Code". The placement of air terminals and routing of conductors shall consider appearance and protection requirements. Air terminals shall be placed to take advantage of any protection afforded by adjacent structural features. On a flat-top building protected by air terminals, all metallic parts and equipment projecting higher than the air terminals, such as heating, ventilating, and air conditioning equipment shall be bonded to the lightning protection system.

14.4.2.7 FIRE PROTECTION

The fire protection systems shall be installed and constructed in a complete manner and shall include all components necessary to provide a complete and operable system.

The fire alarm system shall comply with the requirements of NFPA Standard No. 72 for protected premises signaling systems. The system shall be electrically supervised and monitor the integrity of all conductors. All fire alarm system wiring shall be new and installed in conduit. The number and size of conductors shall be as recommended by the fire alarm system manufacturer.

All field wiring to the indicating devices shall be completely supervised.

The Fire Alarm Control Panel (FACP) shall be connected to a separate dedicated branch circuit, a maximum of 20 amperes. The addressable FACP shall communicate with and control the following types of equipment used to make up the system: smoke detectors, heat detectors, manual pull stations, and other system-controlled devices.

When required by applicable codes, a sprinkler system shall be provided. In public areas, the sprinkler heads shall be the concealed type. All facility’s fire protection systems shall be connected to Metra, local police, and fire departments using an automatic dialer system.

14.4.3 SUBSTATIONS

14.4.3.1 DESIGN CONSIDERATIONS

- Determining the power source and lengths of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.
- Two primary AC feeders rated 12.6 KV, three-phase, 60 Hz shall be provided to each traction power substation. The two feeders shall originate from different buses.
- A tie breaker compartment shall be provided to make each primary feeder available to service the loads.
- Traction power substations will be normally operated with bus tie closed and both AC line breakers closed.
- Lightning protection shall be provided for all feeders subjected to lightning exposure.
- Temporary work and phasing shall be coordinated with Metra and utility.

14.4.3.2 LOW VOLTAGE POWER SYSTEM

Two auxiliary transformers shall be provided at each traction power substation. Normally, the load will be equally divided between transformers. Automatic transfer switches shall be provided to transfer all loads except electric heating to remaining transformer in the event of failure of either transformer.

One transformer shall be energized from each of the two bus sections. Each transformer shall normally supply the vital auxiliaries of the rectifier energized from the same bus section so that a transfer switch failure shall not render all rectifiers inoperative.

Transformers shall be dry-type with class 220 insulation and 80 degree C rated temperature rise at rated full load above 40 degree C ambient.

14.4.3.3 MEDIUM VOLTAGE POWER SYSTEM

This section covers the requirements for the 4.16KV Light and Power (L&P), and 2.4KV Signal System power requirements in Metra systems. The medium voltage power requirements for the traction power system are not covered in this section.

The power feeds for the three phase, four wire 4.16KV switchgear shall be obtained from the 12.47KV traction power switchgear through 12.47KV – 4.16KV step down transformer, unless 4.16KV feeds are directly provided from utility. The 12.47KV-4.16KV transformer shall have two separate feeds from the 12.47KV switchgear through a transfer switch. The 4.16KV switchgear shall have a minimum of two feeders and varies by each location. The normal power to each feeder is from the main bus and the alternate power from the transfer bus via manual transfer switch. All transfer switches shall be housed in switch enclosures. The entire railway L&P system shall be tied together through the main bus and transfer bus inside the 4.16KV switchgear.

The power feed for the single phase 2.4KV signal system shall be from the 4.16KV switchgear through a 2.4KV-2.4KV isolation transformer. The number of signal feeders varies by location and shall include the normal and auxiliary signal feed. The normal power to each feeder is from the signal main bus and the alternate power from the signal transfer bus via manual transfer switch. All transfer switches shall be housed in switch enclosures. The entire signal power system shall be tied together through the main bus and transfer bus inside the 2.4KV switchgear.

14.4.3.4 SERVICE EQUIPMENT

The AC primary switchgear shall be an indoor metal-clad draw out type with an interrupting capacity of 500 MVA symmetrical for a 12,600 volt, three-phase, 60 Hz electrical service. The switchgear for each primary AC feed shall include cubicles for the incoming line, bus tie, auxiliary power, ComEd (Commonwealth Edison) metering, rectifier transformer feeders. The switchgear bus shall be rated 1200 amperes continuous at 400 C and shall be insulated, supported, and braced to withstand short circuit stresses at least as great as those for which the circuit breakers are designed.

Distribution breakers shall be molded cases with a minimum of 65KAIC rating and shall be provided with TVSS protection.

14.4.3.5 GROUNDING AND LIGHTNING PROTECTION

Grounding shall be provided for the medium voltage switchgear as per the NEC and IEEE codes and standards. A ground switch shall be provided for grounding the transfer bus for the 4.16KV and 2.4KV systems. Lightning arresters shall be provided for all the feeder cables coming to the 4.16KV and 2.4 switchgear from the railway ROW.

14.4.3.6 FIRE PROTECTION SYSTEM

The fire protection systems shall be installed and constructed in a complete manner and shall include all components necessary to provide a complete and operable system.

The fire alarm system shall comply with the requirements of NFPA Standard No. 72 for protected premises signaling systems. The system shall be electrically supervised and monitor the integrity of all conductors. All fire alarm system wiring shall be new and installed in conduit. The number and size of conductors shall be as recommended by the fire alarm system manufacturer.

All field wiring to the indicating devices shall be completely supervised.

The FACP shall be connected to a separate dedicated branch circuit, a maximum of 20 amperes. The addressable FACP shall communicate with and control the following types of equipment used to make up the system: smoke detectors, heat detectors, manual pull stations, and other system-controlled devices.

When required by applicable codes, a sprinkler system shall be provided. In public areas, the sprinkler heads shall be the concealed type. All substation fire protection systems shall be connected to Metra, local police, and fire departments using an automatic dialer system.

14.4.4 MAINTENANCE FACILITIES

14.4.4.1 DESIGN CONSIDERATIONS

See Section 15.11.6 for considerations for maintenance facilities, in addition to the following design considerations:

- Determine the power source and length of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine the amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.

14.4.4.2 POWER SOURCE

- Power sources shall come from the utility.
- Coordinate with the utility on power, service agreement, and contracts, breakdown of the cost and service entrance location sketched.
- Coordinate with the utility on available fault current.
- A standby generator and ATS or generator receptacle box shall be provided to back up the utility power.
- When a maintenance facility is being rehabilitated there shall be a determination whether to change the type of service.

14.4.4.3 SERVICE EQUIPMENT

Where ComEd metering transformers are installed in switchboards, ComEd shall review and approve the switchboard shop drawings before drawings are submitted for approval. Each rented concession shall be metered separately. Meter enclosure panels shall have vandal-resistant transparent viewing panels for reading.

The service shall be protected by a molded case circuit breaker or metal-clad draw out breakers equipped with LSIG trip elements and have interrupting capacity sufficient to interrupt maximum available short circuit current at its load terminals.

Service equipment and distribution breakers shall be molded case with a minimum of 65KAIC rating and shall be provided with TVSS protection.

A typical maintenance facility shall have one electrical room at a location reviewed and approved by Metra.

Ground fault protection shall be coordinated with branch circuits such that the least number of circuits are tripped should a ground fault occur.

14.4.4.4 EMERGENCY SYSTEMS

The emergency power systems shall consist of battery-supported UPS, standby generators and ATS or generator receptacle box as required providing power to the following loads, as a minimum.

- Egress stair lighting
- Drainage system
- Fire protection pumps
- Communications, supervisory control, and data acquisition, and fire detection and alarm systems
- Selected building lighting
- Selected receptacles in switchboard rooms, generator rooms, mechanical rooms, restrooms, stairways, and offices.

System design shall be based upon ANSI/IEEE Standard and the criteria defined herein.

UPS units shall be connected to draw power from, if normal power fails. The UPS units shall be designed to operate "online" such that when normal power fails, the batteries will provide power for a designated period through the inverter output. If a UPS malfunctions, a static switch shall automatically connect the load directly to the normal supply while simultaneously opening the inverter-output circuit breaker. A maintenance bypass shall be provided to manually transfer the load to the normal supply for routine service or maintenance.

A standby generator can be used to power emergency loads and full loads at the location. Standby generators shall be gas fired. Diesel engine driven generators will not be allowed. Generator output shall be the same as the facility power, and kW capacity as determined by the design calculations. An automatic transfer shall be used to power the load from the generator on the loss of utility power.

Either emergency backup system used shall be able to backup the loads for a minimum period time of four hours.

14.4.4.5 CONTROL SYSTEMS

Install an open-source building management system to control all lighting and HVAC equipment in offices.

14.4.4.6 GROUNDING AND LIGHTNING PROTECTION

Each electrical load center shall be grounded to provide safety for personnel and to provide fast, reliable relaying. Grounding shall consist of a main GJB which shall be comprised of a copper bus bar. The incoming water line shall be connected to GJB using a ground cable.

Ground rods shall be located adjacent to the outside building. The number of rods and interconnections among rods shall be adequate to provide a ground resistance not to exceed five ohms. Each ground rod shall be not less than 10 feet in length and shall consist of solid stainless steel material type 304. The maximum resistance of a driven rod shall not exceed five ohms. Total ground grid resistance shall not exceed five ohms.

The building and surrounding area shall be evaluated to determine if lightning protection shall be provided. Lightning protection shall be provided for all feeders subjected to lightning exposure.

Lightning protection systems and equipment shall be installed, where required, to provide protection of persons, equipment, and facilities against the hazards posed by lightning. The lightning protection system shall comply with the requirements of a UL “Master Label System” and NFPA 78, “Lightning Protection Code". The placement of air terminals and routing of conductors shall consider appearance and protection requirements. Air terminals shall be placed to take advantage of any protection afforded by adjacent structural features. On a flat-top building protected by air terminals, all metallic parts and equipment projecting higher than the air terminals, such as heating, ventilating, and air conditioning equipment shall be bonded to the lightning protection system.

14.4.4.7 FIRE PROTECTION SYSTEM

The fire protection systems shall be installed and constructed in a complete manner and shall include all the components necessary to provide a complete and operable system.

The fire alarm system shall comply with the requirements of NFPA Standard No. 72 for protected premises signaling systems. The system shall be electrically supervised and monitor the integrity of all conductors. All fire alarm system wiring shall be new and installed in conduit. The number and size of conductors shall be as recommended by the fire alarm system manufacturer.

All field wiring to the indicating devices shall be completely supervised.

The FACP shall be connected to a separate dedicated branch circuit, a maximum of 20 amperes. The addressable FACP shall communicate with and control the following types of equipment used to make up the system: smoke detectors, heat detectors, manual pull stations, and other system-controlled devices.

When required by applicable codes, a sprinkler system shall be provided. In public areas, the sprinkler heads shall be the concealed type. All maintenance facility's fire protection systems shall be connected to Metra, local police, and fire departments using an automatic dialer system.

14.4.5 YARDS

14.4.5.1 DESIGN CONSIDERATIONS

- Determine the power source and lengths of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.

14.4.5.2 POWER SOURCE

- Power sources shall come from the utility or from the yard buildings.
- Coordinate with the utility on power, service agreement, and contracts, breakdown of the cost and service entrance location sketched

- Coordinate with the utility on available fault current
- A standby generator with ATS or generator receptacle box shall be provided to back up the utility power.
- When a yard is being rehabilitated there shall be a determination if to change the type of service.

14.4.5.3 SERVICE EQUIPMENT

Where ComEd metering transformers are installed in switchboards, ComEd shall review and approve the switchboard shop drawings before drawings are submitted for approval. Meter enclosure panels shall have vandal-resistant transparent viewing panels for reading.

The service shall be protected by a molded case circuit breaker or metal-clad draw out breakers equipped with LSIG trip element and have interrupting capacity sufficient to interrupt maximum available short circuit current at its load terminals.

Service equipment and distribution breakers shall be molded case with a minimum of 65KAIC rating and shall be provided with TVSS protection.

A typical yard facility shall have one electrical room at a location reviewed and approved by Metra.

Ground fault protection shall be coordinated with branch circuits such that the least number of circuits are tripped should a ground fault occur.

14.4.5.4 EMERGENCY SYSTEMS

A standby generator can be used to power emergency loads and full loads at the location. Standby generators shall be gas fired. Diesel engine driven generators will not be allowed. Generator output shall be the same as the facility power, and kW capacity as determined by the design calculations. An automatic transfer shall be used to power the load from the generator on the loss of utility power.

Emergency backup system used shall be able to back up the loads for a minimum period time of four hours.

14.4.5.5 CONTROL SYSTEMS

Install open-source building management system to control all lighting and HVAC equipment in yard offices.

14.4.5.6 GROUNDING AND LIGHTNING PROTECTION

Each electrical load center shall be grounded to provide safety for personnel and to provide fast, reliable relaying. Grounding shall consist of a main GJB which shall be comprised of a copper bus bar. The incoming water line shall be connected to GJB using a ground cable.

Ground rods shall be located adjacent to the outside building. The number of rods and interconnections among rods shall be adequate to provide a ground resistance not to exceed five ohms. Each ground rod shall be not less than 10 feet in length and shall consist of solid stainless steel material type 304. The maximum resistance of a driven rod shall not exceed five ohms. Total ground grid resistance shall not exceed five ohms.

The building and surrounding area shall be evaluated to determine if lightning protection shall be provided. Lightning protection shall be provided for all feeders subjected to lightning exposure.

Lightning protection systems and equipment shall be installed, where required, to provide protection of persons, equipment, and facilities against the hazards posed by lightning. The lightning protection system shall comply with the requirements of a UL “Master Label System” and NFPA 78, “Lightning Protection Code". The placement of air terminals and routing of conductors shall consider appearance and protection requirements. Air terminals shall be placed to take advantage of any protection afforded by adjacent structural features. On a flat-top building protected by air terminals, all metallic parts and equipment projecting higher than the air terminals, such as heating, ventilating, and air conditioning equipment shall be bonded to the lightning protection system.

14.4.5.7 FIRE PROTECTION

The yard fire protection systems shall be installed and constructed in a complete manner and shall include all the components necessary to provide a complete and operable fire pump system. The ancillary facility fire protection systems shall be procured installed and constructed in a complete manner and shall include all components necessary to provide a complete and operable system that is in accordance with the criteria specified in the specification. The ancillary facility fire protection systems include, but are not limited to, fire pumps, piping, sprinklers, hangers, miscellaneous appurtenances, hardware, etc., and other components systems as necessary. Yard fire protection systems panel shall be connected to Metra using a SCADA RTU.

14.4.6 COMMUNICATION HOUSES ON RIGHT-OF-WAY

14.4.6.1 DESIGN CONSIDERATIONS

- Determine the power source and lengths of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine the amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.

14.4.6.2 POWER SOURCE

The main power for the communication houses shall be from the station electrical room from which a distribution panel will supply power to all communication equipment, including lights, heat, and air.

14.4.6.3 SERVICE EQUIPMENT

Service equipment and distribution breakers shall be molded case with a minimum of 65KAIC rating and shall be provided with TVSS protection.

Provide NEMA 1A panelboard enclosure for general purpose use in dry locations not exposed to combustible gases but gasketed against dust. Use NEMA 4X enclosures where exposed to outdoors and in wet locations.

Panelboards shall be of the safety dead front type.

Panelboards shall be provided with TVSS protection. Panelboards shall be sized for 250 percent increased capacity.

All panelboards shall be lockable with a CAT 60 lock. Panelboards and breakers shall have a minimum of a 65KAIC rating. Each panelboard shall be sized to contain circuit breakers for connected loads and 25 percent capacity for future expansion. Each panelboard shall be fully equipped with full bus work and terminations to readily accept the future breakers. Each panelboard shall be equipped with a ground bus.

14.4.6.4 EMERGENCY SYSTEMS

The emergency power systems shall consist of battery-supported UPS.

The UPS units shall be designed to operate "online" such that when normal power fails, the batteries will provide power for a designated period through the inverter output. If a UPS malfunctions, a static switch shall automatically connect the load directly to the normal supply while simultaneously opening the inverter-output circuit breaker. A maintenance bypass shall be provided to manually transfer the load to the normal supply for routine service or maintenance.

The emergency backup system used shall be able to backup the loads for a minimum period time of four hours.

14.4.6.5 GROUNDING AND LIGHTNING PROTECTION

Each communication center shall be grounded to provide safety for personnel and to provide fast, reliable relaying. Grounding shall consist of a main GJB which shall be comprised of a copper bus bar. A supplementary ground rod shall use an earth-driven electrode as its grounding electrode. Resistance to earth shall not exceed five ohms. Grounding rod shall be installed in the ground well.

Lightning arresters shall be provided for all the power feeds cables coming to the communication room from the railway ROW.

14.4.6.6 FIRE ALARM

A fully functional fire alarm system shall be provided in the communication room with alarms reporting to SCADA. The addressable FACP shall communicate with and control the following types of equipment used to make up the system: smoke detectors, heat detectors, manual pull stations, and other system-controlled devices.

14.4.7 SIGNAL HOUSES ON RIGHT OF WAY

14.4.7.1 DESIGN CONSIDERATIONS

- Determine the power source and length of time to bring the service online.
- Understand the function, considerations, restrictions, and capacity of the space. Determine equipment and usage.
- Determine the amount of space required for equipment.
- If space is existing, determine capacity and distribution of electrical equipment.

14.4.7.2 POWER SOURCE

The power feed for signal houses shall be from the 2.4KV AC feed from the Metra substation. This voltage shall be stepped down to 120/240 using an isolation transformer at the signal house.

14.4.7.3 SERVICE EQUIPMENT

Service equipment and distribution breakers shall be molded case with a minimum of 65KAIC rating and shall be provided with TVSS protection.

Provide NEMA 1A panelboard enclosure for general purpose use in dry locations not exposed to combustible gases but gasketed against dust. Use NEMA 4X enclosures where exposed to outdoors and in wet locations.

Panelboards shall be of the safety dead front type.

Panelboards shall be provided with TVSS protection. Panelboards shall be sized for 250 percent increased capacity.

All panelboards shall be lockable with a CAT 60 lock. Panelboards and breakers shall have a minimum of a 65KAIC rating. Each panelboard shall be sized to contain circuit breakers for connected loads and 25% capacity for future expansion. Each panelboard shall be fully equipped with full bus work and terminations to readily accept the future breakers. Each panelboard shall be equipped with a ground bus.

14.4.7.4 EMERGENCY SYSTEMS

The emergency power systems shall consist of battery-supported UPS. UPS units shall be connected to draw power from a standby source if normal power fails.

The UPS units shall be designed to operate "online" such that when normal power fails, the batteries will provide power for a designated period through the inverter output. If a UPS malfunctions, a static switch shall automatically connect the load directly to the normal supply while simultaneously opening the inverter-output circuit breaker. A maintenance bypass shall be provided to manually transfer the load to the normal supply for routine service or maintenance.

Emergency backup system used shall be able to backup the loads for a minimum period time of four hours.

14.4.7.5 GROUNDING AND LIGHTNING PROTECTION

Each communication center shall be grounded to provide safety for personnel and to provide fast, reliable relaying. Grounding shall consist of a main GJB which shall be comprised of a copper bus bar. A supplementary ground rod shall use an earth-driven electrode as its grounding electrode. Resistance to earth shall not exceed two ohms. Grounding rod shall be installed in the ground well.

Lightning arresters shall be provided for all the power feeds cables coming to the communication room from the railway ROW.

14.4.7.6 FIRE ALARM

A fully functional fire alarm system shall be provided in the communication room with alarms reporting to SCADA. The addressable FACP shall communicate with and control the following types of equipment used to make up the system: smoke detectors, heat detectors, manual pull stations, and other system-controlled devices.

14.5 LIGHTING

14.5.1 GENERAL

14.5.1.1 DESIGN CODES AND STANDARDS

Code, Standard, Reference, or Guideline
American National Standards Institute
Chicago Electrical Code
International Dark-Sky Association
Illuminating Engineering Society
Institute Of Electrical and Electronic Engineers
National Electrical Code
National Fire Protection Association
Applicable Local Codes
National Electrical Manufacturers Association
National Electric Safety Code
Occupational Safety and Health Administration
Underwriter's Laboratory
BOCA Building Code

14.5.1.2 ENERGY CONSERVATION

Comply with the standards set forth by the more stringent of ASHRAE Standard 90-75, Energy Conservation in New Building Design, or the IECC, latest enforced version, while meeting safety and health requirements. To maintain system uniformity, these guidelines require that a standard specification approach, rather than a performance approach, be taken for energy conservation measures.

14.5.1.3 TESTING

All testing shall be in accordance with manufacturer's recommendations and industry standards. All testing shall be documented on industry-approved forms and submitted to Metra and design team to verify all testing has passed the required capacities before the project is complete. This should become part of any maintenance submittal for this facility. All testing shall be witnessed by Metra or Metra representative.

14.5.1.4 COMMISSIONING

Commissioning of all equipment is to be performed by certified personnel. This work is to be certified by the manufacturer's representative and authorized Metra personnel, and commissioning forms are to be submitted and added to the maintenance binder for this facility. All commissioning shall be witnessed by Metra or Metra representative.

14.5.1.5 LIGHTING LEVELS AND CALCULATIONS

Lighting levels shall be calculated utilizing the "Illuminating Engineers Society Lighting Handbook", latest edition and methods. Minimum footcandle levels shall be maintained over the entire site. Point by point photometric plans of the entire area of work shall be provided for Metra's review and approval.

The lighting illuminance values in each location shall be the average maintained illumination. Maximum footcandles shall be within 25 percent of targeted footcandles listed below.

Light-emitting diode (LED) fixtures shall be used throughout. LED fixtures, after 10 years, shall still provide the lighting output specified in each location, therefore, illumination levels must initially be higher to meet this standard.

Lighting shall be performed using direct lighting. Indirect lighting shall not be factored into the calculations.

Calculations must be performed using overall light loss factor (LLF) as described below:

- 0.75 for interior of facilities including bus garages, rail shops, substations, etc.

- 0.85 for station facility
- 0.80 for all exterior fixtures including wall mounted, and pole mounted fixtures
- 0.85 for general office areas

The values of illuminance shall have a uniformity ratio of three to one average to minimum, and not exceed the uniformity ratio of five to one maximum to minimum.

14.5.1.6 GENERAL ILLUMINATION LEVELS

Table 14-1: Lighting Luminance Values Criteria

Area	Average Maintained Illuminance Levels (Foot Candles (fc))	Fixture Type
Offices		
General Areas (Common Space)	10***	LED
Working Spaces	15*	LED
Entrances	15**	LED
Restrooms	10**	LED
Janitor Closet	10**	LED
Electrical Closet	30***	LED
Substations		
General Outdoor	2*	LED
Outdoor Switch Yard	2*	LED
General Indoor	5*	LED
Operating Aisles	15*	LED

Area	Average Maintained Illuminance Levels (Foot Candles (fc))	Fixture Type
Maintenance Facilities	50*	LED
Yards	5*	LED
Communication Houses on Right of Way	20**	LED
Signal Houses on Right of Way	20**	LED
Metra Command Center (Police)	30***	LED

Key:

Lighting levels are recommendations by Illuminating Engineering Society (IES)

*fc measured at task surface

**fc level measured at finished floor

***fc level measured at 2'-6" above finished floor

14.5.1.7 LED LIGHTING FIXTURE REQUIREMENTS

- Fixtures will be non-corroding, vandal resistant and UL listed.
- Outdoor fixtures shall be UL listed for use in wet locations.
- Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.
- The fixtures shall be rated for operations at -30 to 40 degrees C.
- All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.
- The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available

hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted on a removable tray and connected to the power through quick disconnects. Removable tray shall be connected using fasteners that required no tools to remove LEDs in the fixture, and shall be installed at the nominal length as required to fill the luminous opening of the fixture completely and uniformly

14.5.1.7.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. Manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

The LED light source installed indoors shall have a color temperature of 3,000K and LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.1.8 LIGHTING SPILL REQUIREMENTS

Prior to beginning the design of the lighting system, considerations should be investigated. The maintaining agency should be contacted and the following issue explored:

- Is there a maximum allowable level for spillage of light onto adjacent properties? If not, for light spillage, the light level at the boundary of the property, measured 36 inches above ground level, shall be not more than 0.5 footcandles (5 Lux) above ambient light level

14.5.1.9 LIGHTING PANELBOARDS

Panelboards shall be located in locked rooms, accessible only to authorized personnel. The panelboards shall contain lighting circuits for facilities, stairways, elevators, and passageways. Multiple circuits shall be provided in each area with lighting fixtures wired alternately on the multiple circuits. At least one of the lighting circuits on the above panelboard shall be derived from the reliable supply.

14.5.1.10 EMERGENCY LIGHTING AND EXIT SIGNAGE

Emergency lighting shall be provided in accordance with all applicable codes. The system shall be supplied by individual self-powered battery-operated units. In the event of a power failure, these units shall provide illumination to assist in safe and orderly evacuation to the nearest exit, emergency stairway or other area of safety. Illuminated exit signs must be provided in accordance with applicable codes.

In the first 90 minutes after a failure, emergency lighting must provide a minimum of one foot-candle at any point along the path of egress.

After 90 minutes, the illumination level may decline. However, because the code requires a maximum-to-minimum illumination ratio of no more than 40 to one, the illumination may only decline to an average 0.06 footcandle, no less.

14.5.2 OFFICES

14.5.2.1 DESIGN CONSIDERATIONS

The office lighting system should promote the safety, security, and comfort of the transit employees and guests. Appropriate lighting will also provide a deterrent to crime. The lighting system should provide the lighting levels and types required by the function of each individual area as defined in this chapter. In the interest of reduced energy consumption, designers shall employ passive daylighting strategies to the extent feasible.

Lighting equipment shall conform to the standards established in this manual and shall be UL listed “suitable for the intended use”. All conduit sizes shall conform to the applicable codes. The lighting system shall operate continuously, relying on automatic and manual controls to provide efficient energy use. Vandal-resistant fixtures and lenses should be used as required for their mounting locations.

Adequate lighting shall be provided in the office facilities and associated areas per Table 14-1. Lighting shall not interfere with, or blind train operators, or cause a nuisance to neighboring properties.

14.5.2.2 LIGHTING CONTROL

Provide local switching for all employee, maintenance, equipment, and storage spaces. All other individual circuit switching shall be done at the panelboard. Unoccupied areas and/or areas that are not defined with continuous operation shall be controlled with motion sensors.

14.5.2.3 CIRCUITS REQUIREMENTS

In any given area, fixtures shall be installed on alternate circuits such that upon failure of one circuit, lighting will still be present.

14.5.2.4 LED LIGHTING FIXTURES AND REQUIREMENTS

All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.

The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted on a removable tray and connected to the power through quick disconnects. Removable tray shall be connected using fasteners that required no tools to remove LEDs in the fixture shall be installed at the nominal length as required to fill the luminous opening of the fixture completely and uniformly

Fixtures located outdoors shall be UL listed for use in wet locations.

Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.

LED light source installed indoors shall have a color temperature of 3,000K and LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.2.4.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. Manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

14.5.3 SUBSTATIONS

14.5.3.1 DESIGN CONSIDERATIONS

The substation lighting system should promote the safety, security, and comfort of the transit employees. Appropriate lighting will also provide a deterrent to crime. The lighting system should provide the lighting levels and types required by the function of each individual area as defined in this chapter. In the interest of reduced energy consumption, designers shall employ passive daylighting strategies to the extent feasible.

Lighting equipment shall conform to the standards established in this Manual and shall be UL listed “suitable for the intended use”. All conduit sizes shall conform to the applicable codes. The lighting system shall operate continuously, relying on automatic and manual controls to provide efficient energy use. Vandal-resistant fixtures and lenses should be used as required for their mounting locations.

Adequate lighting shall be provided in the facilities and associated areas per Table 14-1. Exterior lighting around the substation shall not interfere with or blind train operators or cause a nuisance to neighboring property.

14.5.3.2 LIGHTING CONTROL

Provide local switching for all employee, maintenance, equipment, and storage spaces. All other individual circuit switching shall be done at panelboard. Unoccupied areas and/or areas that are not defined with continuous operation shall be controlled with motion sensors.

14.5.3.3 CIRCUITS REQUIREMENTS

In any given area, fixtures shall be installed on alternate circuits such that upon failure of one circuit, lighting will still be present.

14.5.3.4 LED LIGHTING FIXTURES AND REQUIREMENTS

Fixtures will be non-corroding, vandal resistant and UL listed.

Outdoor fixtures shall be UL listed for use in wet locations.

Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.

The fixtures shall be rated for operations at -30 to 40 degrees C.

All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.

The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted on a removable tray and connected to the power thru quick disconnects. Removable tray shall be connected using fasteners that required no tools to remove LEDs in the fixture shall be installed at the nominal length as required to fill the luminous opening of the fixture completely and uniformly

All lighting fixtures mounted to facilities near the train tracks shall be designed to minimize glare in the direction of approaching train engineer eyes.

14.5.3.4.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. Manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

LED light source installed indoors shall have a color temperature of 3,000K and LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.4 MAINTENANCE FACILITIES

14.5.4.1 DESIGN CONSIDERATIONS

The maintenance facility lighting system should promote the safety, security, and comfort of the transit employees. Appropriate lighting will also provide a deterrent to crime. The lighting system should provide the lighting levels and types required by the function of each individual area as defined in this chapter. In the interest of reduced energy consumption, designers shall employ passive daylighting strategies to the extent feasible.

Lighting equipment shall conform to the standards established in this manual and shall be UL listed “suitable for the intended use”. All conduit sizes shall conform to the applicable codes. The lighting system shall operate continuously, relying on automatic and manual controls to provide efficient energy use. Vandal-resistant fixtures and lenses should be used as required for their mounting locations.

Adequate lighting shall be provided in the facilities and associated areas per Table 15-2. Exterior lighting around the maintenance facility shall not interfere with, or blind train operators, or cause a nuisance to neighboring properties.

See Section 15.11.6 for additional considerations for maintenance facilities.

14.5.4.2 LIGHTING CONTROL

Provide local switching for all employee, maintenance, equipment, and storage spaces. All other individual circuit switching shall be done at panelboard. Unoccupied areas and/or areas that are not defined with continuous operation shall be controlled with motion sensors.

14.5.4.3 CIRCUITS REQUIREMENTS

In any given area, fixtures shall be installed on alternate circuits such that upon failure of one circuit, lighting will still be present.

14.5.4.4 LED LIGHTING FIXTURE AND REQUIREMENTS

Fixtures will be non-corroding, vandal resistant and UL listed.

Outdoor fixtures shall be UL listed for use in wet locations.

Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.

The fixtures shall be rated for operations at -30 to 40 degrees C.

All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.

The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted on a removable tray and connected to the power through quick disconnects. Removable tray shall be connected using fasteners that required no tools to remove LEDs in the fixture shall be installed at the nominal length as required to fill the luminous opening of the fixture completely and uniformly

All lighting fixtures mounted to maintenance facilities near the train tracks shall be designed to minimize glare in the direction of approaching train engineer eyes

LED light source installed indoors shall have a color temperature of 3,000K and LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.4.4.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. Manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

14.5.5 YARDS

14.5.5.1 DESIGN CONSIDERATIONS

The yard lighting system should promote the safety, security, and comfort of the transit employees. Appropriate lighting will also provide a deterrent to crime. The lighting system should provide the lighting levels and types required by the function of each individual area as defined in this chapter.

Lighting equipment shall conform to the standards established in this Manual and shall be UL wet listed. All conduit sizes shall conform to the applicable codes. The lighting system shall operate continuously, relying on automatic and manual controls to provide efficient energy use. Vandal-resistant fixtures and lenses should be used as required for their mounting locations.

Adequate lighting shall be provided in the facilities and associated areas per Table 14-1. Exterior lighting around the yard shall not interfere with, or blind train operators, or cause a nuisance to neighboring properties.

14.5.5.2 LIGHTING CONTROL

Provide local switching for all employee, maintenance, equipment, and storage spaces. All other individual circuit switching shall be done at the panelboard.

14.5.5.3 YARD FACILITY LIGHT POLE REQUIREMENTS

The control of the lighting system can be by photocell. The photocell is the preferred control because it adapts to the seasonal daylight variations and to overcast skies. The economics of the photocell system should compare the cost of providing photocells at each luminaire to a single photocell operating several luminaires. The photocell is to have a built-in time delay to avoid oversensitive on/off cycling due to vibration, birds, and the like. The photocell shall be located for easy access and to avoid/minimize the effects of adjacent structures.

Soil testing mentioned is for resistivity and shall be performed by the design consultant or geotechnical consultant.

Poles should be mounted on concrete foundations. The depth and type of the foundation shall be as recommended by the manufacturer and as required by the maintaining authority. Foundation should be extended 30 inches above pavement in parking lots or adjacent to driveways.

14.5.5.3.1 GROUNDING

Each light pole shall be grounded using a ground rod. The ground rod shall be connected to the ground lug at the base of the pole. Soil testing shall be performed prior to purchase and installation.

Where a controller is provided, the controller shall be grounded using a ground rod. Resistance to earth shall not exceed two ohms. The grounding rod shall be installed in a ground well. Soil testing shall be performed prior to purchase and installation.

14.5.5.4 CIRCUITS REQUIREMENTS

In any given area, fixtures shall be installed on alternate circuits such that upon failure of one circuit, lighting will still be present.

14.5.5.5 LED LIGHTING FIXTURE AND REQUIREMENTS

Fixtures will be non-corroding, vandal resistant and UL listed.

Outdoor fixtures shall be UL listed for use in wet locations.

Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.

The fixtures shall be rated for operations at -30 to 40 degrees C.

All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.

The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted within the fixture, and connected to the power through quick disconnects

All lighting fixtures in the yard near the train tracks shall be designed to minimize glare in the direction of approaching train engineer's eyes.

LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.5.5.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. Manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

14.5.6 COMMUNICATION HOUSES ON ROW

14.5.6.1 DESIGN CONSIDERATIONS

The communication houses on ROW lighting system should promote the safety, security, and comfort of the transit employees. Appropriate lighting will also provide a deterrent to crime. The lighting system should provide the lighting levels and types required by the function of each individual area as defined in this manual.

Lighting equipment shall conform to the standards established in this manual and shall be UL wet listed. All conduit sizes shall conform to the applicable codes. The lighting system shall operate continuously, relying on automatic and manual controls to provide efficient energy use. Vandal-resistant fixtures and lenses should be used as required for their mounting locations.

Adequate lighting shall be provided in the facilities and associated areas per Table 14-1. Exterior lighting around the communication houses shall not interfere with, or blind train operators, or cause a nuisance to neighboring property.

14.5.6.2 LIGHTING CONTROL

Provide local switching for all employee, maintenance, equipment, and storage spaces. All other individual circuit switching shall be done at the panelboard. Provide timer/occupancy sensor to prohibit the situation of light fixtures remaining on while no occupancy is present.

14.5.6.3 CIRCUITS REQUIREMENTS

In any given area, fixtures shall be installed on alternate circuits such that upon failure of one circuit, lighting will still be present.

14.5.6.4 LED LIGHTING FIXTURE AND REQUIREMENTS

Fixtures will be non-corroding, vandal resistant and UL listed.

Outdoor fixtures shall be UL listed for use in wet locations.

Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.

The fixtures shall be rated for operations at -30 to 40 degrees C.

All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.

The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted on a removable tray and connected to the power through quick disconnects. Removable tray shall be connected using fasteners that required no tools to remove LEDs in the fixture shall be installed at the nominal length as required to fill the luminous opening of the fixture completely and uniformly

All lighting fixtures mounted to the exterior of the communications houses near the train tracks shall be designed to minimize glare in the direction of approaching train engineer eyes.

LED light source installed indoors shall have a color temperature of 3,000K and LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.6.4.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. The manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

14.5.7 SIGNAL HOUSES ON RIGHT-OF-WAY

14.5.7.1 DESIGN CONSIDERATIONS

The signal houses on ROW lighting system should promote the safety, security, and comfort of the transit employees. Appropriate lighting will also provide a deterrent to crime. The lighting system should provide the lighting levels and types required by the function of each individual area as defined in this chapter.

Lighting equipment shall conform to the standards established in this manual and shall be UL wet listed. All conduit sizes shall conform to the applicable codes. The lighting system shall operate continuously, relying on automatic and manual controls to provide efficient energy use. Vandal-resistant fixtures and lenses should be used as required for their mounting locations.

Adequate lighting shall be provided in the facilities and associated areas per Table 14-1. Exterior lighting around the signal houses shall not interfere with or blind train operators or cause a nuisance to neighboring property.

14.5.7.2 LIGHTING CONTROL

Provide local switching for all employee, maintenance, equipment, and storage spaces. All other individual circuit switching shall be done at the panelboard. Provide timer/occupancy sensor to prohibit the situation of light fixtures remaining on while no occupancy is present.

14.5.7.3 CIRCUITS REQUIREMENTS

In any given area, fixtures shall be installed on alternate circuits such that upon failure of one circuit, lighting will still be present.

14.5.7.4 LED LIGHTING FIXTURE AND REQUIREMENTS

Fixtures will be non-corroding, vandal resistant and UL listed.

Outdoor fixtures shall be UL listed for use in wet locations.

Conduit layout and fixture mountings shall be designed to minimize trapping condensate water in the fixture.

The fixtures shall be rated for operations at -30 to 40 degrees C.

All fixtures shall use high quality commercial-grade LEDs and high efficiency commercial-grade constant voltage power supplies that meet the latest energy saving laws.

The LED boards and driver shall not be mounted directly to the fixture housing and shall be mounted with standard available hardware. All wire connections to the LED board shall be secured through heavy duty connectors capable of withstanding vibrations and movements during shipping, handling, and installation. The power supply shall be mounted on a removable tray and connected to the power through quick disconnects. Removable tray shall be connected using fasteners that require no tools to remove LEDs in the fixture shall be installed at the nominal length as required to fill the luminous opening of the fixture completely and uniformly

All lighting fixtures mounted to the exterior of the signal houses near the train tracks shall be designed to minimize glare in the direction of approaching train engineer's eyes.

LED light source installed indoors shall have a color temperature of 3,000K and LED light installed outdoors source shall have a color temperature of 4,000K.

14.5.7.4.1 WARRANTY

The LED fixtures shall be warranted by the manufacturer for a period of ten years against defects in materials and workmanship that result in a fixture lumen depreciation of 30 percent or greater. The maximum allowed lumen depreciation annually is three percent.

The power supply shall be long-life (100,000 hours) and carry a ten-year warranty. Manufacturer shall be a full line power supply manufacturer with a five-year history of producing power supplies for the North American market.

15. SHOPS AND YARDS

15.1 OVERVIEW

This chapter presents design for rail transit maintenance facilities for Metra and applies to both sites and buildings. Rail yards store trains and rail equipment when not in use, provide a storage area for system maintenance, and support shops.

The criteria in this chapter document Metra's preferences for a newly built yard or shop, though they apply to all shop and yard projects, including new build, renovation, and retrofit. Metra recognizes that, in the case of renovation and retrofit projects, it is possible that not all criteria will be met given the restrictions of the existing space. The designer shall, at the beginning of the design process, work with Metra to understand Metra's needs for the project and to identify what changes to the existing facility are required to accommodate these needs. During preliminary design the facility design team must become familiar with the unique needs of the maintenance operation proposed and use these design criteria where applicable.

Each design shall have a project-specific Basis of Design (BOD) report to explain the assumptions made and detail input received from Metra and other sources. Any deviations made from these design criteria must be documented and discussed with the Metra PM as early as possible in the design process.

This document does not present specific space requirements for a facility. Careful consideration must be given to the activities that will be performed at the facility and how these activities fit into the overall capacity of Metra's facilities and to the system-wide fleet maintenance plan. Programmatic spaces required in buildings and within yard sites, as well as major equipment, can possibly be shared with another Metra facility, providing opportunities for cost savings.

Yards and shops for train operations are complex facilities that interact with or connect to nearly every other aspect of the transit system. Accordingly, this section has design criteria addressing multiple design disciplines, and references related to sections in this manual.

Any deviations from the design criteria must be documented and approved through the design variance process (Section 2.3.7). In the event of any conflict between the design criteria, standard specifications, standard drawings, or codes listed below, the most stringent requirements shall be met.

15.2 STANDARDS, CODES, AND REGULATIONS

All applicable codes, standards, references, and guidelines shall govern the design of yards and shops. The design consultant shall confirm applicable codes from the Authority Having Jurisdiction (AHJ) prior to commencing work.

The following standards and codes shall be used as supplemented, amended, or otherwise modified by the building, fire, and related codes of the AHJ. Applicable codes include but are not limited to:

Code, Standard, Reference, or Guideline
State, county, and City code as applicable for the local jurisdiction
Department of State Police, Fire Prevention Commission, COMAR 29.06.01, State Fire Prevention Code
International Codes Council, International Building Code (ICC/IBC)
International Mechanical Code
Institute of Electrical and Electronics Engineers, IEEE C2, National Electric Safety Code
International Energy Conservation Code
International Plumbing Code
National Fire Protection Association
• NFPA 1, Fire Code • NFPA 10, Standard for Portable Fire Extinguishers • NFPA 13, Standard for the Installation of Sprinkler Systems • NFPA 54, National Fuel Gas Code • NFPA 72, National Fire Alarm and Signaling Code • NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems • NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids • NFPA 101, Life Safety Code • NFPA 256, Standard Methods of Fire Tests of Roof Coverings • NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems

Code, Standard, Reference, or Guideline
Plumbing-Heating-Cooling Contractors Association
Occupational Safety & Health Administration Standards
Metra Fleet Maintenance Plan

15.3 SUSTAINABLE DESIGN GOAL

Maintenance and storage facilities shall incorporate proven sustainable materials, methods, and technologies into their design to increase life-cycle value, reduce energy and resource use, and enhance the health and comfort of employees. Shop buildings shall be designed to meet any additional sustainability goals as specified by Metra for the individual project.

Sustainable design requirements of the AHJs at the site location shall be met. These may be state, city, and/or county regulations/requirements.

Potential sustainable design considerations should be evaluated for life-cycle cost and return on investment (ROI). Key stakeholders should collaborate to develop the sustainability vision and the list of sustainable features for the yard and shop.

15.4 KEY STAKEHOLDERS

The following key stakeholders shall be consulted early in the project lifecycle and throughout the design process:

- Facility users, including representatives from maintenance, inspection, and yard operations
- Metra Materials Control Department
- Metra Transportation Department
- Metra Engineering Department
- Metra Safety and Environmental Department
- Metra Police
- Local emergency response personnel

15.5 DESIGN RATIONALE AND FUNCTIONAL REQUIREMENTS

15.5.1 MAINTENANCE PHILOSOPHY

The design rationale for storage and maintenance facilities is based on the operations and maintenance approach defined herein. The typical facility may accommodate storage, servicing, and maintenance of all, or a portion of all revenue service trains, with provisions for spare trains. Maintenance tasks are tracked through a management information system, which maintains records of work performed on each train.

Performing regular maintenance is critical for meeting Metra's service requirements. Broadly speaking, maintenance operations are separated into routine maintenance and major repair operations.

The designer shall work with Metra to document the assumptions made on how levels of maintenance shall be performed, if any will be outsourced to a vendor, and the frequency of these maintenance activities during the life of the vehicles in the fleet.

15.5.2 MAINTENANCE CYCLE

Conventional maintenance philosophy defines several levels of maintenance activities. These include:

- Unscheduled activities
- Major (or heavy) repairs, such as after an accident/incident
- Corrective maintenance, such as after a breakdown
- Scheduled activities
- Daily servicing
- Preventive (or routine) maintenance
- Routine scheduled inspection, such as required by federal regulation
- Overhauls (cars, locomotives, and EMUs)

These activities are described in greater detail in Section 15.6. The diverse nature of equipment and manpower requirements for various levels of maintenance make it desirable to separate the shop facilities at which these operations are performed. Routine maintenance work will frequently be performed at Service and Inspection Shops, referred to hereafter as S&I Shops, and heavy or specialized maintenance work will be performed at a Major Repair Shop.

Table 15-1 compares work items and equipment to illustrate some of the differences in the maintenance activities of the two types of shops:

Table 15-1. General Differences between Service and Inspection Shops and Major Repair Shops

Service And Inspection Shop	Major Repair Shop
Cars and locomotives are handled as single units	Cars and locomotives are handled as single units
Unit parts and components are replaced	Unit parts and components are rebuilt or repaired
Running repairs are made when major disassembly of parts is not involved (Truck work may be an exception to this item)	Major repairs are made when disassembly of unit pairs or major components are involved
Portable hand tools are primarily used with few machine tools	Extensive use is made of machine tools
Majority of work is on-car requiring relatively small work support areas	Work is both on-car and on major components requiring a relatively large support area
Complete cars are rapidly cycled	Components are methodically routed through rebuilding process
Lubricants are replenished during servicing procedure	Lubricants are completely replaced during rebuilding procedure

15.5.3 YARD OPERATIONS AND PROCESS FLOW

Due to the need to coordinate the functions of so many areas, the process flows for each yard and/or shop shall be reviewed and documented.

Most Metra trains return to their main yard during the day between rush hours, mostly during first shift with some second shift. Most maintenance work in shops is completed during this time. Shops mostly do not have a third shift. Lighter interior cleaning and daily inspections are conducted at outlying layover yards. This work may occur during third shift.

Common functions for the storage yard include train storage, access to and from maintenance shops, maneuvers on lead tracks for making/breaking consists, inspections, train interior cleaning, exterior train washing, train dispatching, and maintenance-of-way (MOW) functions.

When a train returns to the yard at the end of a revenue trip, it shall be able to proceed through the train washer (if present at the yard) and then to a storage track. This movement should be performed without any reverse moves and with minimal operating of track switches.

While on the storage tracks, train interior cleaning will be performed. A service aisle shall be provided between alternating tracks to facilitate efficient and safe cleaning. The service aisles and the crossover aisles shall be asphalt paved and conveniently interconnected with the yard roadways. The service aisles shall have a continuous five-foot width to allow movement of workers' service carts. The crossover aisles shall be located at the ends of stub-ended tracks, and at the opposite end of the normal parking area for a consist. A minimum of 15 feet shall be provided between crossover aisles and ends of the train, to conform with Metra's requirements for safe crossing of tracks.

When a train requires inspection or repair, it should be moved into the shop from a storage track with as few reverse moves as possible, and it should be returned to the storage tracks once inspection or repair is complete. Typically, ladder tracks provide the most efficient access between the storage tracks and the maintenance facility shop tracks. When a train is ready to be put into service, it should be moved directly from the storage tracks into mainline service.

As a general rule, the yard track configuration should facilitate train movements between the designated storage tracks, train washer, and maintenance shop with minimal switching moves and without blocking the movement of other trains. A train should be able to bypass the train washer if it does not require washing on a particular day. If possible, a loop should be provided in the yard. A run-around track that bypasses the storage tracks and the maintenance shop should be part of the loop track. The loop track should eliminate reverse moves and provide the ability to turn cars and trains in the yard. This track can also be used for daily safety testing of vehicle propulsion and braking systems.

The diverse functions of a yard necessitate a yard layout that provides maximum flexibility in train movements. During design, consideration shall be given to critical times in the yard and ensuring that the yard can meet peak-hour service operations. In addition, the yard should be developed with contingency plans in mind, in case of a malfunctioning unit, derailment, or switch failure. This means that trains should be able to enter and exit the yard at more than one point. Primary and secondary access to the yard should be provided from at least one mainline track. Crossovers to any other mainline tracks should be provided in the direction of travel to allow yard access from any tracks. Within the yard, double-ended tracks are preferable to stub-ended.

Train movements on yard tracks are supervised by a yard controller. The yard controller coordinates with the Operations Control Center (OCC) but is a separate entity who maintains control over the train movements within the yard. Close coordination and communication between the OCC and yard control are essential. Train movements within the yard shall be executed by the train operator or maintenance hostler in coordination with and approval from yard control.

15.6 PROGRAM REQUIREMENTS

Facilities are typically sized to simultaneously service at least 10 percent of the locomotive fleet and five percent of the coach fleet. The program of operations in the yard and shop includes the following:

15.6.1 HOURS OF OPERATION

The facility shall be designed to allow for operations 24 hours per day, seven days per week, with the ability to secure the building at times when minimal staffing is present. Most work in Metra facilities is performed during first shift, with less work occurring during second shift and minimal work during third shift. However, the design shall still permit 24-hour operation.

15.6.2 PRE-TRIP INSPECTION AND INSERTING TRAINS INTO SERVICE

Each train is visually inspected and safety tested prior to dispatching into revenue service. Inspections are generally performed at outlying points prior to starting operation for the day.

Pre-trip testing is performed to verify that on-board operating and system control equipment is functioning properly. The pre-trip test is performed on a yard track with ample length to properly perform operations tests on the control and propulsion systems under operating conditions. A position on each yard lead shall be equipped to allow testing of all modes of the cab signal system. After completing the pre-trip inspection and receiving clearance from operations, the train may enter the mainline.

Each train receives a pre-trip safety inspection in the yard to ensure that the train is fit for revenue service. These visual and functional checks of the train interior and exterior focus on high-wear and safety-critical items such as wheels, doors, operating controls, and communication systems.

15.6.3 DAILY SERVICING

Daily servicing tasks include visual inspection of the running gear, lights, carbody, doors, and car interior; interior cleaning; exterior washing; brake system testing; and on-board signal/communications testing. For diesel-electric locomotives, refueling and checking/replenishing fluids is also required. Daily service tasks are completed on every car, each day that it is in service.

Locomotives are refueled at the main yard, and only emergency fueling is performed at outlying points.

15.6.4 PREVENTIVE (ROUTINE) MAINTENANCE

Preventive maintenance involves the detection and resolution of minor maintenance problems before the malfunction either necessitates major repair of the vehicle or causes a breakdown in service. Running repairs are also be included in routine maintenance. Routine maintenance functions are typically completed without specialized equipment and return the train to revenue service within a 24-hour period.

Preventive maintenance tasks are scheduled based on time or mileage intervals and include items such as detailed inspections, adjustments, enhanced interior cleaning, filter replacement, and other activities recommended by the train manufacturer as determined to be necessary by Metra. Metra preventive maintenance intervals are laid out in the Fleet Maintenance Plan.

Train inspections shall be performed on designated inspection tracks, which can also serve corrective maintenance functions. The shop layout shall provide for segregation of work functions into designated areas to minimize interference with other functions and time lost in material handling. Aisles shall be clear of fixed equipment to allow unburdened and safe movement of workers and materials. If the site permits, the layout shall provide maintenance tracks that are long enough to handle full-length trains without decoupling.

At a scheduled time, each vehicle undergoes a brake inspection as required by the Federal Railroad Administration (FRA) by positioning the vehicle over a pit. During this inspection, maintenance technicians perform visual and functional checks of the unit’s interior and exterior, focusing on high-wear and safety-critical items such as wheels, brakes, doors, operator controls, and communication systems. Maintenance technicians also correct those identified defects that can be rectified within the inspection period. Defects that cannot be repaired within the inspection period are repaired as part of an unscheduled repair (corrective maintenance) event.

The longer duration maintenance intervals build upon the content of the more-frequent inspection with additional work. The maintenance program is developed and updated by the vehicle maintenance department and shall inform facility design.

15.6.5 CORRECTIVE MAINTENANCE

Corrective maintenance includes vehicle component replacement/change-out, lubrication and adjustments, testing, and unscheduled repairs. Corrective maintenance tasks generally require less than one eight-hour shift to complete.

Wheel truing is a common corrective maintenance operation. Most facilities choose to have their own wheel truing machine to remove flat spots on vehicle wheels and to restore wheel flanges and rims to the correct wheel profile. It is desirable to have lead track that is as long as the longest consist serving both sides of the wheel truing machine. The designer shall determine through conversation with Metra the length of the longest consist to be served by the yard.

15.6.6 HEAVY REPAIR

Major or heavy repairs include the replacement of major components, car body repair, complete overhaul, and other work that is time consuming and requires the use of special machinery and heavy lifting equipment. Major repairs generally require more than 24 hours to perform and will include major component replacement or repairs such as truck changeout or HVAC repair. Wreck repairs and overhauls are significant major repair activities that can require the vehicle to be out of service for extended periods.

Heavy repair tasks include major repairs and overhauls and heavy component change-outs requiring more than one shift or requiring the use of specialized maintenance equipment such as vehicle hoists, drop tables, or cranes to complete. Replacing undercar components, refurbishing interiors, and lubricating pivot bearings are examples of heavy repairs.

Repairs to accident damage are another form of heavy repair. The amount of body repair work performed in a yard will depend on the accident rate and severity of collisions encountered by the fleet. Minor damage can be repaired by mechanics and this work can be performed on most shop tracks. Major body repairs may be performed on a shop track dedicated to major repairs.

Currently, Metra performs painting for the Metra Electric District at KYD Yard. Other facility designs typically will not include a vehicle paint shop, but if a paint shop exists, it should be located on a track adjacent to the designated major repair area. Painting and body preparation and sanding work shall not be performed in the same workspaces.

Overhauls are considered heavy repairs. Most modern maintenance facilities are used to perform a combination of levels of maintenance and not all of them will perform overhauls. Should the fleet maintenance plan include provisions for performing heavy repairs, the layout and shop equipment shall be enhanced accordingly. For example, tractor trailer access to the maintenance facility shall be required.

15.6.7 SERVICING PLAN

Vehicle servicing is performed daily and includes interior and exterior cleaning, some minor maintenance, fluid checks, and visual inspection. Depending on the size and configuration of the yard, the entire train may go to the servicing track or just the locomotive(s). Smooth operation of the servicing facilities is one of the most important functions of the maintenance facility because it has a direct impact on time and schedules. Service tracks should, therefore, be flexible enough to handle all vehicle types anticipated in the future.

Preferably, servicing and maintenance areas should all be housed within the same building. Alternatively, exterior washing lanes may be completely segregated from other service lane activities. Serious consideration should be given to which of these variations is appropriate, depending upon wind and weather conditions, specific site configuration, and the operational requirements of the individual facility. The number of service lanes required is determined by a combination of the total number of vehicles serviced by the facility and the amount of time allocated to each activity. An industrial engineering analysis shall be performed to determine the potential throughput of the facility.

Vehicle washing is typically performed as the train enters/exits the site or as the train moves through the washer from the maintenance facility or storage yard.

Interior cleaning is usually completed while the vehicle is parked on a storage track.

Train interiors are cleaned daily. This activity involves removal and disposal of trash from operator cabs, replacing trash liners, sweeping operator cabs and cleaning interior mirrors, removal and disposal of trash from passenger areas, wiping seats front to back, and reporting loose seat cushions, wiping handrails and stanchions, cleaning floors to remove soil and stains, and removing graffiti. Windows will be washed on an as-needed bases. This activity is performed on the yard storage tracks.

15.6.8 HEAVY INTERIOR CLEANING

In addition to the daily interior cleaning, train vestibules are cleaned more thoroughly every six months. This cleaning is performed in main yards at water shanties provided for this use. Cars are all entered from ground level. Cars receive a heavier cleaning every four to five years. Refer to the Fleet Maintenance Plan for specific intervals.

15.6.9 TRAIN WASHING

Train washing is performed when temperatures are above 40 degrees F. Metra generally washes each train a minimum of one time per week during warmer months. This is performed at main yards. For the purpose of train washing, a facility shall be provided off the lead into the yard.

15.6.10 COMPONENT REPAIR SHOPS

The main train components that require periodic maintenance are the trucks, wheelsets, traction motors, couplers, and A/C units. Due to the size and weight of these components, hoists, cranes, or other lifting devices are needed, and a substantial portion of the workshop area is required for both repair and storage.

15.6.11 OUTSOURCING PLAN

Metra can choose to outsource all, some, or none of its maintenance work. Its current outsourcing approach is documented in the Fleet Plan. During programming, the designer needs to determine the impact of outsourcing on the space program and equipment needs.

Metra brings vendors onsite periodically to perform certain activities, such as abatement. Additionally, for equipment that is operated on BNSF and UP, those railroads perform routine maintenance.

15.7 FUNCTIONAL AREA REQUIREMENTS

15.7.1 YARDS

Yards shall satisfy two basic functions: storage of trains for operations, and support of the Service and Inspection Shops. The basic concepts of design for train storage facilities are to:

- Minimize reverse movements and non-revenue car mileage
- Optimize introduction and removal of trains from revenue service
- Facilitate changes in train consists during different operating periods

In the design of a yard layout, consideration shall be given to the maintenance facilities and equipment required in each yard and to the operation of each yard as it fits into the operating program of its division.

15.7.1.1 TRACTION POWER FOR YARD TRACKS

On facilities for electric lines all storage tracks, pre-trip inspection yards, service and inspection yards, wash tracks, transfer tracks, on-line emergency storage tracks, and any other track long enough to hold a revenue train shall have an overhead contact system (OCS). The OCS serves as hotel power for the trains as they layover. The traction power for each track shall be individually controlled by the yard control office/tower. See Chapter 11, Traction Power and Chapter 12, Overhead Contact System (OCS).

15.7.1.2 STORAGE YARDS

The length of storage tracks shall be designed in multiples of four car modules with the desirable minimum length equal to the length of a typical revenue consist. This applies to both double-ended storage tracks and stub-ended tracks.

A facility shall be provided for supervisory and yard and train operating personnel. This facility shall have a reporting and dispatching area and locker space and be of sufficient size.

The transfer track shall have direct access to the mainline and shall be segregated from but have direct access to the storage tracks. To simplify interface with train control systems, the special trackwork involving both yard and central control should be minimized.

For stub-ended storage tracks, a minimum two-foot buffer must be provided between the coupler of the rail car and the front face of the bumper.

The storage tracks shall be constructed at alternating track centers of 14 feet minimum and 18 feet to permit access to cars by personnel and equipment. For yards on electric lines, each storage track's OCS shall have the capability of being independently electrically isolated.

15.7.1.3 PRE-TRIP SAFETY INSPECTION AREA

Each train receives a pre-trip safety inspection in the yard to ensure that the train is fit for revenue service. These activities require adequate yard lighting with light fixtures positioned to illuminate the area between trains and, to the extent possible, the running gear under the car body. Walking surfaces shall be paved in the wider spaced track areas and provide the ability to walk completely around the train.

These inspections are performed while the train is parked on track. No pit is provided and inspections are performed from ground level (or from a low platform, TOR+8”).

15.7.1.4 DAILY INTERIOR CLEANING AREA

Train interior cleaning is performed on the yard storage tracks at hot water shanties provided for this purpose. If cleaning is required at outlying points, hot water is provided at the welfare building, no shanty is provided.

Paved access to train interiors shall be provided between every other storage track to accommodate cleaning carts. Spacing shall also allow for lighting and OCS poles. The stipulated 18 feet of track spacing allows for a space of 7’-10” between car sides. A paved access path six feet wide shall be provided in this space with some spacing for light poles or other utilities. The design shall accommodate the width of utility carts used by Metra at the facility.

The cleaning platform(s) shall have hot and cold water and service sinks for the interior cleaning crews. The sinks should be located on a platform that is at the height of the car floor. The cleaning platform should be at a location in the yard where trains may easily access it from the other storage tracks.

15.7.1.5 TRAIN WASH

An automatic, single-direction, drive-through train washer shall be provided with air strippers and a water reclamation system. The wash system shall be located to allow trains to pass through it without a reversing move to/from the storage tracks or yard lead. The washer shall be designed to permit a train or consist to travel through the washer without engaging the wash mechanism on days when washing is not scheduled.

Wash facilities shall have the capability to wash all surfaces of the train. Wash equipment shall provide focused cleaning of both the front and rear of the train and shall be strong enough to ensure brake dust on the undercarriage is removed. See Section 15.8.1 for functional requirements of the train washer.

Train washing should be located on a dedicated wash track adjacent to a yard lead track so that trains can be washed either as they enter or exit the yard.

15.7.1.6 SERVICE AND INSPECTION YARDS

A service and inspection yard shall be made up of a service and inspection (S&I) shop and a storage facility. The S&I yard requirements are similar to those of the storage yard except that the building enclosing the exterior train washing facility and inspection pit may be combined in the S&I shop or kept separate. Equipment rooms for the Yard Control Building may be consolidated with similar S&I shop facilities.

Some additional requirements for an S&I yard are as follows:

- Direct access to the S&I shop from the transfer tracks shall be provided so that trains can be moved directly into the shop for exterior washing, inspections and running repairs.
- The shop exit tracks shall have access to storage tracks and to transfer tracks without interfering with normal shop operations. This will ensure an efficient flow of cars out of the S&I shop.
- A bypass track shall be provided to facilitate easy access to either end of the S&I shop and to minimize interference between yard operation and shop operation.
- Entrance to the S&I shop from the storage yard shall be designed with a minimum of necessary reverse train movements.

Refer to Chapter 4, Track Geometry for additional track design criteria

15.7.2 MAINTENANCE FACILITIES

15.7.2.1 SHOP TRACKS

Shop tracks consist of track constructed within the limits of the maintenance shop building and adjacent shop aprons. Three types of track shall be used in the shops depending on the functions performed on that track:

- Pit and/or pedestal track
- Direct-fixation track

- Embedded track

Track through the shop shall consist of track embedded in concrete slab or mounted on steel pedestals. Track in the train washer shall be direct-fixation with bases mounted on plinths on a sloped floor beneath the rail base, allowing water to flow to drains. Direct-fixation and embedded track in the shop and train washer track shall be designed in accordance with accepted dynamic impact track analysis practices applicable to the specific direct-fixation fastener system.

Embedded track shall be designed per the requirements of Chapter 4, Track Geometry.

Shop tracks through pit areas shall use new 136 RE welded rail. The rail shall be supported by and bolted to individual steel posts. Running rail may span from pedestal to pedestal without a supporting beam. Spacing shall be determined by structural calculations that will address the support of the wheel loads from the heaviest vehicle, including MOW vehicles and locomotives, without the need for a horizontal support beam. The design of the posts shall consider dynamic, thermal, or lateral forces that could be transferred to the rail during train movements or maintenance activities. The connection between different rail sizes must be in an embedded track area, a minimum of four feet from the pedestal track.

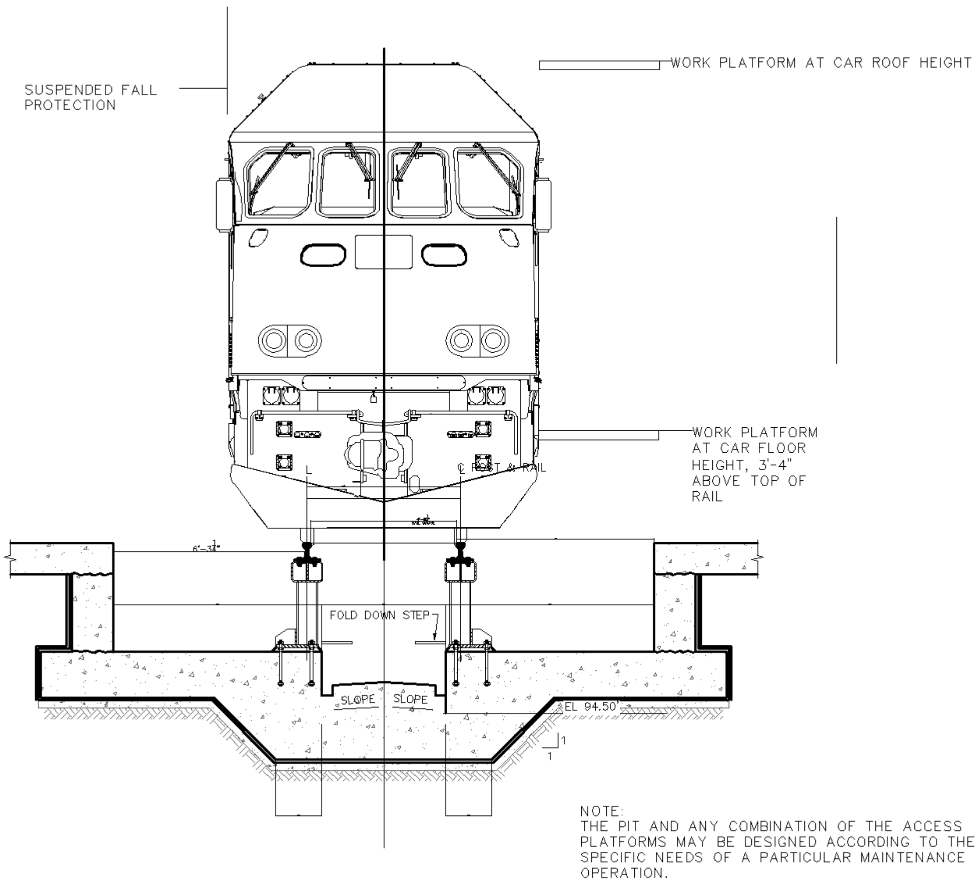
Alternative methods of support and fixation may be considered, subject to Metra written approval. Insulated joints with negative returns shall be used as required by electrified-operable segments in the shop.

15.7.2.2 PIT TRACK WITH PEDESTAL TRACKS AND PLATFORM

A pit track is a working track used for inspections. It shall be of sufficient length to service at least one consist. Within the pit track are multiple pit spots, which are work bays of sufficient size for a railcar or married pair. Pit tracks are preferable except in areas where a jacking system is required. The work bays used for corrective maintenance should be identical to inspection bays, providing operating flexibility within the shop. Each pit spot position bay shall be outfitted as follows:

- Provide a deep center pit between rails with two means of egress. The depth of the pit shall be five feet below top of rail unless the specific project requires a different depth (Figure 15-1.) Provide depressed floors outside rails for easy access to sides of trucks, depth to be three feet below top of rail, unless the specific project requires a different depth.

Figure 15-4. Center Pit Configuration



- Steps to pits shall be non-combustible and constructed with no free space underneath. Steps shall reach the bottom of the pit with a minimum of three feet of clear space before the vehicle coupler.

- Roof level platforms shall be provided and shall have appropriate fall prevention. Platforms shall be level with the roof of the vehicle and shall be provided with gates to provide an area on the top of the vehicle that is surrounded on all four sides. The support structure of the platforms shall not reduce usable height underneath the platform for entering the car's interior.

- Provide a platform on one side of the track at station platform height for entrance to the interior of the coaches.

- Provide a crane or monorail above each vehicle repair position of sufficient capacity and coverage for loads to be conveyed and to facilitate removal and replacement of rooftop components located anywhere on the vehicle roof. Monorail design shall reflect actual weights of fleet rooftop components. Hoists shall be radio controlled. As each vehicle type differs in minor ways, the designer shall determine the correct capacity. Heavy repair areas for locomotives will require a higher capacity crane, 30 tons or more, for removal of engines, head end power units or generators.

- For yards serving electric lines, provide 750 volts of direct current (VDC) (design team to confirm) auxiliary power reel or receptacle aligned with the position of the plug on the cars. The auxiliary power reel shall be interlocked with handrails and gates on the roof-level maintenance platforms to prevent technicians from accessing the vehicle roof while the power is activated.

- Provide welding receptacles at shop floor level, one on each side of each pit spot.

- Provide 110 voltage in alternating current (VAC) 20A receptacles and compressed air outlets at pit, shop floor level, and both platform levels. Provide compressed air and electric outlets at pit level, additional receptacles and outlets at truck locations, and air and electric outlets at all platform levels, on both sides of each car.

- Provide hot- and cold-water outlets on the car floor level platforms, one for each coach or locomotive position (one hot and one cold on each side). Provide a portable vacuum system for cleaning roof level electronic cabinets.

- Reels for gear oil, grease, engine oil, coolant, and diesel exhaust fluid (DEF) shall be provided at each preventive maintenance and corrective maintenance repair position. Provide gear oil, grease, and water reels at each train truck location in pit areas. Locate bulk lube storage tanks and drums in a central lube storage and dispensing room.

- Provide adequate floor drainage, including trench drains at the track centerlines, between rails, at rollup doors, and on the vehicle drip line on the field sides of the rails. Trench drains shall be wide enough to allow cleanout with an ordinary flat bladed shovel.

- Removable guardrails shall be provided along inspection and repair pits. Removable guardrails shall be constructed of fiberglass to reduce weight. Provide a designated area to place the guardrails when removed.
- Mobile waste oil collectors shall be provided at each car spot in pit areas.
- Provide a material lift with 4,000-pound capacity to access both pit floor level and elevated platforms from center aisle of shop. Provide ramps from shop floor level to side access depressed floor, if necessary, to perform required maintenance and component removal/replacement activities.
- Provide one data terminal at each vehicle repair spot.
- Pits shall be non-combustible, and equipment shall be made of non-combustible construction.
- Walls and floors shall be constructed of masonry or concrete.
- Walking surfaces shall be non-combustible materials, with non-skid surfaces.

15.7.2.3 BLOW PIT

If a blow pit is required, it shall be constructed to the same requirements as the pit track, with these exceptions:

- Concrete surfaces shall have a heavy broom finish
- Platforms at car-floor level or car-roof level shall be grating with a non-slip hot-dip galvanized finish
- Floors shall be sloped to the trench drains that run continuously at the vehicle drip line and in center of track
- Exhaust shall be at rate twice as high as the pit track
- Equip the blow pit with a high-pressure hot water washer with four remote discharge points

- Design lighting to illuminate the underside of the vehicle at 30 foot-candles (fc), and 50 fc on vehicle sides

15.7.2.4 HEAVY INTERIOR CLEANING SPOT

If a separate heavy interior cleaning spot is in the program, it shall be equipped the same as a pit spot but without the roof access platform. Other specific requirements for this work area are:

- Provide hot and cold-water outlets in a janitorial room, a service sink, and adequate storage space for cleaning equipment and supplies
- Provide mop racks and a chemical dispensing system
- Shelving shall be constructed of non-corrosive material
- Provide a portable wet vacuuming system or similar method for washing vehicle floors, walls, and seats.
- Movable stairs or a floor-level platform shall be provided for ease of entry to the car interior with cleaning equipment

15.7.2.5 DROP TABLES AND CRANES (MAJOR REPAIRS AND DE-TRUCKING)

Tasks to be performed at repair positions outfitted with drop tables and/or cranes include change-outs of complete truck assemblies, drive units, and other undercar or side-mounted components.

Full truck drop tables, with the option for a single axle drop, are preferred.

At each repair position, provide one welding receptacle and three compressed air, three electric, and one water outlet(s) on each side of the car, adjacent to maintenance locations. Provide one compressed air outlet for brake testing.

Provide an overhead bridge crane, of sufficient capacity and coverage for loads to be conveyed, to service the release area and facilitate truck handling in the shop. The designer shall determine the correct capacity for the crane.

Provide adequate floor drainage in this area.

Provide a data terminal at each train work spot.

15.7.2.6 ROOF ACCESS POSITION/FLAT TRACK (ROOF LEVEL MAJOR REPAIRS AND COMPONENT CHANGE-OUTS)

Permanent roof access platforms may also be built at flat track areas. The criteria for the roof access platforms shall be the same as those described for the pit spot, including provision of an appropriate fall protection system. The designer shall discuss the need for permanent roof access platforms with Metra.

15.7.2.7 BODY REPAIR POSITIONS

Body repair and painting work as a result of vehicle accidents and overhaul/refurbishment campaigns shall be performed at selected site maintenance repair positions. Body repair and painting shall not be performed at the same location within the maintenance shop. The body repair position shall support minor accident repairs, replacement of pre-painted or colored plastic/fiberglass components, door and window replacements, seat change-outs, and similar type work. Portable respirators are used when sanding, grinding, or welding operations are performed in this area. Body repair positions shall be designed with the following features and equipment:

- Provide means for moving cars to/from the work bays.
- Provide welding receptacles and convenience compressed air, water, and electric services along both sides of the bay at each truck location.
- Provide a centralized dust collection system designed to capture dust generated by hand tools at the point of use.
- The floor slab shall be of sufficient strength and thickness to support portable car hoists.
- The floor slab shall accommodate cored anchor pots in the slab to be used for vehicle frame straightening and body repair. An anchor pot may have up to 10 kips of force while straightening equipment is used; the designer shall confirm requirements with Metra and the car builder.
- Provide 480 VAC receptacles for portable car hoist system. Receptacle rating shall be confirmed during detailed design.
- Provide one data terminal at each train work spot.

15.7.2.8 VEHICLE BODY PREP AND PAINTING

Vehicle painting, including masking and other clean activities, shall be performed inside a prefabricated spray paint booth. The paint bay shall include a spray paint booth with downdraft dry filter-type exhaust, equipped with self-contained air handling units (AHUs) and a heated curing cycle to expedite the paint-drying process. The complete booth assembly shall be designed to comply with applicable codes. Clear working dimensions inside the booth shall be designed to accommodate the largest vehicle (or married pair, if appropriate) to be painted, plus 10 feet on each end. A separate paint mixing room shall be provided. The width shall be sufficient to accommodate the vehicle and personnel lifts (one on each side of the car).

Painting and cleaning locations and locations where flammable or combustible materials are stored or used shall meet the requirements of NFPA and applicable local regulations.

Pneumatic personnel lifts shall be provided in the booth to access surfaces for painting. A breathing air system shall be provided for the booth. The breathing air system shall be sized for two operators.

The segment of track inside the paint booth shall not be electrified.

15.7.2.9 WHEEL TRUING

The shop shall be equipped with a two-car position wheel-truing bay designed to support on-car wheel truing operations. The lead track to this facility shall accommodate a typical consist without fouling a switch.

The entire axle shall be trued by use of an in-ground wheel truing machine with a milling cutter. The make and model of the wheel truing machine shall be approved by Metra early in design.

15.7.2.10 RUBBER-TIRED VEHICLE BAYS

Maintenance bays may be required for rubber-tired MOW vehicles, including pickup trucks, vans, SUVs, dump trucks, and hi-rail trucks.

The bays should be sized for the largest rubber-tired vehicle to be serviced and shall have a minimum clear height of 20 feet.

Rubber-tired vehicle bay appurtenances may include:

- Fixed or portable-type vehicle lifts with capacity to handle MOW fleet vehicles

- Convenience electrical and welding outlets, compressed air outlets, and data outlets

- Hose reels for dispensing lubricants and coolants (if a central distribution system is provided)

The designer shall work with Metra to determine appropriate appurtenances to include in rubber-tired vehicle bays.

15.7.3 SUPPORT SHOPS

Two main principles are important for the satisfactory flow of heavy repair parts. Parts must either be selected and then stored at the point of installation, or they must be safely transported to the point of installation without excessive effort. The work, especially on trucks and wheelsets, should be carried out following a U-flow principle where units are received, move into storage, and then transported out on the same side of the storage area through which they entered. This flow helps to economize the workshop area, keeps transportation distances short, and centralizes supervision, thereby reducing the use of personnel and materials. HVAC shop, propulsion, and other roof-mounted component repair shops may be located on an upper floor or mezzanine with crane coverage or other material handling equipment to facilitate easy movement of components between the train roof and the repair shops. Batteries and propulsion boxes are often roof-mounted and should also be maintained off the car in a mezzanine work area.

15.7.3.1 TRUCK SHOP

The truck shop shall include a dedicated area and equipment for the disassembly and rebuild of trucks. Work activities include truck overhaul/repair, system component removal/rebuild/repair, and repair/installation of cabling. Given the heavy weight of the trucks and components, overhead crane coverage is essential. Requirements for truck shop areas are as follows:

- Adjacencies: The truck shop shall be near the maintenance bays, immediately adjacent to the de-trucking area, and accessible by embedded release tracks. The shop should be near the truck wash/cleaning bay and wheel shop, and accessible to the storeroom.

- Shop configuration/finishes:

- Clear height under crane hook: 16 feet minimum
- Floor: Troweled concrete with integral hardener and sealer
- Walls: Concrete masonry unit, precast concrete panel (if exterior wall), or other durable material with epoxy paint finish
- Ceilings: Exposed to structure
- Utilities:
    - Electrical
    - 480 VAC, three phase
    - 120 VAC, one phase
    - Other as required by equipment
- Compressed air
- Lighting:
    - General area lighting: See Lighting Criteria in Section 15.11.6.5
    - Task at workstations: See Lighting Criteria in Section 15.11.6.5
- Data
- Phone
- Non-potable water
- Floor drain to industrial drainage and oil/water separator
- Conditioning: Heated and ventilated
- Major equipment:
    - Cranes (bridge and jib)
    - Truck hoists
- Truck cleaning area
- Truck painting area (a small paint booth of sufficient size to paint one truck at a time)

- Truck turntable (may be located outside shop depending on shop configuration related to track work)
- Tramming station to check alignment of the truck frame, apply a force to simulate the rail vehicle weight, and spinning posts
- Welding station with provision for pre- and post-heat weld treatment for castings
- Other
- Embedded rail for movement of trucks to/from shop

15.7.3.2 WHEEL SHOP

The wheel shop shall be configured to support equipment for wheel repair, including mounting and demounting wheelsets, reconditioning gearboxes, and refurbishing wheels and axles. Requirements for the wheel shop are as follows:

- Adjacencies: The wheel shop shall be adjacent to the truck shop and accessible to an indoor, temperature-controlled storeroom.
- Shop configuration/finishes:
  - Clear height under crane hook: 16 feet minimum
  - Floor: Troweled concrete with integral hardener and sealer
  - Walls: Concrete masonry unit, precast concrete panel (if exterior wall), or other durable material with epoxy paint finish
  - Ceilings: Exposed to structure
- Utilities:
  - Electrical
  - 480 VAC, three phase
  - 120 VAC, one phase
  - Other as required by equipment
  - Compressed air

  - Lighting
  - General area lighting: See Lighting Criteria in Section 15.11.6.5
  - Task at workstations: See Lighting Criteria in Section 15.11.6.5
  - Data
  - Phone
  - Non-potable water
  - Floor drain to industrial drainage and oil/water separator
- Conditioning: Heated and ventilated
- Major equipment (more than one of each may be required):
  - Cranes (bridge and jib) and monorail
  - Axle lathe
  - Axle cleaning station
  - Wheel boring machine
  - Wheel mount and demount press
  - Gearbox workstation (mounts on a fake quill and spins the gear box with the high-speed coupling to check operation)
  - Magnetic particle inspection station for axles
  - Storage systems for wheels, wheelsets, axles, gearboxes

15.7.3.3 WASH/CLEANING

The wash/cleaning area shall be an enclosed area for cleaning trucks and other large components.

- Adjacencies: Wash/cleaning shall be accessible by service/release tracks and should be adjacent to the truck shop.
- Room configuration/finishes:
  - Clear height: 14 feet minimum

- Floor: Sealed, rough (broom finish) concrete
- Walls: Concrete masonry unit with epoxy paint or glazed concrete masonry unit (CMU); paint or glazing shall be appropriate for the environment
- Ceilings: Exposed to structure, coated with epoxy paint

- Utilities:
  - Electrical: Waterproof as required to support equipment (National Electrical Manufacturer Association (NEMA) 4X)
  - Compressed air
  - Non-potable water
  - Emergency eye wash and shower
  - Floor drain to industrial drainage and oil/water separator
  - Lighting: General, waterproof (see Lighting Criteria in Section 15.11.6.5)
  - Conditioning: Heated and ventilated, exhaust stacks for cleaning equipment
- Major equipment:
  - High pressure/hot water washers and/or dry ice blaster
  - Clean tanks
  - Dip tanks

15.7.3.4 HVAC SHOP

The HVAC shop shall be configured with bench and open areas to support reconditioning and repair of AC units. The designer will work with Metra to determine the specific needs of the shop based on the equipment that will be serviced there. For example, some Metra locomotives have an underbody HVAC with a different power supply requirement.

- Adjacencies: The HVAC shop shall permit convenient movement between the train roof and/or underbody and the shop with the use of material handling equipment, have direct access to maintenance bays, and be accessible to the storeroom.

- Shop configuration/finishes:
    - Clear height under crane hook: 16 feet minimum to the mezzanine deck
    - Floor: Troweled concrete with integral hardener and sealer
    - Walls: Concrete unit masonry or other durable material with epoxy paint finish
    - Ceilings: Exposed to structure
- Utilities:
    - Electrical
    - 480 VAC, three phase
    - 120 VAC, one phase
    - Other as required by equipment
    - Compressed air
    - Lighting
    - General: See Lighting Criteria in Section 15.11.6.5
    - Task at workstations: See Lighting Criteria in Section 15.11.6.5
    - Data
- Phone
- Test room to allow an HVAC unit to be connected and test operation. Room must have ability to be heated to at least 85°F.
- Conditioning: Heated and ventilated
- Major equipment:
    - Cranes (bridge and jib) and/or monorail

- Diagnostics
- Work stand
- Test stand
- Refrigerant recovery
- Storage systems for major components
- Scale

15.7.3.5 BRAKE SHOP

The brake shop shall be configured to support the equipment and activities associated with the repair of braking systems. Various hydraulic and pneumatic components may be brought to this shop for diagnosis and repair.

- Adjacencies: Truck Shop
- Shop configuration/finishes:
    - Clear height: 14 feet minimum
    - Floor: Troweled concrete with integral hardener and sealer
    - Walls: Concrete masonry unit or other durable material with epoxy paint finish
    - Ceilings: Exposed to structure
- Utilities:
    - Electrical
    - 480 VAC, three phase
    - 120 VAC, one phase
    - Other as required by equipment
    - Compressed air suitable for brake testing
    - Lighting

- General: See Lighting Criteria in Section 15.11.6.5
- Task at workstations: See Lighting Criteria in Section 15.11.6.5
- Data
- Phone
- Conditioning: Heated and cooled

- Major equipment:
    - Workstations
    - Storage systems for component staging
    - Brake test racks (the designer will work with Metra to identify which test racks shall be included and requirements for each)
    - Climate controlled room for valve rebuilds
    - Separate cleaning and painting areas (to prevent contamination)
    - Keeping cleaning and painting separate to prevent contamination

15.7.3.6 GENERAL REPAIR

This shall be a dedicated area for general repair functions. The requirements for room configuration, utilities, and conditioning will also apply to a Common Work Area or Coupler Shop.

- Adjacencies: The general repair area shall be adjacent to the maintenance bays or located on the maintenance bay floor.
- Room configuration/finishes:
    - Clear height: 14 feet minimum
    - Floor: Troweled concrete with integral hardener and sealer
    - Walls: Concrete masonry unit or other durable material with epoxy paint finish
    - Ceilings: Exposed to structure

- Utilities:
  - Electric
  - 480 VAC, three phase
  - 120 VAC, one phase
  - Other as required by equipment
  - Compressed air
  - Emergency eye wash and shower
  - Lighting: General, see Lighting Criteria in Section 15.11.6.5
  - Floor drain to oil/water separator
- Conditioning: Heated and ventilated
- Equipment may include the following, to be selected jointly with representatives from Mechanical Department:
  - Drill presses
  - Hydraulic presses
  - Buffer/grinders
  - Band saw
  - Blast cabinet
  - Open-face paint booth
  - Parts cleaning
  - Workbenches/vises
  - Lifting equipment

15.7.3.7 UPHOLSTERY SHOP

This shall be a dedicated area for as-needed repair to train car upholstery. The requirements for room configuration, utilities, and conditioning are the same as for a general repair shop.

- Adjacencies: The upholstery shop shall be adjacent to the maintenance bays or located on the maintenance bay floor.
- Equipment will be identified by representatives from the Mechanical Department and may include:
    - Workbenches/vises
    - Lifting equipment

15.7.3.8 MACHINE AND SHEET METAL SHOP

A shop configured for the equipment and activities related to general machining and metal work shall be provided.

- Adjacencies: The machine and sheet metal shop shall be located near the welding/fabrication shop.
- Room configuration/finishes:
    - Clear height: 14 feet minimum
    - Floor: Troweled concrete with integral hardener and sealer
    - Walls: Concrete masonry unit or other durable material with epoxy paint finish
    - Ceilings: Exposed to structure
- Utilities:
    - Electric
    - 480 VAC, three phase
    - 120 VAC, one phase
    - Other as required by equipment
    - Compressed air
    - Non-potable water
    - Lighting
    - General: See Lighting Criteria in Section 15.11.6.5

    - Task at equipment: Normally equipment mounted
    - Data
    - Phone
    - Conditioning: Heated and ventilated
- Major equipment, to be selected jointly with representatives from Mechanical Department:
    - CNC-controlled water jet cutter
    - Workstation crane
    - Lathes
    - Milling machines
    - Drill presses
    - Hydraulic presses
    - Buffer/grinders
    - Metal brake
    - Metal shear
    - Iron worker

15.7.3.9 WELDING AND FABRICATION

A closed shop or workstation shall be provided for welding and fabrication.

- Adjacencies: The welding shop shall be located near the machine and sheet metal shop.
- Room configuration/finishes:
    - Clear height: 14 feet minimum
    - Forklift access and overhead crane, monorail, or jib crane coverage

  - Floor: Troweled concrete with integral hardener and sealer
  - Walls: Concrete masonry unit other durable material with epoxy paint finish
  - Ceilings: Exposed to structure
  - Sized for a 10-foot long welding table
- Utilities:
  - Electric
  - 480 VAC, three phase welding receptacles
  - 120 VAC, one phase
  - Other as required by equipment
  - Compressed air
  - Lighting
  - General: See Lighting Criteria in Section 15.11.6.5
  - Task at equipment: normally equipment-mounted
  - Welding exhaust ventilation: Hoods, point extraction units, or downdraft units
  - Non-potable water
  - Floor drain to industrial drainage and to oil/water separator
  - Conditioning: Heated and ventilated
- Major equipment, to be selected jointly with representatives from the Mechanical Department:
  - Welding platens
  - Fume extraction
  - Welders
  - Plasma Cutters

- Storage racks for sheet stock and bar stock

15.7.3.10 ELECTRONICS SHOP

If included in the scope of the project, a closed shop shall be provided for electronic bench repair.

- Room configuration/finishes:
    - Clear height: 12 feet minimum
    - Floor: VCT or similar with anti-static pads at workbenches
    - Walls: Concrete masonry unit or other durable material with epoxy paint finish
    - Ceilings: Acoustical ceiling tiles with integrated lighting
- Utilities:
    - Electric
    - 480 VAC, three phase
    - 120 VAC, one phase
    - Compressed air
    - Lighting:
    - General: See Lighting Criteria in Section 15.6.6.5
    - Task at workstations
    - Data
    - Phone
- Conditioning: Heated and cooled
- Major equipment:
    - Workstations
    - Test centers for communication, surveillance, and control equipment

- Bench test equipment (for electric lines, include propulsion test equipment for EMUs)
- Fume extractors for soldering

15.7.3.11 BATTERY ROOM

The needs and/or configuration of the battery room are dependent upon the train vehicles to be maintained and batteries used. General guidelines for battery rooms are as follows:

- Adjacencies: The battery room shall be located near the storeroom and the maintenance bays.
- Room configuration/finishes:
  - Clear height: 12 feet minimum
  - Floor: Troweled concrete, acid resistant with sealer
  - Walls: Concrete unit masonry or other durable material with epoxy paint finish
  - Ceilings: Exposed to structure
  - Storage racks to protect against battery damage and to provide convenient accessibility
  - Lifting device to lift and transport batteries, or adequate space for a forklift
- Utilities:
  - Electric
  - 480 VAC, three phase
  - 120 VAC, one phase
  - If batteries are not sealed, supply distilled water
  - Other as required by charging equipment
  - Electrical devices must be explosion-proof

  - Lighting: Explosion-proof (see Lighting Criteria in Section 15.11.6.5)
  - Conditioning: Ventilated and exhausted to the outside
  - Fire Protection: Thermal runaway fire protection is required for any Lithium based battery technology.
  - Other: Acid-neutralizing basin at drain
- Major equipment:
  - Battery bench
  - Charging station
  - Water deionizer
  - Emergency eye wash and shower

15.7.3.12 TOOL STORAGE

Storage of controlled-use tools and equipment shall be provided. Preferably, a vending machine type inventory solution for tool management will be used. Otherwise, a secure room shall be provided.

- Adjacencies: Tool storage shall be located near the storeroom, maintenance areas, and Maintenance Supervisor.
- Room configuration/finishes:
  - Clear height: 12 feet minimum
  - Floor: Troweled concrete
  - Walls: Chain link fencing with lockable gates or concrete masonry unit with epoxy paint
  - Ceilings: Exposed to structure
- Utilities:
  - Electric: 120 VAC, one phase
  - Lighting: General, see Lighting Criteria in Section 15.11.6.5

  - Conditioning: General shop ventilation

- Major equipment (as applicable):
  - Industrial tool vending/storage system
  - Storage cabinets
  - Storage shelving

15.7.3.13 TOOLBOX STORAGE

Areas for the storage of technicians' toolboxes shall be provided. Metra generally allows maintenance technicians to store their personal toolboxes near or in their assigned work areas in a designated space. The number of toolboxes that need to be accommodated in each area shall be verified by the designer.

- Adjacencies: Toolbox storage shall be provided at workstations as necessary.
- Room configuration/finishes:
  - As required for the workstation/space function; provide a handrail or other structural member that will allow the technicians to lock their toolboxes to it

15.7.3.14 HAZARDOUS MATERIAL STORAGE ROOM

A hazardous material storage room shall be provided for the controlled storage of new and waste materials considered hazardous by code or Metra standards. Storage rooms or buildings shall be designed in accordance with the IFC, Occupational Safety and Health Administration (OSHA) 29 CFR 1910 Subpart N, or applicable NFPA standard.

Flammable material cabinets may also be provided on the shop floor if necessary to accommodate storage of small amounts of flammable materials.

- Adjacencies: The hazardous material storage room shall be located near the lubrication room, the loading dock, and the paint bay. A separate prefabricated structure may also be used.
- Room configuration/finishes:

- Clear height: 12 feet minimum
- Floor
- Light broom finish with integral hardener and sealer
- Curbed to provide containment
- Walls: Concrete masonry unit or other durable material with epoxy paint finish
- Ceilings: Exposed to structure

- Utilities:
  - Lighting, explosion-proof (see Lighting Criteria in Section 15.11.6.5)
  - Fire suppression system appropriate for the types of materials that will be stored
  - Conditioning: Heated and ventilated, independent exhaust
- Major equipment:
  - Containment pallets
  - Flammable material cabinets

15.7.3.15 PORTABLE EQUIPMENT STORAGE

A dedicated area shall be provided to store portable shop equipment.

- Adjacencies: Portable equipment storage shall be located near the maintenance bays.
- Room configuration/finishes:
  - Clear height: Shop height
  - Floor: Troweled concrete
  - Walls: None (areas designated by paint stripe on floor)
  - Ceilings: Exposed to structure

- Utilities:
  - Electric: For charging equipment
  - Lighting: General, see Lighting Criteria in Section 15.11.6.5
  - Conditioning: General shop ventilation

15.7.3.16 STOREROOM

A storeroom shall be provided to perform various storage functions including shipping/receiving, warranty recovery, parts issuing, warehousing, and component storage. Within the storeroom, equipment and parts storage shall be secured, and issuance of parts shall be controlled through procedures.

- Adjacencies: The storeroom shall be centrally located to support shops and maintenance bays and shall have a shipping/receiving area with loading docks.
- Room configuration/finishes:
  - Clear height:
  - 24 feet minimum in high-bay areas
  - 12 feet minimum in low-bay areas
  - Floor: Troweled concrete
  - Walls: Concrete masonry unit with epoxy paint
  - Ceilings: Exposed to structure
  - Separate temperature-controlled area for sensitive materials
  - Forklift Access
- Utilities:
  - Electrical:
  - 120 VAC, one phase
  - As required for forklift charging stations

- Lighting: General, see Lighting Criteria in Section 15.11.6.5
- Data
- Phone
- Conditioning: Heated and ventilated. Temperature-controlled space shall be heated and cooled

- Major equipment:
  - Storage systems including high-density drawer cabinets, shelving, pallet racks, cantilever pallet racks, movable rack systems, pick bins, and vertical lift modules
  - Forklifts
  - Dock leveler(s), with seals, restraints, or dock lift

15.7.4 ANCILLARY AREAS

Ancillary spaces support administration, transportation, and maintenance. Requirements for these areas should be coordinated with, and reference, other chapters of this manual, particularly Chapter 14, Mechanical, Electrical, and Plumbing.

Additional ancillary areas that may be include in design include offices, open work areas, common rooms, storage rooms, operator ready/break room, restrooms, and a dispatch facility. The designer shall discuss the need for such areas and the functional area requirements with Metra during design.

15.7.4.1 EMERGENCY CONTROL CENTER (ECC)

An emergency control center, to be used for National Incident Management System (NIMS), shall be provided in accordance with the following.

- Finishes:
  - Floor: Raised floor system, with carpet, VCT, or equivalent
  - Walls: Gypsum board
  - Base: Rubber
  - Doors: Hollow metal with hollow metal frames, lockable

    - Ceilings: Acoustic tile
- Utilities:
    - Electric
    - 120 VAC, one phase
    - As required by equipment
    - Data including programs necessary for monitoring and controlling when in emergency situations
    - Phone
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Conditioning: Heated and cooled
- Furniture: Requirements to be set per local safety manager and input from local authorities

15.7.4.2 TRAINING ROOMS

A dedicated space to train operators shall be provided. If programmed, a space to train vehicle maintenance technicians may also be planned. Convenient access should be available to the maintenance shop for observations and hands-on training.

- Finishes:
    - Floor: VCT or equivalent
    - Walls: Gypsum board
    - Base: Rubber
    - Doors: Hollow metal with hollow metal frames, lockable
    - Ceilings: Acoustic ceiling tiles
- Utilities:
    - Electric: 120 VAC, one phase
    - Lighting: See Lighting Criteria in Section 15.11.6.5

- Phone
- Data
- Conditioning: Heated and cooled
- Furnishings/equipment:
    - Tables and chairs
    - Computer based training centers
    - White boards
    - Audio/Visual equipment

15.7.4.3 YARD CONTROL

A dedicated area for yard control operations shall be provided. Direct vision or closed-circuit television (CCTV) coverage of the entry and/or exit area of the yard shall be provided. If space permits, locate yard control space in the OCC area, if one exists, adjacent to dispatch.

- Finishes:
    - Floor: VCT with electrostatic pads at workstations
    - Walls: Gypsum board
    - Base: Rubber
    - Doors: Hollow metal with hollow metal frames, lockable
    - Ceilings: Acoustic ceiling tiles
- Utilities:
    - Electric
    - 120 VAC, one phase
    - UPS for all computer/video equipment
    - Lighting
    - See Lighting Criteria in Section 15.11.6.5

- Task lighting at workstations
- Phone
- Data
- CCTV for designated parts of the yard
- Conditioning: heated and cooled
- Furnishings/equipment:
- Control consoles
- Chairs
- White boards
- Video walls

15.7.4.4 QUIET ROOM

A quiet room may be provided for the use of employees for short rests. Locate such spaces in a portion of the facility that is accessible but somewhat isolated from the loudest shop operations.

- Finishes:
  - Floor: VCT
  - Walls: Gypsum board
  - Base: Rubber
  - Doors: Hollow metal with hollow metal frames, lockable
  - Ceilings: Acoustic ceiling tiles
  - Furniture should include upholstered chairs and/or recliners

15.7.5 FACILITIES MAINTENANCE DEPARTMENT

A shop for plant maintenance of the physical plant and material storage shall be provided.

Facilities maintenance department staff are responsible for the routine inspection, maintenance, and cleaning of structures and buildings, mechanical and electrical systems, shop equipment, signs, graphics, passenger stations, fencing, roadways, and parking lots.

Landscape and gardening work, major graffiti removal, major building equipment repair, and major electric motor rebuild may be subcontracted to vendors.

15.7.5.1 SHOP REQUIREMENTS

A vehicle bay may be required for facilities maintenance trucks and vans for station cleaners. The bay may be utilized by other departments when not being used by facilities maintenance personnel.

The bay shall be sized to accommodate the loading and unloading of the largest department vehicles and shall have a clear height of 16 feet minimum.

The vehicle bay shall include the following appurtenances:

- Drain to industrial drainage and oil/water separator
- Adjacencies: The facility maintenance shop can be isolated. It will require an overhead door on an exterior wall where trucks will back into an open area for loading materials.
- Room configuration/finishes:
    - Minimum clear height under hook: 16 feet
    - Floor: Troweled concrete
    - Walls: Concrete block or other durable material with epoxy paint finish
    - Ceilings: Exposed to structure
    - Forklift access
    - Overhead bridge crane, capacity to be determined by programming meetings with the using department
    - Provide storage for salt bags and snowplows. A dedicated area for the storage of standard snowplows shall also need to accommodate smaller snowplows that can plow between tracks.

- Utilities:
    - Electric
    - Electrical outlets, 120 VAC and 480 VAC
    - Welding outlets
    - Other as required by equipment
    - Compressed air for portable tools
    - Emergency eye wash and shower
    - Lighting: General, see Lighting Criteria in Section 15.11.6.5
    - Data
    - Phone
    - Conditioning: Heated and ventilated
- Major equipment:
    - Drill presses
    - Buffer/grinders
    - Band saw
    - Portable dust collection
    - Storage shelving and cabinets
    - Pallet racks
    - Crane for loading materials on trucks. Depending on the final layout, this crane could also be used for moving components within the shop.

15.7.5.2 COMPUTER AND COMMUNICATIONS EQUIPMENT ROOM

A conditioned and humidity-controlled room for computer and communication equipment shall be provided. The equipment room shall be located adjacent to or directly below the Control Room.

- Finishes
  - Floor: Raised floor with static-dissipating VCT
  - Walls: Gypsum board
  - Base: Rubber
  - Doors: Hollow metal with hollow metal frames, lockable
  - Ceilings: Acoustical ceiling tiles
- Utilities
  - Electric
  - 120 VAC, one phase
  - UPS
  - As required by equipment
  - Lighting: See Lighting Criteria in Section 15.11.6.5
  - Phone
  - Data
  - Conditioning: Heated and cooled

15.7.6 MAINTENANCE ADMINISTRATION

The maintenance area shall contain offices, open work areas, and support areas for Metra maintenance personnel. These areas should be adjacent to the maintenance shop.

15.8 FUNCTIONAL REQUIREMENTS – MAJOR SHOP EQUIPMENT

15.8.1 TRAIN WASHER

The train wash facility shall be fully enclosed, sprinklered, and heated, and shall contain equipment capable of washing the exterior of trains in a drive-thru manner. The facility shall be capable of washing eight eight-car trains per hour, with a train speed of three miles per hour (mph). The washer shall clean the train's sides, roof, windows, and door pockets.

The facility shall be divided into segments that contain a chemical application area, dwell area (time for chemicals to react and loosen the dirt from the train surface), and a clean/rinse area (chemicals are agitated on the train surface, rinsed from the train, and the rinse water is blown off of the train). There shall be two separate areas or rooms: the process equipment room which contains the storage tanks, pumps, piping, controls, etc.; and a bulk storage room used to store chemicals, spare parts, etc.

At brush and spray locations, CMU walls shall be protected from water, dirt, and chemical spray. Failure to protect these areas can result in the deterioration of the building structure and envelope due to chemical exposure. Floors, drains, housekeeping pads, and all other ancillary surfaces are to be chemical resistant by nature or coating. The facility shall be configured to allow trains moving through the wash bay at train wash speed to have an adequate dwell time while the train is moving through the wash system to be cleaned. Observation windows shall be provided at appropriate application locations (arches, brush area, rinse area) to visually confirm operation of equipment. All equipment heaters, water heaters, etc., as well as ducts and conduits routed through or located in the wash bay, shall be corrosion resistant material due to the wet corrosive environment. Building structure (roof trusses, etc.) located in brush and spray areas shall be corrosion resistant.

Train washer equipment will generally include the following:

- Detergent arch
- Side, roof, and eaves brushes
- High pressure spinners
- Rinse arch
- Air strippers
- Above ground storage tanks
- Pumps (secondary pumps for important applications)
- Reclaim system

Provide truck and forklift access to accommodate delivery of equipment and bulk chemicals (55-gallon drums, 250-gallon totes, motors, pumps, brushes, etc.). Provide dedicated space for a bulk storage room and for storage of chemicals, spare parts, etc.

Containment structures will be below ground.

All process equipment (pumps, tanks, etc.) shall be located in a process equipment room to protect the equipment and personnel from the wash chemicals as well as allow for equipment maintenance. The process equipment and bulk storage rooms shall address spill containment, HVAC in a corrosive environment, and the requirement of flooring and structural members to be chemical resistant. Air intake and exhausts shall use gravity dampers and not motorized dampers. The process equipment room as well as train wash area are to contain an emergency shower/eyewash station due to the chemicals used and stored in this area.

15.8.1.1 WASH EQUIPMENT & LAYOUT

The chemical application area shall be equipped with two application arches capable of applying acid or alkaline through separate piping and spray nozzles. The dwell area shall be approximately 150 feet long, from the last application arch to the cleaning/rinse process area. The cleaning/rinse process area shall consist of brushes or jets, pre and final rinse high pressure arches, high-pressure nozzles, and a high velocity air water stripping arch. Spray nozzles on arches shall be quarter turn quick disconnect type. The equipment (arches, etc.) contained in the train wash shall be mounted on 12-inch high concrete pads to prevent corroding anchors and equipment mounting points. All anchor bolts in contact with concrete shall be stainless steel. Grease fittings or other items which require periodic maintenance shall be located remotely from OCS and with easy access for personnel without the use of a ladder.

15.8.1.2 PROCESS EQUIPMENT

The acid and alkaline wash shall use direct injection with static mixers to mix the wash. Softened water shall be used for the chemical application and final rinse. The water shall have pH and suspended solids correction for recycling and discharge.

The wash system shall reuse all water generated and collected in the process. Fresh water shall be used for chemical application, final rinse, and makeup water. Recycled water shall be pH corrected to neutral and filtered before reuse. The reclaimed water shall have a defoaming agent application. The acid and alkaline storage tanks shall have a secondary containment with dedicated drains to the wash system tanks.

Storage tanks shall have aeration for use during periods of nonuse of the train wash to prevent the contents from becoming septic. Tank levels shall be measured using ultrasound level sensors placed in tubes in the tank. Manhole covers for in-ground tank access shall be round composite covers capable of being lifted by maintenance personnel. The filtration system shall provide continuous backwash as part of the system and pump strainers shall be capable of opening with no tools required. Provide pH sensors/probes, one for correcting the pH and one for confirming the pH level before opening the discharge valve.

15.8.1.3 WATER METERING AND WATER DISCHARGE

Separate water metering shall be provided for incoming domestic water to the wash and metering of the sanitary discharge. Discharge of water from any of the train wash processes or tanks shall be controlled to meet regulatory requirements. Isolation (control) valve shall be located on the incoming domestic water supply at the entrance to the building. The isolation valve shall be programmed to close when fluid levels exceed system capacity.

15.8.1.4 OCS

A means of de-energizing the OCS, if it exists, for the train washer, independent of all other yard operations, is required. This will allow for maintenance activities to be performed on the train washer.

15.8.1.5 CONTROLS

The wash system shall have external and remote indications of system status and train speed. The physical location of trains shall initiate or stop various wash and rinse procedures. The entire train wash process shall be controlled by a PLC. The PLC shall have a Human Machine Interface (HMI). A second HMI shall be installed in the yard control tower that provides notification of door position (open or closed), remote door operation, wash operation (on, in process, over speed, and down for maintenance), and temperature reading with freeze warning (to indicate the requirement to close the doors or call for maintenance on the heating units).

The HMI shall have a web server, email server, File Transfer Protocol (FTP) server, and be capable of data logging, trending data, emailing predefined events/alarms, and on and off status capability of various processes and equipment. A Process and Instrumentation diagram (P&ID) (laminated) for the wash system shall be provided and mounted adjacent to the PLC along with a valve schedule. The HMI, the motor control center, and other electrical components must be in a separate room from the wash bay and area with pumps and chemical storage.

A train wash activator shall be located approximately 30 feet ahead of the train wash entrance. A traffic signal light with red, yellow, and green indicator lights shall be located at the entrance of the train wash, end of the dwell area, and at the exit of the train wash. The indications are as follows:

- Green – train wash activated; proceed, speed is correct
- Yellow – excessive speed, slow down
- Red – stop

A fourth traffic light shall be located outside the washer approximately one train-length from the washer to provide train speed indication until the entire train has been washed. A fifth traffic light shall be located at the exit of the train wash oriented to face reverse traffic flow. This light will provide indication for trains required to be routed through the train wash in the reverse direction.

15.8.2 WHEEL TRUING FACILITY

The wheel truing facility shall have the following functions and features:

- An under-floor wheel truing system capable of truing wheels and brake rotors. Depending on the types of equipment being serviced in the facility, the following capabilities shall be provided:
    - The capability to drop a wheel set and true the set as a single unit
    - The capability to true the wheel set under the vehicle (required for some locomotives and coaches)
- Chip collection and conveying system to deposit swarf into a collection bin
- System to dump wheel truing machine chips directly into dumpster
- Interlock the wheel truing machine with the stinger system
- Two tool posts with measuring devices for wheel wear and diameter
- Brake disc turning capability

- Computer control with diagnostic capabilities, compatible with operating system
- Capable of machining tapers, treads, and flanges in a single pass machining without having to initiate a new set-up procedure
- Ability to machine either solid axle or stub-axle wheel sets
- After cutting, the maximum diameter difference shall be 0.3 mm (±0.15mm) or less. Equal wheel diameters on a wheelset shall be provided within this tolerance without involving the operator.
- The value for the profile accuracy is ±0.2 mm (± 0.0079 inches) For tolerance purposes, standard unit tolerances are provided for reference only and metric unit tolerances shall prevail. Equipment shall be capable of cutting up to and removing flat spots without needing to undercut and remove unnecessary tread.
- Provide electronic measuring devices for wheel wear, wheel diameter, and wheel profile. Measuring devices shall monitor and control the compatibility of both wheel sets on the same truck to provide a balanced condition. Measuring devices shall be capable of entering data into the automatic control system.
- Sensors shall stop operations upon any machine failure
- Automatic lubrication for critical areas of wear
- Grounding of wheel-truing machine to track to eliminate stray current infiltration
- Task lighting as necessary for proper machine operation
- Data acquisition system, with data storage of machining and profile wear data for each vehicle. System shall have data transfer capability.
- Roll-over capacity of train weight of empty car or locomotive without overstress
- Jib or bridge crane(s), as necessary, for machine operation, handling of individual wheelsets, maintenance, and cutter changes
- Inspection/repair pit on inbound and outbound sides of machine, if necessary, for pre-truing prep work and brake adjustments

- Body hoist on outbound side of machine, if necessary, for post-truing shimming. This requirements for this hoist shall be confirmed with Metra Mechanical.
- Convenience air, non-potable water, and electric outlets along the full length of track on both sides of each car position at each truck location
- Dedicated ventilation system for wheel-truing pit in accordance with applicable codes
- Data outlet
- An adjacent storage area “wheel garden” capable of storing up to 100 axles

15.8.3 BRIDGE CRANES

Bridge cranes shall meet the following requirements:

- Provide multiple cranes (for example, one each at the north and south ends of a shop) for redundancy and efficiency.
- Provide a dedicated crane system for any RIP tracks.
- Safety factor for load-bearing parts shall be at least five, based on the minimum ultimate strength of the material used.
- Maximum deflection for runways shall not exceed L/600th of the support span.
- At a minimum, structural steel members shall conform to ASTM A36 Specification (Fy = 36 ksi).
- Welded connections shall be per AWS specifications.
- Overhead cranes installed in maintenance facilities shall comply with the standard for cranes and monorails, as required by NFPA 70.
- Crane bridge girders and runway tracks shall be straight and true.
- Cranes shall be designed for American National Standards Institute (ANSI) MH 27.1 and ANSI B30.11 Class “C” service at a minimum.
- Bearings for crane and hoist equipment shall have a minimum “L-10” average life of 5,000 hours for Class “C” service.

- An impact factor shall be used for sizing runway and bridges. Impact factor shall be based on 15 percent of live loads.
- For shops servicing electrified lines, the clear hook height shall be sufficient to accommodate the full extension of a pantograph, and/or any electrified contact system.
- A three-inch minimum vertical clearance shall be maintained between various building structures, lights, pipes, ducts, sprinklers, and/or other obstructions.
- A two-inch minimum horizontal clearance shall be maintained between various building structures, lights, pipes, ducts, sprinklers, and/or other obstructions.
- Underhung cranes for connecting to monorails or if the hoist needs to travel to or past the runway.

15.8.4 VEHICLE HOISTS

If fixed lifts are used in the facility, the following shall apply. Metra may also choose to provide lift functionality with the use of portable jacks, or use drop tables. The designer shall discuss this with Metra.

Rail vehicle lift systems shall be designed in accordance with OSHA standards for safety requirements in the construction, testing, and validation of lift systems. Lifts shall be capable of safely lifting all types of Metra rail vehicles, on their wheels, to a minimum height of five feet above the shop floor as measured from the lift rails to permit inspection, maintenance, and repair activities. C-frame style hoists shall be specified, permitting a truck that has been removed and lowered to the shop floor elevation to pass through the raised hoist structure of the adjacent truck. C-frame style hoists shall be configured such that the structure and any utilities or other items are clear of the truck and allows the truck to pass without having to move or remove any hoist items or truck components. If turntables are provided and located to move the trucks out from under the vehicle, the C-frame feature is not required.

Lifting screw and lifting nut assemblies shall be self-locking and non-reversing under load, independent of the drive train and motor brake. The drive nut shall be capable of lifting or lowering only when the lifting screw is power driven. The drive nut shall not move and shall support the rated load in the event there is a power failure, a drive train disconnection, or a motor brake malfunction. Nut wear sensors shall be provided to measure wear from operation and shall trigger an alarm through the lift system controller when nut wear exceeds parameters as specified. The load holding properties of the lifting screw and drive nut shall be accomplished by using a screw thread with appropriate angle. The threads and other dimensions of the lift jack screw shaft shall be in accordance with American standard Acme threads. Lift shall be capable of being lowered manually if the lift is stuck/locked in the up position.

Travel synchronization of lift systems to within the specified tolerances shall be required throughout the vertical travel of the lift system. An interlock shall be provided to stop the lift if the hoists are not within the synchronization tolerances. The lift manufacturer shall have in effect a Quality Assurance program that meets the requirements of ISO 9001. Hoists shall be aligned such that at any point in the lifting range, the elevation of any two points on any of the four truck hoists supporting a married pair are within 0.25 inches of each other.

The lift control shall be accomplished by a PLC-based system configured to control all motions as specified. Proprietary microprocessor based printed circuit boards are not acceptable. Local lift system status monitoring shall be accomplished using a Human Machine Interface (HMI). The HMI shall monitor lift status and display alarm conditions as specified. The lift manufacturer shall provide a web based remote monitoring capability for the lift system that includes all points as specified. The contractor shall provide the specified communications link from the lift system controller to the local Metra network switch. The contractor shall terminate the communications cable at the lift system controller and Metra will terminate the communications cable at the local switch. Hoist cannot operate when the stinger is energized for the track (electric division only).

Deep pit lifts may be used at locations with basements. If a basement is not practical due to site conditions, a shallow pit design shall be used. The deep pit lift configuration shall provide unrestricted access to all lift components when the lift is positioned at any height including the fully lowered position. Unrestricted access shall encompass visual inspection of all lift system components and the ability to perform periodic routine maintenance of all lift system components without the removal or disassembly of the lift. The lifting pit shall be designed so that confined space entry requirements do not affect pit entry. Pits shall be equipped with a means of removing water from the pit either by pit drain or pit sump pump. The pit floor shall be sloped to the drain. The pit or basement area must be ventilated for personnel safety and to control humidity. The pit openings shall be covered with steel diamond plate, sized to be safely removed without the use of heavy equipment. Pits for hoists shall be provided with lighting, a 120 VAC power outlet, and a compressed air outlet.

The lift system shall have four minimum capacity car hoists and eight body supports. Car hoist capacity and the capacity of a pair of body supports shall not be less than 60 percent of the AW0 vehicle weight. The lift shall be equipped with body supports that safely support the raised rail vehicle as measured from the bottom of the jacking pad located on the rail vehicle. This allows the trucks to be removed and lowered to the shop floor for repair or replacement. The car hoist and body support lift drive assembly controls shall gradually start and stop the lift motion to reduce wear on mechanical components. The lift shall be equipped with an automatic lubrication system that properly lubricates the lifting screw and lifting nut per the lift manufacturer's specifications. Each car hoist shall be equipped with spring loaded wheel chocks that deploy when the lift is raised above the shop floor.

The drive system shall be automatically self-locking at any elevation and shall be completely below shop floor level and raise a superstructure from floor level to the specified elevation or any intermediate elevation.

Car hoists shall have a positive roller guide system.

Lifting screws and lifting nuts of car hoists and body supports shall receive lubrication from automatic lubrication systems.

Safeguards shall be provided to allow the body supports to operate only when the car weight is removed from the body supports.

Gaps between pit covers or floor closure covers and any other equipment or fixed point shall not exceed 3/8-inch.

Each area of the deck plates outside the rails shall contain a hinged access hatch for worker access. Each hatch shall have a recessed handle to raise and lower the hatch.

Hoists shall be provided with a master control console with status indicators.

The hoist shall support the roll-over capacity of the train weight of the empty car plus crush (AW3) or locomotive, without overstress.

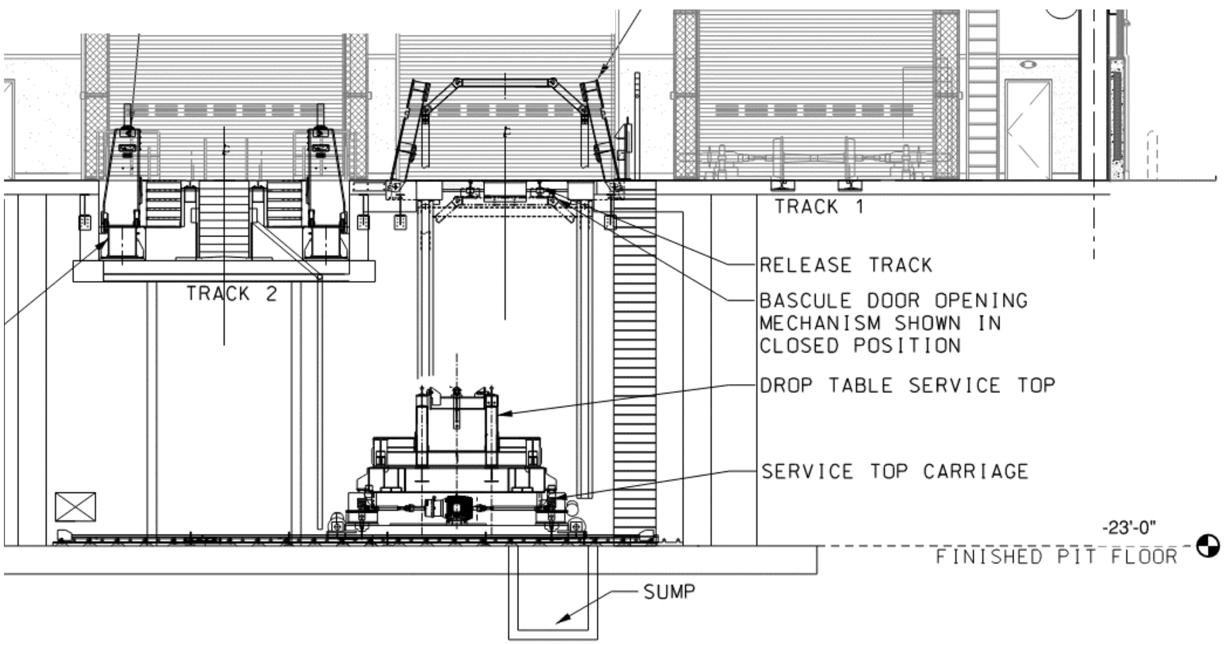
15.8.5 DROP TABLE

Drop tables may be used for truck changes. A drop table is the preferred method of removing locomotive trucks because of the higher vehicle weight. The shop track for the drop table should be a minimum of approximately two coach lengths. The drop table system shall be capable of removing and replacing trucks and wheelsets on all vehicles that may be serviced in the shop. The table shall be capable of dropping either a truck or a wheel set.

The service top length will be sufficient to allow two-axle trucks to be removed from the vehicles, lowered, and transferred to a release track that is adjacent and parallel to the service top. The trucks will be removed one at a time. The service top shall be equipped with a set of movable body supports that hold the vehicle at its normal height while the truck is lowered into the drop table pit. The release track will have a bascule type set of doors flush with the shop floor that are pushed open when the service top carriage rises at the release track. The release track rails will be embedded in the shop floor on both sides of the drop table and sized to provide truck and wheelset storage. The drop table shall also have an auxiliary function to remove and replace a single wheelset with attached traction motor and gear box (commonly called a Combo).

Recessed inspection pits shall be provided on both sides of the Drop Table to provide access for technicians to get under the vehicle and disconnect the electrical and mechanical couplings between the truck and body of the coach or locomotive. Figure 15-2 illustrates the track spacing and general pit configuration of a drop table.

Figure 15-5. Drop Table Configuration



A drop table system requires comprehensive coordination between the chosen manufacturer, the design team, the drop table system installer, and the Contractor. Extended design and fabrication periods should be considered as they may impact the construction schedule.

15.8.6 TURNTABLES

Turntables shall be located at the intersection of the service rail and stock bar (maintenance rail) and on the stock bar (maintenance rail) intersection in the maintenance area. Turntables allow rail trucks to be rotated from the S&I shop service rail and moved into the maintenance area as well as to be rotated in the maintenance area. As a standard, manual turntables shall be installed at rail maintenance facilities. Turntables shall be capable of safely rotating a single rail vehicle truck as well as permitting rail vehicle travel over the turntable (rollover capacity).

The manufacturer of the turntables shall be ISO-9001 certified and registered. Minimum expected life of this equipment shall be 50 years. All equipment furnished shall be heavy duty, industrial type.

The manual turntable shall be capable of rotating a single car truck 360 degrees in either direction. Turntable shall be designed for standard track gauge of 4'-8-½" and have the following dimensions and capacities:

- Table diameter: 12 feet minimum
- Turning capacity: 120 percent of the heaviest truck
- Rail rollover capacity: 60 percent of the AW0 vehicle weight

Manual locks shall be provided at 90-degree positions and set to align the turntable rails with the shop rails. The turntable shall be equipped with automatic spring-loaded wheel chocks that deploy when the turntable is not aligned with the shop rails. The turntable shall have crossing rails that match up with the shop running rails when the turntable is in its locked position at 90-degree increments. The turntable shall be mounted flush in the floor with rails recessed and set such that the gap between the shop rails and turntable rails shall not exceed 1/4 inch and the variation in horizontal and vertical alignment shall not exceed 1/8 inch when the turntable is fully loaded and locked. The maximum gap between the turntable surface and the curb angle of the shop floor shall be 1/2 inch. The rails shall be suitable for the design loads and configured to provide smooth movement between shop rails and the turntable. Maximum variation in the plane of the table shall be 1/4 inch measured between any two points on the surface of the deck under any of the loads specified herein.

The turntable shall be constructed so that the entire assembly may be conveniently removed from the pit as a unit. The turntable shall be of one-piece welded construction. The top surface of the turntable shall be 3/4-inch-thick non-skid solid diamond steel plate capable of supporting shop vehicle traffic

(H-20 loading). The top shall be equipped with a door opening to provide unrestricted access to turntable components to perform periodic routine maintenance. Deck support beams shall be designed and positioned such that the deck can support 300 pound/sq. ft. uniform load and a 6,000-pound load on a six-inch diameter circle. The turntable shall be complete with curb angles supplied by the equipment manufacturer and installed by the contractor. Curb angles shall be notched after installation to accept shop rails and manual locking mechanism.

15.9 SUPPORT SPACES

Functional spaces that are required to support the operation of the facility and the yard shall be provided. See further requirements in Chapter 14, MEP.

15.9.1 MECHANICAL EQUIPMENT ROOM

A dedicated room to house mechanical and plumbing equipment for the building shall be provided. This section applies to air compressor rooms also.

- Finishes:
    - Floor: Smooth finished concrete with integral sealer
    - Walls: Concrete masonry unit with epoxy paint
    - Base: None
    - Doors: Double leaf, hollow metal with hollow metal frames, lockable
    - Ceilings: None
- Utilities:
    - Electric
    - 120 VAC, one phase
    - As required by equipment
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Data
    - Conditioning: Heated and ventilated

15.9.2 FLUIDS DISTRIBUTION ROOM

A dedicated room for housing lubrication equipment shall be provided.

- Finishes:
    - Floor: Smooth finished concrete with integral sealer
    - Walls: Concrete masonry unit with epoxy paint
    - Base: None
    - Doors: Double leaf, hollow metal with hollow metal frames, lockable
    - Ceilings: None
- Utilities:
    - Electric
    - 120 VAC, one phase
    - As required by equipment
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Water
    - Compressed air for pneumatic pumps and outlets for tools
    - Conditioning: Heated and ventilated
- Major equipment:
    - Lubrication pumps
    - Storage vessels: Storage shall be in double-wall vessels (to avoid the need for a containment structure).

15.9.3 ELECTRICAL EQUIPMENT ROOM

A dedicated room for the building electrical equipment shall be provided. Separate rooms shall also be provided for the yard traction power substation (TPSS) (if located in the shop), the shop TPSS, and the building power distribution room.

- Finishes:

    - Floor: Smooth finished concrete with integral sealer
    - Walls: Concrete masonry unit with epoxy paint
    - Base: None
    - Doors: Double leaf, hollow metal with hollow metal frames, lockable
    - Ceilings: None
- Utilities:
    - Electric
    - 120 VAC, one phase
    - As required by equipment
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Conditioning: Heated and ventilated

15.9.4 FIRE PUMP ROOM

If needed in the facility, a dedicated room for fire protection equipment shall be provided.

- Finishes:
    - Floor: Smooth finished concrete with integral sealer
    - Walls: Concrete masonry unit with epoxy paint
    - Base: None
    - Doors: Double leaf, hollow metal with hollow metal frames, lockable
    - Ceilings: None
- Utilities:
    - Electric
    - 120 VAC, one phase
    - As required by equipment

    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Data
    - Conditioning: Heated and ventilated
- Other: On exterior wall near electric service feed

15.9.5 COMPUTER/COMMUNICATIONS EQUIPMENT ROOM

A dedicated room for the computer and communications backbone equipment shall be provided. The designer shall discuss the requirements for such rooms with Metra Communications.

- Finishes:
    - Floor: Raised floor with static-dissipating VCT
    - Walls: Gypsum board
    - Base: Rubber
    - Doors: Hollow metal with hollow metal frames, lockable
    - Ceilings: Acoustical ceiling tiles
- Utilities:
    - Electric
    - 120 VAC, one phase
    - UPS
    - As required by equipment
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Phone
    - Data
    - Conditioning: Heated and cooled

15.9.6 OUTDOOR STORAGE AREAS

Outdoor areas used for storage of parts and maintenance materials shall be designated by signage and should be assigned to a department to manage. The surface should be well drained or paved to prevent damage to the materials being stored or to a forklift or truck that may be handling the materials. If the type of materials stored could be subject to theft, provide security fencing.

15.10 SITE DESIGN REQUIREMENTS

The discipline design requirements listed in the following sections are applicable to the yard and shop buildings in general. However, if any criteria or requirements listed under functional area modules conflict with, or are stricter than, these general requirements, the specific requirements listed for a functional area module shall govern.

15.10.1 TRACK DESIGN REQUIREMENTS

The following shall guide the optimal layout of proposed maintenance and storage facilities:

- Provide sufficient storage tracks to store vehicles/trains assigned to the facility.
- To the extent possible, provide storage tracks that are double ended to provide operational flexibility and reduce non-revenue movements.
- Provide a double-throat lead track with direct access from mainline tracks to the train washer, and to the storage tracks via a bypass track.
- Shop lead tracks shall be accessible from either end.
- The minimum length of a storage track shall be based on the length of one train plus a 5-foot gap allowance between trains.
- If possible, storage tracks should be tangent and level.
- Powered yard switches shall be heated.
- Spirals and super-elevation shall not be used in yards or shops.
- Track layouts in yard and shops must maintain minimum clearances from the dynamic outline of the rail vehicles to fixed obstructions.

Track spacing shall be based on the width of the rail vehicle, width of the widest service vehicle, and dynamic envelope. Track spacing shall allow for the passage of cleaning carts and other motorized equipment, where applicable, as well as any poles or fixtures required between tracks.

15.10.2 TRACK GEOMETRIC AND PROFILE CRITERIA

Yard track horizontal curvature requirements are included in Chapter 4, Track Geometry.

15.10.3 APPROACH SLABS AND APRONS

An approach slab, also referred to as a transition slab, shall be installed at interfaces between embedded track at shop aprons and ballasted track. The minimum ballast depth above the approach slab, measured between the bottom of cross ties to the top of approach slab, shall be eight inches, increasing to 12 inches at the end of the slab farthest from the embedded track.

Aprons where tracks enter the shop building shall be a minimum of 20 feet wide and have embedded rails. The width of apron on sides without tracks may be smaller unless a wider width for fire lanes is required.

15.10.4 STRAY CURRENT PROTECTION

Stray current control measures are essential to reduce corrosion of metallic elements of underground structures. Stray current control criteria are addressed in Chapter 13, Stray Current and Corrosion Control.

15.10.5 TRACTION POWER SUBSTATION

In electrified territory, there is generally a traction power substation (TPSS) on the site of a maintenance facility. A separate TPSS shall be provided for the yard and shop. The yard substation may be located within the shop building in a separate room, or elsewhere within the yard. The location chosen for the substation shall allow trucks from the Traction Power Department to drive up to the building and shall have a minimum of one parking space for a large truck. Duct banks will run from the substation to many locations on the site, so the chosen location should optimize the number and length of these duct banks. Refer to Chapter 11, Traction Power for design criteria on duct banks, manholes, pull boxes, junction boxes, cable vaults, and other associated systems and materials.

At-grade substations require an access road that is a minimum of 18 feet wide, with a 20-foot-long parking area, and a turnaround sufficient for a WB-50 vehicle. The requirement for land area will vary with the type of substation.

The TPSS will typically require a UPS and batteries to supply back-up power. Batteries shall be located in a separate battery room designed to comply with applicable code requirements.

15.10.6 SITE ROADS AND PARKING

15.10.6.1 NON-REVENUE VEHICLE PARKING

Paved parking spaces shall be planned to accommodate Metra vehicles, which may include a wide variety of vehicle types. Multiple departments may have needs for vehicle parking. Dedicated spaces, sized appropriately for the specific vehicles, should be provided. Parking spaces should be close to the locations where the assigned driver may be working while at the maintenance facility.

Vehicles with hydraulic systems or other complex equipment on-board shall either be stored in an enclosed, unheated building or under a canopy.

15.10.6.2 EMPLOYEE VEHICLE PARKING

A paved parking lot, segregated as much as possible from any maintenance operations, should be provided for Metra or Metra employee vehicles. If space does not allow for one large lot, the lot may be broken down into multiple smaller lots. The parking lot most convenient for Metra operations may be used for Metra vehicles, while the other lots may be used for employee vehicles. The employee entrance should be easily accessible from the lot(s) and the travel path from the parking lot to the facility entrance should not cross any rail tracks or delivery vehicle paths, if possible.

Within the parking lot(s), each parking space shall measure nine feet wide by 18 feet long (minimum). In addition, an appropriate number of accessible parking spaces shall be provided in accordance with the most recent edition of the ADA Accessibility Guidelines (ADAAG)).

The entrance to the employee parking lot should be separate from the entrance that any delivery vehicles will use, if possible. If the parking lot is in an interior area of the site, fencing is required to confine pedestrians to designated areas.

The parking lot(s) shall be sized according to planned activities and occupancy at any point in time. Assuming three work shifts, the Metra rule of thumb is to allow enough parking spaces for two-thirds (2/3) of the total employees to compensate for shift overlap.

Up to 10 percent of available spaces shall have chargers for electric cars. The charger design shall be a universal configuration that will work for a maximum number of electric automobile models.

If site conditions allow, provide accommodations for bicycle parking.

15.10.6.3 VISITOR PARKING

Visitor parking spaces shall be provided in the employee parking lot, accessed via the employee parking lot entrance. The driving path to visitor parking and the walking path from visitor parking to the building entrance should not cross any rail tracks or delivery vehicle paths, if possible. Parking lot(s) shall be sized according to planned activities and occupancy at any one point in time. Site design shall allow for parking by a transit bus, one at a time.

15.10.6.4 PEDESTRIAN ACCESS

If the site of the facility is located in an area where an employee or visitor may access the site as a pedestrian (for example, if public transit stations are nearby), then include consideration of pedestrian access in site planning.

15.10.6.5 DELIVERY ENTRANCE

The entrance used by delivery vehicles should be separate from the entrance to the employee parking lot, if possible. The entrance for delivery vehicles shall lead to a dock along the maintenance facility building with enough space for a tractor and 53-foot trailer to back to the dock with a clockwise move and pull out with a forward move.

15.10.6.6 ACCESS ROADS

Service roads need to be designed for efficient access by employee, service, and delivery vehicles. Full access within the yard shall be achieved through a perimeter road and cross lanes. Access shall be provided and maintained in accordance with locally adopted road and access standards.

Every effort should be made to eliminate or minimize the crossing of yard tracks by service roads.

Provide life safety and emergency vehicle access to the facility. The site plan should be discussed and coordinated with Metra Safety and local fire and life safety entities to ensure sufficient access is provided for efficient response. Fire lanes need to be planned according to the requirements of the local AHJ. Generally, fire lanes need to allow fire truck access to all sides of a building, or to get within a specified distance from any point on a building perimeter. Turning radii of access roads shall be long enough to permit emergency access. The minimum inside curb radius shall be 25 feet and the minimum outside curb radius shall be 50 feet. The Fire Marshall of the AHJ shall approve the turning radius.

In accordance with local municipal code requirements, access roads shall be provided with approved provisions for fire and emergency apparatus to pass other vehicles and to turn around.

Provide access to the yard and each building, as appropriate, for freight that will move over the road.

If the maintenance facility will also serve as the headquarters for the MOW department (as it often is), outside bulk storage shall be provided to accommodate poles, signal equipment, rail, ties, ballast, and cable. Bulk storage shall be served by road and rail access. Planning for site roadways shall also consider that rail vehicles are sometimes delivered by highway vehicles. Access roads should therefore accommodate extra-long low-boy trailers and provide a path for the delivery vehicle to the unloading track and to the exit.

Service and access roads in the yard shall be coordinated with signaling, third rail, and traction power requirements to avoid maintenance equipment or vehicles from reducing the width of roadways. Access roads connecting storage tracks to shop areas and service aisles shall be asphalt paved.

15.10.7 SITE DRAINAGE

Positive stormwater drainage is a major factor in a successful project design. Pavement slopes should range from a minimum slope of 0.5 percent (along concrete gutters) to a maximum slope of five percent, with a two percent slope being desirable. Concrete slabs should be minimum one percent slope only if necessary. Bituminous pavement may be 1.5 percent only if necessary. Deviating from these minimum slopes shall be approved by Metra. Slopes in parking areas and site walkways must also comply with Americans with Disabilities (ADA) requirements.

Provide underdrains whenever aggregate base courses are proposed on relatively impervious (clay or silt) subgrades or whenever the water table is within three feet of subgrade. The draining water from the sub-grade and base course reduces the risk of damage from frost heave or loss of sub-grade support to the pavement as result of saturation. Underdrains can be as simple as several short lengths (i.e., 5-10 feet) extended from drainage structures, or more complex if existing conditions warrant longer lengths.

Identify the existing drainage patterns during design to maintain them as much as possible. The topographic survey should extend a minimum of 20 feet beyond the proposed improvement area to document drainage patterns both to and from the area of work. Maintain drainage from adjacent higher properties by rerouting around, passing under, or passing across the proposed lot without creating erosion, flooding, or icing conditions on the proposed or adjacent sites.

Tunnels under tracks shall have a drainage collection system that discharges to the municipal system if possible. 100-year High Water Levels (HWLs) for municipal drainage systems are generally within 12 inches of the street elevation, therefore a sump pump discharge should be provided for the tunnel to prevent back-up of floodwaters from the municipal system into the tunnel. The sump pump system shall be a duplex system, with each pump sized to adequately drain the tunnel. If the tunnel is the only way to cross the tracks, an emergency generator should be considered as an option. Review Chapter 6, Civil and Drainage for additional information.

Size the storm sewer collection system for the storm frequency required by the local jurisdiction, typically a 10-year storm. Perform a calculation for the 100-year storm high water line (HWL) to ensure it is no more than 10 inches deep, using an overflow route that will be accessed at the HWL to keep close to that level in the event that drains are plugged. This calculation is required even if stormwater detention is not needed on the project.

Provide stormwater detention only if required by local ordinance. Common methods include separate grassed or paved basins, underground oversized pipe(s) or chambers, subsurface drainage using bioswales or infiltration fields, and containment on the surface of the proposed parking lot. A combination of these methods can be considered to minimize costs. Restrictors under six inches in diameter are not desirable.

An underground stormwater storage system may maximize available space, but at a high cost. Permeable pavement may also be considered, though the cost and maintenance considerations shall also be included in the evaluation. Storage of stormwater on the surface of the parking lot is only recommended if no other storage area is available or the costs of the other alternatives are too high. For parking lot storage, use a maximum ponding depth of 10 inches and locate outside of the driving aisles.

Many stormwater management regulations require retention of runoff from the “first flush”, usually between one-half to one inch of runoff from a given portion of the site. These regulations often differentiate this requirement for the portion of a site that is being developed or redeveloped. Understand and evaluate the implications of this during the early design stages.

15.10.8 SITE LIGHTING

Refer to Chapter 14, MEP for additional lighting criteria.

Yard lighting shall be designed in accordance with the Illuminating Engineering Society's recommendations for rail yard lighting, in addition to local ordinances and standards. Lighting for parking lots, pedestrian walkways, and other supporting exterior spaces shall provide for the safety of the pedestrian and driver. The arrangement of the lighting shall make both pedestrians and drivers aware of the organization of the area by providing visual information for maximum clarity. To minimize disturbance of the surrounding residential neighborhoods, if present, design shall minimize glare and light spillage.

Sense of security in a parking lot is increased when the perimeter is uniformly well-lit. Therefore, perimeter conditions shall be continuously lit per the lighting control requirements in the following paragraph. The continuous lighting shall be in addition to the minimum interior illumination of each lot. The maximum-to-minimum lighting level ratio shall be low to avoid overly bright spots which by comparison make the overall average illumination appear darker. Close coordination is required between the outdoor lighting and landscaping disciplines to avoid problems such as conflicting layouts of lamps, trees, and tree shadows over parking spaces and drives. Verify with agencies having jurisdiction if any requirements to control light pollution in surrounding areas are in effect as agreed to with neighborhood organizations.

Exterior lighting shall be controlled by a combination of a NEMA-type photocell and a time clock. The time clock shall turn off 80 percent of the lighting during non-operating hours; the remaining 20 percent of site luminaires, on a separate control and evenly distributed throughout the site, shall remain on all night for security. Security lights shall be turned off by the photocell when north sky luminance rises above a certain level. The photocell shall be mounted on a pole in the middle of a parking lot with an unobstructed view to the north sky. Lighting system controls shall be compatible with an automated energy management system.

Fixture selection shall be coordinated with the U.S. Green Building Council (USGBC) LEED rating system, if applicable, for points for dark sky or other light pollution issues.

Because interior car cleaning will occur nightly, lighting shall be arranged to maximize the illumination of areas between storage tracks.

15.10.9 FUELING ISLAND

A fueling island is a dedicated, canopy-covered area for fueling diesel rail-bound equipment and diesel or gasoline highway vehicles. Sanding and fluids replenishment shall also be accommodated at this location. For rail-bound equipment, a vendor may visit the site and fuel the equipment from a fuel truck. If required, the fueling island should be located where rail-bound vehicles can access it without interfering with revenue vehicle movements and highway vehicles can access it by crossing a minimum number of yard tracks. The facility should have a drive-through configuration.

- Equipment/furnishings
- Hose bib for water
- Bulk storage and distribution system for locomotive service fluids
- Emergency eye wash and safety shower
- Diesel fuel and DEF dispensers and fuel management system
- Traction sand storage and dispensing
- Spill cleanup kit
- Area configuration/finishes
- Minimum clear height: 16 feet
- Finishes
    - Floor: Soil, grease, water, and slip-resistant concrete and grating
    - Walls: Soil and grease resistant, note that facility may be open on one or more sides
    - Ceiling: Painted exposed structure in lanes
- Bollards located at entrance to the fueling lane, if fueling highway vehicles
- Sealed control joints in floor slab at adequate spacing
- Structure as needed to support equipment
- Utilities

- Plumbing
    - Trench drain with removable traffic-rated slip resistant grating to sediment and oil interceptor (one each per lane)
    - Product and vapor recovery piping, as required, to and from fuel tanks and dispensers
    - Water connection to emergency shower/eye wash
    - As required by equipment
- Electrical
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Lighting on emergency power circuit
- Power
    - Fuel dispensers, sand dispensing, and submersible pumps on emergency power circuit
    - As required by equipment
- Communications
    - Paging/intercom system speakers

- Fuel Management System
- Provide power and signal conduit from island terminals
- 120 VAC, one phase
- As required by equipment
- Conditioning: None
- Major equipment
    - Fuel Tank(s)
        - Fuel receiving including metering, filtering, and air elimination

        - Above ground storage tanks, minimum size to be 10,000 gallons or increments of 10,000 gallons
        - Submersible pump shall be provided from tanks to each dispenser
        - Containment shall be provided to contain total gallons of diesel fuel
        - Vapor recovery shall be provided
    - DEF storage and delivery
        - Provide storage for DEF in quantity equal to five percent of diesel fuel storage
        - Provide protection for DEF tank from heat greater than 90°F and cold less than 10°F
- Traction sand: Typically consists of a large storage silo with pneumatic delivery piping to the required sand dispensers. The sand access ports are usually high on the locomotive carbody and ends will require platforms for service personnel to access the ports.

15.10.10 SECURITY

A security system shall be provided throughout the building, monitored from a security office at a central location. The system shall control access and monitor and detect intrusion. At rail entry points to the yard where gates are feasible, intrusion detection systems shall be provided, with notifications being provided to the security office or operations office.

A CCTV system shall have cameras throughout the shop building and yard which shall be monitored from the security office. CCTV real-time and archived images shall be retrievable by management staff at any time. See Chapter 10, Communications.

A guard booth shall be positioned at the main street entrance to allow the guard to have visual and physical control over the entryway. Locate guard booth to permit vehicle queuing off the public street; provide bypass lane for Metra employees.

Characteristics of the booth shall be as follows:

- Furnishings: Workstation with chair

- Utility Requirements: Grounded electrical convenience outlets, telephone, data terminal, air conditioned, and heated
- Floor Finishes: Fatigue mitigating flooring
- Wall Finishes: Painted gypsum board and/or concrete masonry unit. Building and glazing to meet Ballistic Level-3 requirements.
- Ceiling Finishes: Painted exposed structure
- Lighting: LED. Refer to Section 15.11.6.5.
- Provide ADA accessible unisex restroom facility for guard if a guard is to be stationed at the facility entrance

15.10.11 SOUND ATTENUATION

Sound attenuation shall be provided if sound levels at neighboring properties are anticipated to be objectionable. Potential mitigation methods include, but are not limited to, sound walls, enclosing the source, applying wheel/rail lubricators, and providing other methods that may be employed for a specific noise source. Common sounds from a rail yard that may reach objectionable levels are wheel squeal from short radius curves, testing horns, and idling diesel locomotives.

15.10.12 WASTE HANDLING/RECYCLING

Appropriate space for storage and handling of waste must be provided. Sustainable design opportunities should be investigated and incorporated as appropriate.

There are four types of materials for which storage may be required:

- Waste: This consists of trash and waste products that cannot be recycled. A trash compactor shall be provided to dispose of such waste.
- Scrap: Ferrous and non-ferrous scrap metals. A contract scrap dealer may provide containers for collection and removal.
- Recyclable Materials: Recycling containers shall be provided for paper, cardboard, plastic, glass, and metals.
- Hazardous Wastes: Design must address the specific hazardous wastes and the volumes generated. Storage facilities shall address the specific needs of each material.

The waste handling area should be located outside, near an overhead door leading from the maintenance work areas, and near the material storage area. Allow adequate maneuvering space for trash collection trucks to access the containers and exit the site. Compactors and containers should be located on concrete paved areas.

- Utilities:
    - Electric
    - 120 VAC, one phase
    - 480 VAC, three phase for compactor
    - Lighting: See Lighting Criteria in Section 15.11.6.5
    - Conditioning: None if facility is strictly comprised of a canopy, ventilation if the facility is enclosed

15.11 OTHER BUILDING DESIGN REQUIREMENTS

15.11.1 STRUCTURAL LOADS AND DESIGN

The shop structure shall be designed for design loads shown below. These may be modified depending on specific conditions and activities at any given maintenance facility. Design loadings must comply with the currently adopted version of the IBC.

- Train Load: Shop tracks (embedded rail or pedestal supported rail and turntables or hoisting equipment that trains will pass over) shall be designed to support the specified train weight of the empty vehicle without any overstress, or the specified weight of the designated rescue locomotive, whichever is greater. In addition, secondary shop tracks (i.e., those not accessible by an entire train or single vehicle such as release tracks) shall be designed to support a train truck loading of 15,000 pounds spread over two axles with a center-to-center (c/c) distance of 8’-6”.

- Highway Truck Load: Shop floor areas that can be accessed from the exterior by highway vehicles shall be designed to support an H20 American Association of State Highway and Transportation Officials (AASHTO) highway truck loading.

- Forklift Load: Shop floor areas that can be accessed by forklifts shall be designed to support a 4,000-pound capacity forklift having single axle loading (wheels four feet c/c) of 12 kips. If a different forklift will be needed for the planned maintenance activities, use the associated loading for that condition.

- Jack Load: Shop floor areas within 10 feet of the center of shop-embedded rail shall be designed to support a portable jack loading applied over a bearing area of two feet by two feet. For locomotives: 80 kips; for coaches: 38 kips.

- Work Platform Load: Platforms shall be designed for a minimum live loading of 125 psf. Operational studies of work platform use shall be made and the platform designed for concentrated loads from pallet jacks, dollies, or components if maintenance operations dictate such a loading.

- Roof and Floor Miscellaneous Utility Load: In addition to dead and snow loads, the roof framing system shall include a design dead loading of 10 psf for miscellaneous utilities supported from the framing system.

- Crane and Monorail Load – Based on shop material handling requirements, structural framing shall be incorporated into the building framing system to support the specified crane and monorail loadings including gravity, impact, lateral, and longitudinal loads based on American Society of Civil Engineers (ASCE) Standard 7.

15.11.2 ARCHITECTURAL DESIGN

Materials used for shop buildings shall generally be selected based on durability, appearance, and energy efficiency.

15.11.3 CLEARANCES

15.11.3.1 MINIMUM VERTICAL CLEARANCES

Vertical clearance to the shop structure shall be dependent upon vehicle height (on rail and lifted), locations of bridge crane operation, and additional height required to accommodate lights, utilities, sprinklers, and HVAC ducts and equipment. Areas accessed by vehicle maintenance personnel shall have a minimum vertical clearance of 6'-8" from the walking surface to the permanent overhead structure or utility. Additional clearance provisions shall accommodate fall protection systems where necessary.

Rooms and corridors in support personnel areas shall have a minimum floor to ceiling clear height of 8'-6", with nine feet minimum preferred in large rooms and entrance hallways.

15.11.3.2 VEHICLE CLEARANCES TO FIXED BUILDING STRUCTURE OR ELEMENTS

Vehicle clearances to fixed building structures or elements shall be as follows:

- For exterior doors, allow two feet of minimum clearance between vehicle dynamic outline and building door jambs.
- For steel columns and other permanent members, allow five feet of minimum clearance between vehicle dynamic outline and member.
- For vehicle fixed work platforms (car floor level or roof level), allow a three-inch minimum clearance between the vehicle dynamic outline and the edge of platform or any fixed utilities supported from the platforms. This clearance may be determined based on use of a vehicle dynamic outline, limited to a vehicle speed of five mph on tangent track.
- Minimum vertical clearance of any fixed building support, utility, or duct shall be three feet unless a greater distance is required by the latest adopted version of electrical codes.
- Minimum vertical clearance in the yard shall be 16 feet except for electric lines where additional clearance shall be provided for the OCS.

15.11.4 EGRESS PATHS

Shop layout shall allow for emergency egress paths that comply with building code requirements and that are based on the premise that all shop positions dedicated for maintenance of trains are occupied.

15.11.5 MECHANICAL DESIGN REQUIREMENTS

15.11.5.1 HVAC SYSTEMS

Shop buildings shall have HVAC systems to:

- Control indoor temperature, ventilation, and humidity
- Filter odors and dust
- In general, provide an acceptable environment for maintenance and operating personnel working in the building

Spaces within shop facilities will generally fall within one of two categories:

- Heated and cooled
- Heated and ventilated

Refer to the sections below for the type of system required for each space. Refer to Chapter 14, Mechanical, Electrical, and Plumbing for design temperatures.

Infrared heaters shall not be used in the vehicle areas.

15.11.5.2 AIR MONITORING

Demand-controlled ventilation using carbon dioxide gas detection monitors shall be used where occupant loads vary, such as conference rooms, training rooms, lobbies, etc. Carbon monoxide gas detection monitors and alarms shall be used in shop areas accessible by gasoline or diesel-powered vehicles, such as unloading areas.

15.11.5.3 EXHAUST AND VENTILATION

The number of air changes per hour (e.g., total air circulated) in the various occupancy areas of the building shall be based on the requirements of applicable codes, heating and cooling loads, and odor or dust control (whichever is greater) but shall not be less than four air changes per hour. For diesel locomotive shop areas, design shall be based on the operating plans for locomotive movement and for operating the locomotives while in the shop area.

During design, the potential need for supplemental ventilation within pit areas shall be addressed, based on applicable code requirements and the interpretations of the AHJ, covering site-specific criteria including, but not limited to, the physical characteristics of the pits, the functions performed therein, and the possible presence of hazardous substances or vapors.

Specialized systems designed to address the specific operations and contaminants generated by these operations shall be installed in the following areas:

- Welding
- Painting and body repair

- Battery charging
- Steam cleaning
- Electronics

15.11.5.4 NOISE

Equipment and building construction shall be chosen to maintain sound levels at or below noise criterion level NC-50 with HVAC systems running.

15.11.5.5 ENERGY CONSERVATION

HVAC equipment shall be sized and specified to comply with the requirements of the IECC. The following specific items shall be used:

- Heat recovery components shall be included as an integral part of the building heating and ventilation system.
- A web-based centralized energy management system (EMS) shall be used to monitor and control building HVAC equipment. The following features shall be included in the EMS:
    - Ability to conform to peak-load criteria for energy cost savings
    - Automated equipment maintenance scheduling
    - Monitoring of equipment to ensure that operations are within prescribed limits
    - Temperature setbacks corresponding to occupancy and utilization patterns
    - Ability to monitor and record indoor and outdoor conditions affecting HVAC systems, as well as alarms, failures, and abnormal operating conditions
    - Ability to automatically control selected equipment such as air handlers, pumps, fans, and automated dampers, as well as lighting in selected areas
    - Energy conservation concepts such as energy harvesting and the use of solar, wind, and geothermal power shall be studied and, if cost-effective over the life cycle of the facility, shall be incorporated into the building HVAC and electrical design

15.11.6 ELECTRICAL DESIGN REQUIREMENTS

15.11.6.1 POWER

Electrical power shall be distributed throughout the building to support vehicle maintenance equipment and operations, as well as general building operations including HVAC, lighting, communications, etc.

- General Power Distribution throughout Shop Building: 277/480 VAC power shall be provided throughout the shop with transformers locally to power 120/208 V panels. Cable shall be XHHW-2 general cable, non-smoking type.

- Power at Vehicle Maintenance Tracks: The following shall be provided at car positions used for periodic inspection and running repair:

  - 120 VAC duplex receptacles shall be located at no greater than 50 feet maximum spacing, and 30 feet maximum spacing in pits. Receptacles shall have ground fault interrupter (GFI) protection. Access shall be provided to receptacles below floor (pit) level, at floor or depressed floor level outside rails, and at car floor or roof level platforms, where they exist.

  - AC receptacles for testing power to vehicle shall be provided. Voltage depends on vehicle requirements, usually 208 V, three phase, or 480 V, three phase. Location and voltage depend on specific vehicle requirements.

  - DC receptacle for providing testing power to vehicle shall be provided. Receptacle locations depend on location on vehicle, 750 VDC.

  - Welding receptacles, suitable for portable welders to be used in shop, shall be provided, one per car position on each side minimum. Provide additional receptacles per functional area modules.

  - Special receptacles, as required, for plug-in of portable maintenance equipment.

  - Power for vehicle maintenance equipment (e.g., hoists, cranes, etc.), as required.

- Power in Support Shops: The following shall be provided in all support shops:
    - 120 VAC duplex receptacles shall be located at workbenches, columns, and walls in the shops. Receptacles with GFI protection shall be provided at no more than 30 feet maximum spacing.
    - Special receptacles dependent on component maintenance requirements.
    - Power for vehicle maintenance equipment, as required.
- Power in Transportation and Maintenance Offices, Administration, Conference Rooms, etc.: The following shall be provided in these facilities:
    - 120 VAC quadraplex receptacles, per National Electrical Code (NEC) and room layout, minimum one receptacle per wall.
    - 120 V and 277/480 V power for HVAC, lighting, and other building systems, as required.
- Conduit
    - Outdoor, underground conduit shall be Schedule 40 PVC.
    - Conduit under building floor slabs shall be Schedule 80 Polyvinyl chloride (PVC) or PVC coated rigid galvanized steel (RGS).
    - In maintenance areas, above floor conduits shall be RGS to height of 8 feet over finished floor. Above 8 ft, conduit may be electrical metallic tubing (EMT) unless installation location may be subject to damage from operations.

15.11.6.2 EMERGENCY POWER

A generator shall be provided for backup power unless a second independent feed from the utility company can serve as an equally reliable emergency power source. If an emergency power source is provided, it shall have adequate reserve to bring machinery to a safe shutdown condition, where required.

A natural-gas or diesel-powered standby generator shall be provided for the shop and the administrative areas. It shall have automatic startup capabilities upon failure of normal power, and re-transfer with adjustable time delays upon restoration of normal power. It shall be capable of supplying control system loads, including input to the uninterruptible power supply (UPS), for a minimum of 24 hours. Determine the necessary connected loads for the emergency system jointly with representatives of the Mechanical Department.

The yard control facilities shall have an emergency power system to meet the requirements of central station signaling systems (NFPA 72) and utilize an UPS. The system shall consist of a UPS capable of delivering a rated load at 480/277 V, three-phase, and a step-down transformer and distribution panels for 208/120 V single-phase and three-phase loads to meet yard control facility requirements. UPS batteries shall be capable of supplying a rated load for a minimum of two hours, or greater if required.

When two separate reliable services are available from the utility company, backup provisions may include a UPS with two hours UL-listed battery backup and an outdoor generator connection.

Other essential loads to receive emergency power include:

- Emergency lighting
- Fire alarm system and fire pump equipment
- Communications and computer networks
- Security system
- Elevators
- Signaling
- OCC
- ECC

UPS for fire alarm, communications, computers, security, and yard controls shall be provided (see Chapter 10, Communications).

15.11.6.3 GROUNDING

The building shall be grounded in full compliance with NEC and National Electrical Safety Code (NESC).

15.11.6.4 STINGER INTERFACE AND NEGATIVE RETURNS

The provisions of this section apply only to facilities serving an electric line.

A 750 VDC stinger shall be provided on some or all shop tracks to allow moving of trains into and out of the shop under their own power.

A 750 VDC substation located within the maintenance building shall be dedicated for shop power only and shall have a grounded negative return and be isolated from the yard traction power.

Shop tracks shall be grounded to the building ground and shall have isolation joints in the rails at shop entrances.

The stingers shall be interlocked with maintenance shop equipment and with platform locations, as indicated in the functional requirements for vehicle maintenance areas. Stingers shall be interlocked to bay doors. The stinger shall have a conductor-bar type arrangement running the full length of the S&I track or other tracks in the shop as required.

15.11.6.5 LIGHTING

Lighting shall be provided to achieve safe, reliable, and secure operation of the shop. Illumination levels are shown in Table 15-2.

The use of daylight for energy conservation is encouraged. Where daylight is used to supplement electric lighting, an evaluation shall be made to determine lighting zones and photoelectric control schemes to minimize required electric lighting.

Pit light fixtures shall be covered and impact-resistant, parabolic, and sealed per code.

Table 15-2. Illumination Levels		
	Illumination Levels (Foot-candles)	
Areas	Average, Normal	Minimum, Emergency
Vehicle Repair – Open Areas	50	1
Vehicle Repair – Pits	50	5
Component Shops	50	1
Storage Areas	30	1
Office Areas	50	2
Assembly Areas	30	2
Active Traffic Areas	25	1
Electrical and Mechanical Rooms	30	5
Entrance Lobbies	25	2
Platform	50	5
Under Platforms	50	5
Task Lighting	100	n/a

15.11.7 PLUMBING DESIGN REQUIREMENTS

Plumbing and drainage systems shall be provided throughout the shop building, as required to support maintenance and personnel operations.

15.11.7.1 PLUMBING SERVICES FOR VEHICLE MAINTENANCE

The following plumbing services and connections shall be provided in vehicle maintenance areas:

- Cold Water: Hose bibs or hose reels shall be located along vehicle maintenance tracks at the various levels (e.g., inspection pit, depressed floor, car floor, or roof level, where they exist) at spacing no greater than 50 feet. Hose bibs or reels shall also be provided in component shops as required by maintenance operations.

- Hot Water: Hot water bibs shall be provided in vehicle areas used to clean vehicles or components. Hot water bibs shall also be provided in component shops as required by maintenance operations.

- Service Fluids Dispensing: For dispensing gear oil, grease, windshield washer fluid, or other lubricating fluids required to maintain trains, a centralized dispensing system shall be provided for these fluids at shop vehicle maintenance positions used for periodic inspection and corrective maintenance.

- Waste Oil Collection

    - Portable waste oil collectors shall be provided at vehicle maintenance positions used for periodic inspection and corrective maintenance. A waste oil drain shall be provided to drain portable collectors on each shop track. The waste oil shall drain or be pumped to a central waste oil storage tank. The tank location shall be accessible so that a waste oil removal vendor can periodically remove and transport the waste oil from the building.

    - For diesel locomotives, a long probe connected to a hose and vacuum pump used to empty the engine’s sump shall be provided.

- Floor Drainage

    - Trench drains shall be provided on the interior side of shop exterior train and rollup doors and in the center of inspection pits or pedestal supported tracks.

    - Trench drains shall be provided along the vehicle drip line on shop tracks. The maximum distance between floor drains shall be 50 feet. Spot area drains are prohibited in vehicle maintenance areas.

    - Floor drainage within the vehicle maintenance areas of the building shall be classified as industrial waste and the collection system shall be separated from the building sanitary waste collection system. Industrial waste lines may tie into sanitary lines after treatment. Lines shall also be designed in accordance with all applicable regulations.

- Waste Piping: Industrial waste piping connections for steam and high-pressure cleaning equipment used in the vehicle repair or component repair areas throughout the shop building shall be provided.

- Emergency Eye Wash and Showers: Tempered and cold-water hookups throughout the shop vehicle maintenance area shall be provided within 55 feet of all hazardous work locations. Hazardous work areas include areas where a liquid could be splashed on a person, but also where dust and grit could get into a worker’s eyes.

- Oil/Water Separation or Pretreatment Facility: A facility for the treatment of industrial wastes to allow the treated effluent to be discharged into the sanitary system shall be provided. The facility shall be designed in accordance with all applicable regulations.

15.11.7.2 PLUMBING SERVICES IN SUPPORT AREAS

- Hot and cold-water service shall be provided, as required, for drinking fountains, urinals, toilets, lavatories, showers, and service sinks throughout the building.

- A sanitary waste collection system shall be provided to collect sanitary waste generated throughout the building.

- A gas piping distribution system shall be provided to distribute natural gas to heating appliances and equipment, as required, throughout the building.

15.11.7.3 COMPRESSED AIR SYSTEM

Compressed air shall be provided throughout the shop building to support vehicle maintenance operations. The system shall meet the following requirements:

- Compressed air outlets, typically with a filter, regulator, and lubricator, shall be provided along vehicle maintenance tracks at the various levels (e.g., pit, depressed floor, car floor, or roof level, where they exist) at a spacing of no greater than 50 feet maximum, with 30 feet maximum spacing in pits. Outlets shall also be provided in component shops and other support areas as required by the various maintenance functions in those areas.

- In areas where compressed air is used for blowdown cleaning or painting of the vehicles or components or parts, dry, non-oil lubricated air shall be provided, and breathable air shall also be provided for the safety of the workers involved in this work.

- A redundant compressed air plant shall be provided with a minimum of two compressors. The air plant shall be sized to maintain the system design load with one compressor out of service. The air plant shall also include an after cooler, dryer, and receiver, along with accessories required for a complete system. The system shall be designed for a nominal system air pressure of 140 psi.

- The air compressor shall be a variable speed, rotary vane, screw compressor.

- The dryer shall be of the refrigerated type unless the air is to be piped outdoors, in which case a heatless, desiccant-type dryer should be provided. Working pressure shall be 125 psi.

- Piping less than two inches shall be Type K or L copper tubing, hard drawn, Class 1 conforming to ASTM B88. Larger size piping shall be carbon steel with flanged pipe and fittings connections.

15.11.7.4 WATER CONSERVATION

Recycling of water shall be incorporated as an integral part of any train wash system. Rainwater harvesting and other conservation methods shall be investigated and implemented consistent with sustainability goals established for the project.

15.11.8 FIRE AND LIFE SAFETY DESIGN REQUIREMENTS

Fire protection systems shall be provided in accordance with the adopted version of the IBC, and the requirements listed in Chapter 14, Mechanical, Electrical, and Plumbing.

15.11.8.1 FIRE AND LIFE SAFETY IN YARDS

An adequate and reliable water supply shall be available for fire protection, including a sufficient number of properly located hydrants, in accordance with COMAR 29.06.01 and the AHJ.

The hydrant system shall be looped, with an isolation valve, in compliance with IBC and local municipal codes. Fire pumps, if required, shall be installed in accordance with code requirements.

Fire flow of 2,000 gallons per minute (gpm) at 20 psi shall be provided at hydrants within 500 feet of the most remote portion of the yard, in accordance code requirements.

Hydrant locations shall be configured no more than 300 feet apart throughout the yard, or as required by the AHJ. No hydrant shall be closer than 40 feet to any building as required by NFPA 24.

The required number of hydrants is determined by dividing the required fire flow for the yard by 2,000 and rounding up to the next whole number, or as otherwise required by the AHJ.

Hydrants shall not be closer than four feet to any fixed object, unless protected by guard posts, or as otherwise required by the AHJ.

Fire protection piping shall be schedule 40 steel meeting NFPA 13 requirements. Normally dry piping shall be galvanized.

15.11.8.2 FIRE AND LIFE SAFETY IN MAINTENANCE BUILDINGS

Planning the fire and life safety systems for maintenance buildings must address the needs of personnel, who are assigned full time in the building and are not transient like passengers in a station. Furthermore, personnel may be working in a pit under a car where emergency egress could be restricted. In some instances, these facilities may require a fire hazard analysis due to their unique layout and qualities.

Regardless of the specific function planned for a facility, designing for safety must be a high priority. Designers must spend sufficient time in a maintenance facility that performs similar functions observing the activities that employees perform.

New designs shall have sprinklers. Depending on the activity, fire extinguishers may be planned for designated spaces. Areas where welding and other heat-generating activities occur are common examples. Exiting paths must consider that a rail vehicle may be in the most-direct path to an exit. Effective fire protection systems may be a mix of different systems and shall be provided in accordance with the adopted version of the IBC, and the requirements listed in Chapter 14, Mechanical, Electrical, and Plumbing.

Emergency eye wash stations and showers shall be planned and included in the shop layout. Hazards requiring convenient access to eye washes include handling of chemicals and gases, but also areas where employees may be under a vehicle in a work pit or when the vehicle is on a lift. Dust and grit commonly are dislodged by maintenance work. See Section 15.11.7.1.

First Aid stations shall be located for convenient access from all work areas. Larger facilities may have a first aid room that is equipped to handle a wider variety of injuries or medical conditions, and where an emergency response team can meet a person requiring medical attention. If no first aid room is present, identify locations where emergency response teams can meet persons requiring medical attention as part of the site layout.

16. CREW FACILITIES (UNDER DEVELOPMENT)

17. VEHICLES

17.1 OVERVIEW

The purpose of this chapter is to establish the basic functional, operational, and physical characteristics of commuter rail vehicles used by Metra on its system, for the purpose of informing track, station, and system design. This chapter shall not be used for the design of new rail vehicles.

For the purposes of this chapter, the term “vehicle” describes rail vehicles used for passenger transportation on Metra’s system, including locomotives, passenger cars/coaches, and electric multiple units (EMUs). Some Metra track is also used by freight trains.

Metra’s trains fall into two categories: cars hauled by diesel locomotives, and EMUs operated on the Metra Electric District using the overhead contact system (OCS). The cars operate in trains that can range in size from two cars minimum to 12 cars maximum.

17.2 TRAIN CONFIGURATION

Metra typically operates its equipment in the following configurations:

- On diesel lines (lines other than the Metra Electric District), a train can consist of one or two diesel locomotives, between two and 10 passenger coach cars, and one cab car. The cab car is similar to the passenger coach car in that it provides passenger seating, but it also has an operator’s cab at one end of the car. Metra does not turn trains at terminal stations, so all trains operate in a push-pull configuration, where the locomotive(s) is always at the lead for the outbound trip (away from downtown Chicago) and the cab car is always at the lead for the inbound trip (towards downtown Chicago).
- On electric lines (the Metra Electric District), a train can consist of two to eight EMUs, operating in north-south married pairs (between one and four pairs per train). Each married pair is the same, but within the married pair the two cars differ with respect to interior configuration and on-board equipment.

New cars will be constructed so that they may be coupled to other conventional passenger cars, to include hotel power and locomotive control train line, and car control train line features.

17.3 CODE COMPLIANCE AND COMPATIBILITY WITH RAILROAD REQUIREMENTS

Vehicles are required to comply with the provisions of Americans with Disabilities Act (ADA). Compliance with applicable Code of Federal Regulation (Title 49) CFR sections is also required with specific focus on the section for light rail vehicles as defined in 49 CFR 38, Sections 38.71 through 38.87, especially boarding and alighting.

Since Metra operates in a complex environment involving interchange with other railroads, vehicles (other than those on the Metra Electric District) meet the clearance requirements of the following entities:

- Illinois Commerce Commission
- Amtrak (Chicago Union Station)
- Burlington Northern Santa Fe (BNSF)
- Canadian National (Illinois Division)
- Norfolk Southern
- Union Pacific

On the Metra Electric District, vehicles meet the clearance requirements of:

- Illinois Commerce Commission
- Chicago, South Shore and South Bend Railroad

17.4 VEHICLE CHARACTERISTICS

This section provides characteristics of Metra's existing fleet and high-level characteristics of future vehicle procurements.

All new vehicles shall be designed to operate at existing Metra facilities, and all new Metra facilities shall accommodate the existing Metra fleet. The standard characteristics of Metra's platforms are discussed in Volume 2: Stations and Parking.

Vehicles undergo inspection and maintenance at Metra yard and shop facilities. See Chapter 15 for information on the characteristics of these facilities. New vehicles shall be designed to interface with existing Metra facilities.

17.4.1 DIESEL LOCOMOTIVES

Metra's diesel locomotive fleet consists of EMD F40, F59PHI, and Motive Power (Wabtec) MP36PH locomotives. Characteristics for these locomotives are as follows:

	F40	F59PHI	MP36PH
Length	56’-2”	58’-2”	68’-0”
Width	10’-7”	10’-7”	10’-7 1/2"
Height	15’-7 1/2"	15’-7 1/2"	15’-6”
Weight	134 US tons on four axles	135 US tons on four axles	148.5 US tons on four axles

17.4.2 COACH CARS

17.4.2.1 BUDD CARS

Budd coach cars operate on Metra’s diesel lines. They are bi-level passenger cars with a vestibule mid-train for boarding. Each car contains a passenger toilet. Budd cars were manufactured and acquired between 1961 and 1980 and have since been rebuilt.

Description	Dimensions
Length (over coupler faces)	85’-0”
Width of Car (over handholds)	10’-4 3/4" or 10’-6 1/2"
Height of Car	15’-8 1/4” or 15’-11”
Track Gauge	4’-8 1/2’’
Weight (Empty)	Up to 122,000 lbs
Seating Capacity	Up to 157 passengers

17.4.2.2 NIPPON-SHARYO CARS

Nippon-Sharyo coach cars operate on Metra’s diesel lines. They are bi-level passenger cars with a vestibule mid-train for boarding. Each car contains a passenger toilet. Nippon-Sharyo cars were manufactured and acquired between 2002 and 2005.

Description	Dimensions
Length (over coupler faces)	85’-0”
Width of Car (over handholds)	10’-4 3/32”
Height of Car	15’-11”
Track Gauge	4’-8 1/2’’
Weight (Empty)	122,000
Seating Capacity	145 passengers 137 seated passengers plus 3 wheelchairs

17.4.2.3 ALSTOM CARS

Metra is in the process of procuring new coach cars from Alstom. These cars will be constructed so that they may be coupled to existing Metra passenger cars (on diesel lines).

Description	Dimensions
Length (over coupler faces)	85’-0”
Width	2,877 mm (approximately 9’-5 17/64”)
Height	4863.9 mm (approximately 9’-11 1/2")
Track Gauge	4’-8 1/2’’
Weight (Empty)	Up to 118,032 lbs
Weight (AW3)	Up to 186,395 lbs
Seating Capacity	Up to 152 passengers Up to 142 passengers plus 2 wheelchairs

17.4.2.4 FUTURE CARS

Future cars will conform to the following:

Description	Dimensions
Length (over coupler faces)	Not to exceed 85’
Width	Width will conform to the applicable clearance outlines for Metra, Amtrak, and host railroads
Height	Width will conform to the applicable clearance outlines for Metra, Amtrak, and host railroads
Track Gauge	4’-8 1/2’’
Weight	Total car weight shall be minimized; designs must include weight at AW0, AW1, AW2, and AW3.
Seating Capacity	Seating capacity will be maximized. Seating shall accommodate at minimum 2 passengers using wheelchairs, with folding seats available for use if no passenger using a wheelchair is present.

Cars will be designed accounting for the following passenger loading conditions:

- AW0: Working order – no passengers/car ready to go
- AW1: All seats occupied with passengers
- AW2: AW1 + 1 standee per 3 ft2
- AW3: AW1 + 1 standee per 1.5 ft^2

17.4.3 CAB CARS

17.4.3.1 EXISTING BUDD CARS

Budd cab cars operate on Metra's diesel lines. They are bi-level passenger cars with a vestibule mid-train for boarding and an operator's cab at one end. Each car contains a passenger toilet. Budd cars were manufactured and acquired between 1961 and 1980 and have since been rebuilt.

Description	Dimensions
Length (over coupler faces)	85'-0"
Width of Car (over handholds)	10'-4 3/4"
Height of Car (Diesel)	15'-8"
Centerline of Coupler above Top of Rail	2'-10 /2''
Track Gauge	4'-8 1/2''
Max Weight (Empty)	126,000 lbs
Seating Capacity	Up to 139 passengers

17.4.3.2 NIPPON-SHARYO CARS

Nippon-Sharyo cab cars operate on Metra's diesel lines. They are bi-level passenger cars with a vestibule mid-train for boarding and an operator's cab at one end. Each car contains a passenger toilet. Nippon-Sharyo cars were manufactured and acquired between 2002 and 2005.

Description	Dimensions
Length (over coupler faces)	85'-0"
Width of Car (over handholds)	10'-4 3/32"
Height of Car	15'-11"

Description	Dimensions
Track Gauge	4'-8 1/2''
Weight (Empty)	126,000
Seating Capacity	138 passengers 130 seated passengers plus 3 wheelchairs

17.4.3.3 ALSTOM CARS

Metra is in the process of procuring new cab cars from Alstom. These cars will be constructed so that they may be coupled to existing Metra passenger cars (on diesel lines).

Description	Dimensions
Length (over coupler faces)	85'-0"
Width	2,877 mm (approximately 9'-5 17/64")
Height	4863.9 mm (approximately 9'-11 1/2")
Track Gauge	4'-8 1/2''
Weight (Empty)	Up to 122,489 lbs
Weight (AW3)	Up to 188,361 lbs
Seating Capacity	Up to 134 passengers Up to 124 passengers plus 2 wheelchairs

17.4.4 EMUS

17.4.4.1 NIPPON-SHARYO HIGHLINER CARS

Nippon-Sharyo highliner EMU cars operate on Metra's electric lines. They are bi-level passenger cars with a vestibule mid-train for boarding and an operator's cab at one end. Each car contains a passenger toilet. The cars operate in married pairs such that the cabs of the two cars are at opposite ends of the pair. Nippon-Sharyo cars were manufactured and acquired between 2005 and 2014.

Description	Dimensions
Length (over coupler faces)	85'-0"
Width of Car (over side entrance threshold)	10'-6"
Height of Car	16'-2" (Pantograph locked down) 24'-8" (Pantograph extended; maximum wire height)
Track Gauge	4'-8 1/2''
Weight (Empty)	145,000
Seating Capacity	130 passengers 123 seated passengers plus 3 wheelchairs

17.4.4.2 FUTURE EMUS

Future cars will conform to the following:

Description	Dimensions
Length (over coupler faces)	85'-0"
Width of Car (over side entrance threshold)	10'-6"
Height of Car	16'-2" (Pantograph locked down) 24'-8" (Pantograph extended; maximum wire height)
Track Gauge	4'-8 1/2''
Weight (Empty)	145,000
Seating Capacity	130 passengers

Description	Dimensions
	123 seated passengers plus 3 wheelchairs

The cars and all appliances will conform to Metra clearances, as well as those of the Chicago, South Shore and South Bend Railroad.

The design will account for a crush passenger load of 100 standing passengers and a full seated load, at 155 pounds per passenger.

17.5 DESIGN CONCEPTS

This section summarizes some elements of vehicle design that interface with the design of other systems. If needed, additional data can be obtained from Metra Mechanical upon request.

17.5.1 MAXIMUM OPERATING SPEED

The design of the cars 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 mph.

17.5.2 FARE COLLECTION METHODS

Fares are collected on board Metra trains by conductors. Tickets may be purchased at ticket windows (in some stations), from Ticket Vending Machines (TVMs), from the Ventra cellphone app, or from the conductor.

17.5.3 ACCESSIBILITY

During normal operation, accessible boarding is provided at all side doors for all passengers including elderly persons and persons with disabilities, including those using assistive devices such as wheelchairs in accordance with the ADA requirements.

Metra Electric District stations use high-level platforms for boarding that are approximately level with the floor of the car vestibule. EMUs are equipped with roll-on bridge plates that cover the gap between the car vestibule and the high-level platform.

Metra's diesel-powered lines operate on track with low-level platforms. On these lines, each train has at least one lift-equipped car to provide access from low-level platforms. Each accessible car is identified with the international "access" symbol. Non-downtown platforms have an accessible boarding area or areas where the lift-equipped train car will stop for boarding. Each accessible car has two to three wheelchair areas for customers who prefer to remain in their chairs. Customers can also transfer to standard seats.

17.5.4 ERGONOMICS

The vehicles, their systems, and subsystems are designed in such a way as to be easy to use, simple, efficient, reliable, accessible, and safe for the widest possible range of passengers and personnel.

Establishing a good man-machine interface through ergonomic design is critical to vehicle functionality. The standard MIL-STD-1472F Department of Defense Design Criteria Standard – Human Engineering is the basis for the absolute minimum ergonomic requirements for vehicle design.

For minimum ergonomic design purposes, new vehicles are designed to accommodate passengers and personnel ranging from the U.S. 5th percentile female to the 95th percentile male. Current U.S. anthropometric details to be used are given in Architectural Graphic Standards, 10th edition – Section 1: Human Dimensions. Where these details are insufficiently comprehensive, MIL-HDBK-759C – Human Engineering Design Guidelines, Section 5.6, Tables 16a though 16f, General Forces are used.

17.5.5 ADHESION MANAGEMENT

The locomotives used on diesel lines are equipped with sand for the purpose of adhesion management. Cars on diesel lines and the EMUs are not equipped with sand.

Metra’s vehicle fleet is not equipped with wheel/flange lubricators. Metra uses wayside lubricators and manual applications of rail lubrication if needed. This use is typically a function of the degree of curvature and is used for rail wear reduction. Noise reduction is a secondary benefit.

17.5.6 NOISE

Metra vehicles comply with the requirements of 49 CFR Part 229 “Railroad Locomotive Safety Standards” as applicable.

On diesel lines, interior noise levels within the passenger compartment shall not exceed 65 Decibel A Scale (dBA) at a minimum at a location one 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 noise levels inside the compartment not exceed 60 dBA in a steady and/or steady but intermittent sound level classification and a preference that noise levels not exceed 70 dBA in a time varying and impulsive sound classification. Below is an example of sound classifications and operational activities:

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

Interior noise levels shall not exceed 70 dbA at a location one 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).

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.

On electric lines, interior noise levels within the passenger compartment shall not exceed 72 dbA at a location one 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).

Interior noise levels shall not exceed 78 dbA at a location one 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).

17.5.7 VEHICLE COMMUNICATIONS

Metra's vehicles are equipped with the following communications systems:

- Train-to-Wayside Radio System(s) – voice / data / Wi-Fi
- Train Management System/ACORN
- Passenger Compartment Digital Video Recording System

- Buzzer System
- Interior passenger area monitoring (Video Cameras / Recorder)
- Public Address (PA) System (interior, exterior)
- Passenger Wi-Fi Provisions, if applicable
- Automated Passenger Counting, if applicable
- Exterior Destination Displays, if applicable

The systems communicate between railcars using trainline connections.

Passenger cars have the following communication functions:

- One-Way communication from the train crew or engine control station to the passengers (Public Address System, Paging)
- Two-way Private communication between the engine control station and the train crew (Intercommunication System Function)
- Two-way communication between passengers and the train crew/engine control station (Emergency Passengers Inter Communication System Function)
- Two-way communication between the Train Information Management system servers and the Train information Management system on the train.

17.5.8 FLAMMABILITY AND SMOKE EMISSIONS

All materials used on passenger vehicles shall meet the fire performance requirements of National Fire Prevention Association (NFPA)-130 Fixed Guideway Transit Systems, Chapter 8. A series of fire performance analyses shall be undertaken to show that these requirements are fully met. This analysis shall include a materials flammability matrix, vehicle fire load estimate, heat release rate calculations, and independent laboratory test reports for all combustible materials. Any proposed variance to the specified fire performance requirements shall be included as part of this submission.

Applicable fire performance tests from

Table 17-1 for materials and components shall be performed to demonstrate compliance.

Materials used in the vehicle shall be tested to demonstrate compliance with the smoke and flammability requirements specified in

Table 17-1. The more restrictive requirements shall govern.

Materials tested for surface flammability shall not exhibit any flaming running or flaming dripping.

The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, according to FED-STD-191A, Textile Test Method 5830.

The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry cleaning, if appropriate, to American Society for Testing and Materials (ASTM) D2724. Materials that cannot be washed or dry cleaned shall be so labeled, and the manufacturer shall recommend and demonstrate compliance with appropriate performance criteria after being cleaned.

Seat cushion material to be tested for surface flammability and smoke emissions shall be first tested in accordance with ASTM D3574, Test I2, “Dynamic Fatigue Test by Roller Shear at Constant Force, Procedure B.” After conducting the roller shear test, the same test sample shall be tested for flammability and smoke emission. Test reports for the roller shear test shall be forwarded for review with the flammability and smoke emission test reports.

Electric wire insulation shall pass Institute of Electrical and Electronics Engineers (IEEE) 383, ICEA-S-66-524 and MIL-C-26240A smoke and flammability requirements.

In the event that elastomeric primary or secondary suspension parts are unable to meet smoke, flammability and functional requirements, specific materials may be granted a variance from smoke and flammability test requirements.

Table 17-1. Test Requirements for Passenger Vehicle Material Fire Risk Assessment

Function of Material	Test Procedures	Performance Criteria
Seat Cushion	ASTM D 3675 ASTM E 662 ASTM E 662	Is < 25 Ds (1.5) < 100 Ds (4.0) < 175
Seat Frame	ASTM E 162 ASTM E 662 ASTM E 662	Is < 35 Ds (1.5) < 100 Ds (4.0) < 200
Seat Shroud/Arm Rests	ASTM E 162 ASTM E 662 ASTM E 662	Is < 35 Ds (1.5) < 100 DS (4.0) < 200
Upholstery	FAR 25.853 (vertical) ASTM E 662	Flame Time < 10 sec. Burn Length < 15.0 millimeters [6 inches] Ds (4.0) < 200
Wall and ceiling panels, partitions, shelves, opaque windscreens (non-glass), end caps and roof housings	ASTM E 162 ASTM E 662 ASTM E 662 ASTM 1354-99 50 kW/m² applied heat flux with a retainer frame	Is < 35 Ds (1.5) < 100 DS (4.0) < 200 Average HRR@180 < 120 kW/m² Maximum HRR@180 < 140 kW/m²
HVAC Ducting	ASTM E 162 ASTM E 662 ASTM 1354-99 50 kW/m² applied heat flux with a retainer frame	Is < 35 Ds (4.0) < 100 Average HRR@180 < 120 kW/m² Maximum HRR@180 < 140 kW/m²
Windows/Windscreen (glass)	ASTM E 162 ASTM E 662 ASTM E 662	Is < 100 Ds (1.5) < 100 DS (4.0) < 200
Light Diffusers	ASTM E 162 ASTM E 662 ASTM E 662	Is < 100 Ds (1.5) < 100 DS (4.0) < 200
Flooring (Structural)	ASTM E 119	Pass (with a minimum 30-minute endurance period at AW3 loading) Alternatives to demonstrate safety may be proposed
Ceiling/Roof	ASTM E 119	Pass (with a minimum 15-minute endurance period) Alternatives to demonstrate safety may be proposed

Function of Material	Test Procedures	Performance Criteria
Flooring (Covering)	ASTM E 648 ASTM E 662 ASTM E 662	CRF > 0.5 W/cm2 Ds (1.5) < 100 DS (4.0) < 200
Thermal Insulation	ASTM E 162 ASTM E 662	Is < 25 Ds (4.0) < 100
Acoustical Insulation	ASTM E 162 ASTM E 662	Is < 25 Ds (4.0) < 100
Elastomers	ASTM C 542 ASTM E 662 ASTM E 662	Pass Ds (1.5) < 100 Ds (4.0) < 200
Exterior Shell including shrouding, equipment box covers, equipment boxes, and articulation section panels	ASTM E 162 ASTM E 662 ASTM E 662	Is < 35 Ds (1.5) < 100 DS (4.0) < 200
Battery Cases	ASTM E 162 ASTM E 662 ASTM E 662	Is < 35 Ds (1.5) < 100 DS (4.0) < 200

17.5.9 TOXICITY

All materials used in vehicle construction, except for materials used in small parts or quantities (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that would not contribute significantly to fire propagation or top smoke or toxic gas generation, are tested for toxicity using Boeing Specification Support Standard BSS-7239.

Materials shall meet the following maximum toxic gas release limits as determined per BSS 7239:

Carbon Monoxide (CO)	3,500 ppm
Hydrogen Fluoride (HF)	200 ppm
Nitrogen Dioxide (NO2)	100 ppm
Hydrogen Chloride (HCL)	500 ppm
Hydrogen Cyanide (HCN)	150 ppm
Sulfur Dioxide (SO2)	100 ppm

18. SYSTEM SAFETY AND SECURITY (UNDER DEVELOPMENT)

19. CYBERSECURITY (UNDER DEVELOPMENT)

APPENDIX A: ACRONYMS AND ABBREVIATIONS

ACRONYM	DEFINITION
AAA	Aluminum Association of America
AAR	Association Of American Railroads
AASHTO	American Association of State Highway Transportation Officials
ABET	Accreditation Board for Engineering and Technology
AC	Alternating Current
ACE	Access Control Enclosure
ACI	American Concrete Institute
ACS	Access Control System
ACSM	American Congress on Surveying and Mapping
ADA	Americans With Disabilities Act
ADAAG	ADA Accessibility Guidelines
AFF	Above Finish Floor
AGA	American Gas Association
AHDGA	American Hot Dip Galvanizers Association
AHJ	Authority Having Jurisdiction
AISC	American Institute of Steel Construction
AISI	American Iron & Steel Institute
AMPP	Association Of Material Protection and Performance
ANSI	American National Standards Institute
APTA	American Public Transportation Association
AREMA	American Railway Engineering and Maintenance of Way Association
ARI	Air Conditioning & Refrigeration Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, & Air Conditioning Engineers
ASJ	All-service Jacketing
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASTM	American Society of Testing and Materials
ATC	Automatic Train Control
ATS	Automatic Transfer Switch
AWG	American Wire Gauge
AWS	American Welding Society
AWWA	American Water Works Association
BAS	Building Automation System
BER	Bit Error Rate
BMS	Building Management System
BNSF	Burlington Northern Santa Fe Railway
BOCA	Building Officials Conference of America
BSS	Boeing Specification Support Standard
CADD	Computer Aided Drafting and Design

ACRONYM	DEFINITION
CBC	Chicago Building Code
CCD	Chicago City Datum
CCDD	Clean Construction or Demolition Debris
CCTV	Closed Circuit Television
CDOT	Chicago Department of Transportation
CDWM	Chicago Department of Water Management
CEC	Chicago Electrical Code
CFR	Code of Federal Regulations
CMU	Concrete Masonry Unit
CO	Carbon Monoxide
COTS	Commercial-Off-The-Shelf
CRSI	Concrete Reinforcing Steel Institute
CSI	Construction Specifications Institute
CTS	Communications Transmission System
CWR	Continuously Welded Rail
DAQ	Delivered Audio Quality
DC	Direct Current
DEF	Diesel Exhaust Fluid
DIO	Digital Input-Output
DMAN	Design Manual
DVF	Design Variance Form
ECC	Emergency Control Center
EIA	Electronic Industry Association
EIRP	Effective Isotropically Radiated Power
EMI	Electromagnetic Interference
EMS	Energy Management System
EMT	Electrical Metallic Tubing
EMU	Electric Multiple Unit
ENS	Emergency Notification Sign
EPR	Ethylene Propylene Rubber
FA	Force Account
FACP	Fire Alarm Control Panel
FCC	Federal Communications Commission
FCM	Fracture Critical Member
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FRP	Fiber Reinforced Polymer
FTA	Federal Transit Administration
FTP	File Transfer Protocol
GFI	Ground Fault Interrupter
GJB	Grounding Junction Box

ACRONYM	DEFINITION
HDPE	High-Density Polyethylene
HMA	Hot Mix Asphalt
HMI	Human Machine Interface
HVAC	Heating, Ventilation, And Air Conditioning
HWL	High Water Line
IBC	International Building Code
ICC	Illinois Commerce Commission
ICEA	Insulated Cable Engineers Association
IDOT	Illinois Department of Transportation
IEC	International Electrotechnical Commission
IECC	International Energy Conservation Code
IED	Intelligent Electronic Device
IEEE	Institute Of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IFB	Invitation For Bid
IJ	Insulated Joint
IMC	Intermediate Metal Conduit
IP	Internet Protocol
IR	Information Retrieval
ISA	International Society of Automation
KAIC	Kilo Ampere Interrupting Capacity
LCD	Liquid-Crystal Display
LED	Light Emitting Diode
LIQ	Letters Of Interest and Qualification
LLF	Light Loss Factor
LPR	License Plate Recognition
MED	Metra Electric District
MEP	Mechanical, Electrical, Plumbing
MIC	Microbiologically Induced Corrosion
MOT	Maintenance Of Traffic
MOW	Maintenance-Of-Way
MPR	Multi-Function Protection Relay
MRE	Manual For Railway Engineering
MSE	Mechanically Stabilized Embankment
MT	Magnetic Particle Testing
NACE	National Association of Corrosion Engineers
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code

ACRONYM	DEFINITION
NETA	National Electrical Testing Association
NFPA	National Fire Protection Association
NIMS	National Incident Management System
NTP	Notice To Proceed
NXDN	Next Generation Digital Narrowband
OCC	Operation Control Center
OCR	Overhead Conductor Rail
OCS	Overhead Contact System
OSHA	Occupational Safety and Health Administration
OUC	Office Of Underground Coordination
OWLS	One-Way Low Speed
PA	Public Address
PLC	Programmable Logic Controller
PM	Project Manager
POE	Power-Over-Ethernet
PPE	Personal Protective Equipment
PQR	Procedure Qualification Record
PS	Point Of Switch
PSE	Plans, Specifications, And Estimates
PTZ	Pan-Tilt-Zoom
PVC	Polyvinyl Chloride
REFC	Reinforced Epoxy Fiberglass Conduit
RFP	Request For Proposal
RGS	Rigid Galvanized Steel
ROI	Return On Investment
ROW	Right Of Way
RTU	Remote Terminal Unit
RWP	Roadway Worker Protection
SAW	Submerged Arc Welding
SCADA	Supervisory Control and Data Acquisition (System)
SCAT	Simple Catenary Auto Tensioned (System)
SCFT	Simple Catenary Fixed Termination
SCU	Station Control Unit
SMAW	Shielded Metal Arc Welding
SOE	Sequence Of Event
SSPC	Steel Structures Painting Council
SWAT	Single Contact Wire Auto Tensioned (System)
SWFT	Single Contact Wire Fixed Termination
SWPPP	Stormwater Pollution Prevention Plan
TBS	Tie Breaker Station
TCRP	Transit Cooperative Research Program

ACRONYM	DEFINITION
TPCQMP	Third Party Contracts Quality Management Plan
TPG	Through-Plate Girder
TPS	Traction Power System
TPSS	Traction Power Substation
TROI-NET	Real Time Train Arrival Display Systems
TRUs	Transformer/Rectifier Units
TVM	Ticket Vending Machine
TVSS	Transient Voltage Surge Suppressor
UIC	International Union of Railways
UL	Underwriters Laboratories
USACE	U.S. Army Corps of Engineers
UT	Ultrasonic Testing
VAC	Volts of Alternating Current
VMS	Video Management System
VPI	Vacuum Pressure Impregnated
VSWR	Voltage Standing Wave Ratio
WPS	Welding Procedure Specification
XHHW	XLP High Heat-Resistant Water-Resistant