Per the Washington Administrative Code 196-23-020:
“…Any final document must contain the seal/stamp, signature and date of signature of the licensee who prepared or directly supervised the work. For the purpose of this section "document" is defined as plans, specifications, plats, surveys, as-built documents prepared by the licensee, and reports.”

Preparation of this Document was directly supervised by the following licensed Civil Engineer:

E. Diana Timpson, PE

Approved: David Crippen, PE, Manager, Capital Project Delivery, Engineering Section

Date
TABLE OF CONTENTS

INTRODUCTION ........................................................................................................................................ 1

01 GENERAL ........................................................................................................................................ 3
   A. Engineering Deliverables Requirements ...................................................................................... 3
   B. Standard Contents: Introduction, Codes, Regulations, Authority Having Jurisdiction .......... 5
   C. Standard Contents: Design Criteria .............................................................................................. 6
   E. Standard Contents: Standard and Guideline Specifications ....................................................... 6

02 CIVIL ............................................................................................................................................. 8
   A. Civil Engineering Introduction, Codes, Regulations and AHJ ...................................................... 8
   B. Civil Engineering Design Criteria .................................................................................................. 9
   C. Civil Engineering Standard Plans .................................................................................................. 10
   D. Civil Engineering Standard Specifications and Guideline Specifications ................................ 11

03 STRUCTURAL ............................................................................................................................... 13
   A. Structural Engineering Introduction ............................................................................................. 13
   B. Structural Criteria: Design Loads and Performance Criteria ....................................................... 15
   C. Structural Criteria: Elements & Materials Guidelines ................................................................. 18
   D. Structural Criteria: Facility & Design Guidelines ....................................................................... 23
   E. Structural Plan Standard Requirements ....................................................................................... 30
   F. Structural Specifications Standard Requirements ......................................................................... 31

04 ARCHITECTURAL .......................................................................................................................... 33
   A. Architectural Requirements Introduction ..................................................................................... 33
   B. Architectural Criteria: Facility-Specific Program and Design Parameters .................................. 33
   C. Architectural Elements: Material Guidelines and Performance Requirements ........................ 35

05 MECHANICAL .............................................................................................................................. 40
   A. Mechanical Engineering Requirements Introduction ................................................................. 40
   B. Mechanical Engineering Criteria - General .................................................................................. 41
   C. Design Criteria for Fire Protection, Plumbing, HVAC and Mechanical Systems ....................... 43
   D. Design Criteria for Occupied Zones ............................................................................................. 45
   E. Design Criteria for Vehicle Maintenance and Industrial Zones ............................................... 46
   F. Design Criteria for Special Equipment ......................................................................................... 48
   G. Design Criteria for Mechanical Lifting Equipment ...................................................................... 54
H. Mechanical Engineering Standard Plans ................................................................. 55
I. Mechanical Engineering Guideline Specs ............................................................ 55

06 ELECTRICAL ......................................................................................................... 57
   A. Electrical Engineering Requirements Introduction ........................................... 57
   B. Electrical Engineering Criteria - General ....................................................... 58
   C. Electrical Engineering Criteria by CSI Specification Sections ..................... 60

07 TRACTION POWER SUBSTATION SYSTEM (TPSS) ........................................ 129
   A. TPSS Introduction, Codes, Regulations, Authority Having Jurisdiction .......... 129
   B. TPSS Design Criteria and Performance Requirements ............................... 130
   C. Standard Plans .............................................................................................. 136
   D. Standard Specs .............................................................................................. 136

08 OVERHEAD CONTACT SYSTEM (OCS) ............................................................ 137
   A. Introduction, Codes, Regulations, Authority Having Jurisdiction ............... 137
   B. OCS Design Criteria and Performance ................................................................ 138
   C. OCS Elements & Materials Guidelines ....................................................... 142
   D. OCS Design Criteria: Loading on Structures ............................................. 143
   E. OCS Standard Plans ...................................................................................... 146
   F. OCS Standard Specs ...................................................................................... 146

09 TRAFFIC ENGINEERING ...................................................................................... 147
   A. Traffic Engineering Requirements Introduction ......................................... 147
   B. Traffic Engineering Design Criteria ............................................................ 147
   C. Traffic Standard Plans, Standard Specifications and Guideline Specifications ... 151

10 REFERENCES ......................................................................................................... 152
   A. Referenced within this Document ..................................................................... 152
   B. Legacy Engineering Documents - For Historical Reference Only ............... 154
   C. Public Access Reference Documents - Available Online ............................ 156
INTRODUCTION

Purpose of Document

This document summarizes Engineering Section Design Standards and Guidelines applicable to preliminary engineering and final design of King County Metro Transit (“KCMT”) capital improvement projects. The document establishes processes and criteria for the KCMT Engineering Section project design deliverables.

The purpose is to provide a consolidated reference document for KCMT and its Consultants in the production of Engineering deliverables including Reports, Calculations, Drawings, Specifications, and other documents related to the design or a capital improvement for Metro Transit.

All Engineering work on KCMT Projects shall meet or exceed the applicable requirements of the Authority of Agency Having Jurisdiction (“AHJ”) to the maximum extent feasible.

This documents provides additional Agency criteria, guidance, institutional preferences, and clarification beyond AHJ requirements.

This document classifies its contents as either a KCMT Engineering Standard requirement or as a Guideline preference.

- Deviations from a Standard requires a formal Record of Decision in coordination with the Engineering Manager and the Engineer of Record (“EOR” whose seal appears on the final drawings or other deliverables).

- Guidelines indicate a strong preference by KCMT Engineering, and serve to provide a starting point and road map for internal projects by KCMT Engineering or an external consultant team.

The Engineering Manager shall make final determinations regarding the application of this document.

Deviation from Standards and Guidelines

KCMT delivers work in a world with social, environmental, political, and economical constraints and the delivery of work to solve problems may require non-standard solutions. Projects often require variance from applicable standards and guidelines for justifiable reasons.

Application of Guidelines shall be reviewed with relevant stakeholders and documented by the project team in meeting notes, decision log, and a Basis of Design report. The KCMT Project Engineer shall be responsible for determining documentation of these decisions based on project size, risk, and potential incorporation as an amendment to this document.

Proposed deviations from Standards requires formal review and documentation. The Engineer-of-Record (EOR) shall prepare a Deviation Request to include:

- Project information
- Source and description of the applicable design standards
- Description of proposed deviations
• Justification for deviations
• Mitigation against potential costs or liabilities

The Deviation Request shall include the KCMT Engineering final decision to be completed by the KCMT Engineering Manager. The Deviation Request shall be signed by the EOR and approved by the Engineering Manager.

The Engineering Manager shall determine if a deviation warrants incorporation into this document.

Precedence of Documents

Precedence of Documents is defined by the individual Project contract in General Requirements as established by Procurement.

Each project team shall consider the contracting method and the likely precedence of documents when utilizing standard plans and specifications.

Guideline Plans and Specifications referenced within this document are not suitable in place of engineered Contract Documents.

Should Agency, Jurisdictional, or Industry Standard standards, documents or directives contain conflicting information, the conflict should be brought to the attention of the EOR for a determination.

Reference Documents

External Reference Reports, Exhibits, Standards, and other documents are indicated **Bold and Italic with a Grey Highlight**.

References within the body of this document are summarized under Section 09 REFERENCES.

Documents are available by request through the KCMT Engineering Manager.

*[Links to be provided at a future date]*.
01 GENERAL

A. Engineering Deliverables Requirements

All KCMT projects that require approval of the Engineering Section shall comply with the requirements described in this Subsection A.

1) Quality Management

KCMT Engineering Section has developed an internal Design Quality Plan (DQP) to apply to all engineering deliverables that require Engineering Section approval.

The DQP addresses processes and requirements internal to the Engineering Section only. The DQP is not intended to replace a Project-specific QMP tempered to the risk, scale, funding for the project.

2) Sustainability and the King County Strategic Climate Action Plan

King County is committed to the design and construction of sustainable buildings and facilities. Sample sustainable design opportunities are provided in the King County Strategic Climate Action Plan (SCAP) and the associated King County Green Building Ordinance (KCBGO). The KC SCAP details priorities and commitments for reducing greenhouse gas emissions.

All projects are subject to King County sustainability requirements. The Sustainable Construction Certification type is determined for each project by King County, per the requirements set forth in the KCBGO. Current acceptable paths include but are not limited to King County Sustainable Infrastructure Scorecard, LEED, Living Building Challenge, and Energy Star.

The 2020 SCAP sets forth directives for all King County construction projects to support in practice.

The KCGBO sets forth guidance and provides tools for projects in support of this ordinance, required for consideration of application to all King County projects. Tools include the King County Sustainable Infrastructure Scorecard

Refer to discipline-specific sections for additional information.

3) Alternatives Analysis Report

An Alternatives Analysis is required for all projects undergoing standard Milestone/Gate review process, and is required by the SCAP.

The KCMT Project Engineer assigned by the Engineering Manager shall confirm requirements and assign responsibility for these studies at project start-up, and is responsible for final approval of the Alternatives Analysis and related documents.

The purpose of the Alternatives Analysis is to determine and evaluate alternatives for the project prior to advancing design. The Alternatives Analysis shall include evaluation and
documentation of the following:

- The existing conditions under evaluation for improvement, and Project (or Program) scope as defined by the Project Charter & Project Management Plan produced by Capital Project Delivery (CPD) Project Management.
- Risk assessment, and benefits of going forward w/ project.
- Methods and opportunities in support of the SCAP & KCGBO goals, including Equity and Social Justice (ESJ).
- Identification and documentation of permitting requirements.
- Pros and cons for each alternative including estimated construction cost, recommendation and justification for decision.

Additional requirements for Alternatives Analysis can be found in Discipline-specific sections.

4) **Life Cycle Cost Analysis (LCCA)**

The LCCA is required under the KCGBO and shall be performed early in the pre-design process. The LCCA shall be submitted to King County Metro Transit Capital Project Delivery, Engineering Section for Review and Approval. LCCAs be performed by using LCCA Tool available in KC Department of Natural Resources and Parks (DNRP).

- The LCCA shall include Operation and Maintenance costs and impacts over the life of the equipment. Alternatives Analysis shall include non-quantifiable O&M impacts such as costs associated to required downtime for preventative maintenance, repairs, required expertise and staff training, difficulties with maintenance, repair of proprietary equipment, and similar long-term concerns.
- LCCAs shall include the cost of disposal of hazardous waste and other regulated components
- The Social Cost of Carbon (SCC) shall be used in LCCAs when evaluating equipment that produces carbon emissions (including diesel generators).

Additional requirements for the LCCA can be found in Discipline-specific sections below.

5) **Code Basis of Design Report**

Establishing and documenting the design criteria for a project in a written Basis of Design prior to detailed engineering is a recommended best practice. Also recommended is confirmation by relevant stakeholders of the Basis of Design in writing before advancing work beyond conceptual design and using the same design criteria throughout the life of the project’s design phase.

The KCMT Project Engineer may require the development of a Code Basis of Design report to clearly identify applicable codes, design standards, and jurisdictional requirements for the engineering work products.
The KCMT Project Engineer is ultimately responsible for code compliance of engineering deliverables including contact documents for construction.

6) Calculations

Requirements are discussed in discipline-specific sections:

- Structural Calculations
- Electrical, Lighting
- Mechanical, Energy calculations
- Other code calculations such as Life Safety and Egress

7) Cost Estimates

Depending on scale of project, Cost Estimates may be required at all intermediate design milestones with the commensurate level of detail. An Engineer’s Estimate is required at 100% Bid Documents for Procurement.

The KCMT Project Engineer shall confirm Cost Estimating requirements and responsibilities at project start-up.

B. Standard Contents: Introduction, Codes, Regulations, Authority Having Jurisdiction

Subsections B through F define an outline and description of standard contents for each discipline section. This standard order of contents is adapted to each discipline for clarity of contents.

Each discipline EOR shall ensure that their respective engineering documents for KCMT Projects meet or exceed AHJ requirements applicable to the work.

The KCMT Project Engineer shall be responsible to ensure Construction Designs conform to the relevant codes, AHJ, testing data and industry advisory councils, associations, institutes, directives and standards applicable to the scope and content of the project.

Establishing jurisdictional authority and identifying the applicable regulations and design standards and guidelines for all project elements is the responsibility of the KCMT Project Engineer. This process typically involves research and documentation of project limits against municipal boundaries, elements of work with the relevant permitting authorities, and the process normally includes direct coordination with local agency representatives. The Project Engineer shall coordinate requirements with KCMT permit specialist(s) and environmental planners early in the planning phase. It is the Project Engineer’s responsibility to ensure the entire engineering team performs their work according to the applicable AHJ.

(See also Code Basis of Design.)

FM Global Recommendations:

King County is self-insured and as such FM Global does not dictate design criteria. Certain projects may undergo technical and quality assurance review. While KCMT takes these recommendations seriously, Engineering is not beholden to FM Global review recommendations.
C. Standard Contents: Design Criteria

Discipline Criteria may include multiple sections addressing one or more of the following:

- Performance Requirements
- Design approach and methodology
- Elements and Materials Standards and Guidelines
- Facility Standards and Guidelines

Additional requirements are included under discipline sections below.

D. Standard Contents: Standard Plans, Standard Drawing Requirements

Use of standard plans is encouraged by KCMT to address typical construction situations. Use of standard plans reduce construction and design cost and helps mitigate risk that materials and construction products are not available for procurement by a contractor in a timely and economic manner. Standard plans streamline fabrication, installation, and construction methods for specific items of work that occur on many projects.

- Any reference to standard plans in a contract drawing shall include the date of the standard plan.
- Standard drawings produced by others shall not be inserted into an engineered drawing prepared for a specific project to avoid the risk of “sealing” engineering work developed by others.
- It is recommended the standard plans applicable for the construction project be included within the project manual. King County Procurement may require standards be attached to the contract as a reference document.

Additional information on both Standard and Guideline Plans are discussed per discipline as available.

CAD Standards:

Designers shall ensure that drawing notes are clear and concise, and that generic terms for items on the drawings agree exactly with the terms used in Project Specifications and the Abbreviation Sheet.

Final as-built copies of all drawings shall be submitted to KCMT Design and Construction for reference.

Refer to KCMT COMPUTER AIDED DESIGN STANDARDS for CAD and graphic requirements for all KCMT Engineering drawings.

E. Standard Contents: Standard and Guideline Specifications

KCMT CPD Engineering subscribes to MasterSpec for all boilerplate CSI format specification sections. The subscription includes quarterly updates, software services for environmental certification criteria-specific language, and manufacturer/products confirmation services.
• All Project Specifications are to be prepared following Construction Specification Institute (CSI) format. Designers are referred to these documents for guidance in preparing project specifications.

• Projects that include significant horizontal work and/or work occurring within a public right of way may use alternate APWA formats in combination with CSI Format with advance approval of the KC Engineering Manager. See Section 02 CIVIL for additional information.

• Select Standard Specs and Guideline CSI Spec are provided by individual disciplines as referenced within that section of this document.

This document references an archived version of select Division 01: General Requirements - Guideline Specifications. These sections are required on all projects, using the most updated version provided by the KCMT Project Engineer and edited as required to comply with Project Requirements. Division 01 Specifications provided by Project Engineer shall be reviewed by the KC Construction Manager (KC CM) assigned to the project prior to issuing for bid or for construction, preferably at the 90% Milestone submittal or earlier. Coordination with KC CM to be coordinated by the KCMT Project Engineer and approved by the Engineering Manager.

All Guideline Specifications referenced in this document, including Division 01 Specs, require comprehensive review and customization to address specific project elements and constraints and the contractual mechanisms used to implement the project.

• Additional Division 01 General Requirements sections not included in the Guideline Specs may be required for a project as determined by the Project Engineer.

• Products, Materials and Equipment shall be specified for competitive open bid with performance characteristics and a minimum of two equivalent vendors. Sole source procurement may only be specified under unusual circumstances and requires advance approval in writing by the Procurement office.

• The KCMT Project Engineer is ultimately responsible for determining that Project Specifications are complete and accurate.
02 CIVIL

A. Civil Engineering Introduction, Codes, Regulations and AHJ

Deliver civil engineering work on Metro projects that meets or exceeds the AHJ design standard or guideline applicable to the work to the maximum extent feasible.

Traffic engineering elements (i.e., lane widths, ITS) are addressed in Section 08 TRAFFIC.

Civil Codes, Regulations and AHJ

The list below includes design manual, specifications and published guidelines that may be applicable to Metro project work. The KCMT Project Engineer shall identify and record the applicable design criteria after establishing the jurisdictional authorities on the project.

King County publications

- King County Surface Water Design Manual
- King County Stormwater Pollution Prevention Manual
- King County Drainage Maintenance Standards
- King County Site Management Plan (SiMPla)

King County Standard Plans and Drawings (as applicable)

Washington State Department of Transportation (WSDOT) publications

- Design Manual (M 22-01)
- Hydraulics Manual (M 23-03)
- Bridge Design Manual LRFD (M 23-50.15, December 2015)
- Geotechnical Design Manual (M 46-03.11)
- Utilities Manual (M 22-87)
- Local Agency Guidelines (M 36-63)
- Amendments and General Special Provisions (updated quarterly)
- Standard Specifications for Road, Bridge and Municipal Construction (M 41-10)
- Standard Plans for Road, Bridge, and Municipal Construction (M 21-01)

AASHTO publications

- A Policy on Geometric Design of Highways and Streets (current edition)
- Roadside Design Guide (current edition)

FHWA Publications
B. Civil Engineering Design Criteria

1) Transit Facilities Guidelines

The document **KCM Transit Route Facility Guidelines** contains extensive recommendations applicable to Metro project work, including guidelines and recommendations addressing vehicle and street design, lane widths, vehicle turning movements, bus stop and associated amenities, signage, and comfort stations.

This guideline document is generally not applicable to transit base work. The KCMT Project Engineer shall determine applicability of these guidelines to a specific project.

2) Turning Movement Analysis

AutoTURN analysis shall be used to confirm operations assumptions. **KCM Transit Route Facility Guidelines** provides commentary on this topic. Additional guidelines for turning movement analysis include:

It is generally good practice to test both 40 and 60 foot coaches, the two standard Metro bus vehicles. 40 foot coaches are generally the constraining vehicle for typical left and right turns, although 60 foot coaches may need more room to straighten out after a turn and align with a curb.

Community Transit and Pierce Transit operate 45 foot coaches on facilities that overlap with Metro service. 45 foot coaches can require more space than a 40’ coach to make similar movements. Consider both long and short term bus coach plans when evaluating turning movement needs.

Lane Splitting: Splitting lanes on the approach to a turn is not desirable, but is often necessary to negotiate a tight turn in an urban environment with constrained right of way. Lane splitting may be acceptable if the turning movement does not provide the opportunity for other vehicles behind the coach to move into the turning movement path while the coach is making the movement. Lane splitting is only permissible if the coach’s turning movement “prohibits” other vehicles from occupying the swept path space needed for the bus to complete the turn.

Field verification: Whenever possible, an on-site coach test should be performed to verify AutoTURN analysis results. Supervisors from Service Quality, Safety and Training shall be
invited to observe field verification tests of passenger facilities such as a transit centers and link light rail transfer stops.

3) **Turning Movement Analysis for Transit Operations At Bases / Site Work**

   To confirm planned operation assumptions, AutoTURN analysis shall be used. The KCMT Project Engineer shall confirm vehicle template / specifications with Metro engineering management and distribute this information as needed.

4) **Pavement Section**

   Pavement sections shall be developed to AHJ standards.

   It is recommended that concrete paving be used in locations of high transit use and locations of high transit turning movement locations.

   Desirable pavement design life for permanent facilities such as transit bases shall be a minimum of 30 years to minimize interruption to operations. A 50 year design life for base pavement is preferred. LCCA shall be performed by the design team to evaluate appropriate pavement section design life.

5) **Drainage Engineering**

   Civil engineering projects commonly require formal analysis and documentation of project impacts against relevant drainage regulations of the AHJ. This evaluation may identify requirements the project must address before the AHJ will authorize construction of the project. Examples of commonly occurring mitigation requirements by jurisdictional authorities include stormwater detention systems and stormwater roadway pollution treatment and water quality systems. System design shall provide fail-safe features, e.g., backup power for pumps, should they be used.

   Water discharged as industrial waste from Metro facilities shall meet the most stringent of King County Industrial Waste Discharge Standards and any other applicable discharge requirements. KCMT Project Engineer shall ensure that design criteria and maintenance practices shall be reviewed and approved by KCMT Environmental Compliance Officer.

   Consideration of maintenance access for drainage facilities shall be a requirement of the design team, e.g., detention vault shall have reasonable headroom for maintenance crew to enter and maintain the structure, and provisions for air circulation will be made for workers inside confined spaces. Best practice is to engage relevant maintenance representatives in the review of non-standard designs prior to final design.

   Materials used for detention structures shall not create environmental pollutants, e.g., corrugate pipes shall not be zinc coated. Use inert materials to the maximum extent feasible, such as HDPE (high density polyethylene) pipes.

C. **Civil Engineering Standard Plans**

   1) **Metro Standard and Guideline Plans**
Transit Passenger Facilities
Metro Standard Pavement Details

2) WSDOT Standard Plan Library

https://www.wsdot.wa.gov/Design/Standards/default.htm

3) Third-Party Standard Plans

As relevant to the work.

D. Civil Engineering Standard Specifications and Guideline Specifications

The Engineering Manager may approve the use of American Public Works Association (APWA) format specs on a case-by-case basis in combination with CSI format for:

- Long, linear projects with the majority of work in the right-of-way.
- Projects where the expected contractors typically deliver transportation agency work for the Washington State Department of Transportation or local agencies such as the City of Seattle DOT or the City of Bellevue.

Should a project utilize multiple specification styles in a contract together, it is critical that the specifications are clear and consistent in payment and responsibility of all parties.

In case of the use of APWA format specifications, note the following:

- While many jurisdictions bid projects via unit prices, Metro may bid lump-sum contracts, or a combination of unit pricing and lump sum bid items.
- Technical specifications shall not contain measurement and payment language which conflicts with other contract measurement and payment requirements.
- All typical WSDOT/APWA contractual clauses must apply to the Metro procurement. Non-pertinent clauses, such as inspection by WSDOT material engineers and WSDOT coordination requirements not applicable to the project, shall be removed.

The KCMT Project Engineer shall obtain concurrence from KC Procurement when APWA style specs are included in a contract package before advertisement.

APWA Style Specifications

Metro has prepared boilerplate specifications in APWA format - Technical Specifications Supplements (“TSS”) to Metro CSI tech specs: KING COUNTY DEPARTMENT OF METRO TRANSIT CAPITAL PROJECT DELIVERY TECHNICAL SPECIFICATION SUPPLEMENT. The TSS is in essence the WSDOT/APWA standard specs with all references of unit prices and non-contract specific items removed.

Third-Party Specifications

Contracts typically incorporate specifications developed by third parties to address work elements not typically found in Metro projects. Examples of this situation may include:
• Watermain material specifications required by a local jurisdiction
• Drainage conveyance material specifications required by a local jurisdiction
• Traffic Controller materials required for system compatibility
• Illumination system materials required for system compatibility
• Unique work elements, such as project artwork
03 STRUCTURAL

A. Structural Engineering Introduction

The KCMT Engineering design standard presents standardized design guidelines, installation and materials for structural elements. This design standard has the purpose of creating a consistent application of structural systems, materials and design criteria throughout KCMT facilities.

These standards are the minimum design standards to assist in planning and design. Compliance with these standards does not relieve responsibility of design engineers to apply professional judgement.

For additional information or questions, please contact KCMT CPD Structural and Architectural Engineering Manager.

1) Structural calculation requirements

The structural calculations become part of the building record, to be used in future building modifications. As such, the calculations shall be legible, logical, self-explanatory, complete, and easily followed.

- Final copies of stamped and signed structural calculations shall be submitted to KCMT Design and Construction for reference and review, prior to construction.

- Structural Calculations sheets shall be formatted, have a coversheet with Engineer’s stamp and signature. It shall include table of contents with all pages being numbered and initialized by the designer performing the calculations.

- All Computer outputs shall be legible and easy to read with appropriate titles and references and shall have all necessary key diagrams to allow evaluation of input and output data.

- All verifications shall be boxed by the engineer and state if the results are OK or Not OK.

2) Geotechnical report requirements

Final copy of geotechnical engineer’s report shall be submitted to KCMT Design and Construction for reference and review, prior to construction.

3) Codes, Regulations, Authority Having Jurisdiction

Construction Designs shall conform to the requirements of applicable codes, jurisdictional authority, testing data and industry advisory councils, associations, institutes, directives and standards applicable to the scope and content of the project. These may include, but are not limited to:

- Current edition of the International Building Code (IBC)
- Current edition of the International Existing Building Code (IEBC)
- Aluminum Association (AA)
- American Concrete Institute (ACI)
- Americans with Disabilities Act (ADA)
American Institute of Steel Construction (AISC)
American Iron and Steel Institute (AISI)
American Lumber Standard Committee (ALSC)
American National Standards Institute (ANSI)
American Society of Civil Engineers ASCE 7 – latest edition
American Society for Testing and Materials (ASTM)
American Welding Society (AWS)
American Wood Preserver’s Association (AWPA)
Architectural Woodwork Quality Standards (AWI)
Code of Federal Regulations (CFR)
Concrete Reinforcing Steel Institute (CRSI)
Consumer Protection Safety Agency (CPSA)
Department of Ecology (DOE)
Environmental Protection Agency (EPA)
Forest Stewardship Council (FSC)
Leadership in Energy and Environmental Design (LEED)
Master Painters Institute (MPI)
National Association of Architectural Metals Manufacturers (NAAMM)
National Fire Protection Association (NFPA)
National Lumber Grades Authority (NLGA)
National Paint & Coatings Association (NPCA)
Occupational Safety & Health Regulations (OSHA)
Paint & Coatings Industry (PCI)
Precast/Prestressed Concrete Institute (PCI)
Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA)
Society for Protective Coatings (SSPC)
Steel Structures Painting Council Specifications (SSPC)
Unified Numbering System for Metals and Alloys (UNS)
Uniform Building Code (UBC)
B. Structural Criteria: Design Loads and Performance Criteria

1) Dead Loads

a. Green roofs shall be designed for the actual weight of soil, planting, and finishes. Soil density shall consider soils to be fully saturated.

b. Roof design dead load for mechanical and electrical equipment – minimum 30 psf over and above the actual loads from mechanical and electrical equipment and systems such as: HVAC equipment, fans, etc., with a resulting minimum of 30 psf unused reserve dead load capacity. Roofs without mechanical or electrical loads and systems shall be designed with an additional 20 psf of unused reserve dead load capacity.

c. In addition to the self-weight of materials, the structure shall be designed to support the following superimposed reserve dead loads:

<table>
<thead>
<tr>
<th>Location and Type of Building Construction</th>
<th>Floor Added Reserve Dead (PSF)</th>
<th>Roof Added Reserve Dead (PSF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular – Single Story Metal Structures</td>
<td>5</td>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Modular - Single Story Wood Structures</td>
<td>5</td>
<td>5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Parking – Concrete or Post-Tensioned Structures</td>
<td>10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Facility - Maintenance or Repair Shops</td>
<td>10&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Facility - 1-4 Story Office / Operation Structures</td>
<td>15&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Facility - Pre-Manufactured Steel &amp; Metal Structures with Roof-Mounted Mechanical Equipment or Built-Up Roofing System</td>
<td>10&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>15&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes:
- For concrete and steel buildings, this load is in addition to the weight of floor slab and beams. For wood buildings, it is in addition to the weight of floor joists, plywood, concrete topping, and GWB ceiling.
- This load is in addition to the weight of roofing material and rooftop equipment.

2) Live Loads

a. Uniform and concentrated live loads shall be per the IBC.

b. Live load reduction is permitted within the requirements of the IBC.

c. For parking structures, the highest parking floor (if exposed to snow) shall be designed for a minimum unreducible live load of 65psf to account for a minimum of 40psf parking live load + 25psf snow load acting simultaneously.
d. Structured floors or lids over pits and vaults that are accessible to buses shall be designed for HS-20 live loading.

e. Floor live loads in rooms with equipment loading and the corridors supporting them shall be the following minimums:
   i. Battery storage = 350 psf
   ii. IT/server = 250 psf

f. Mechanical equipment rooms shall be designed for a minimum live load of 150psf

g. See local jurisdiction for fire truck loading requirements

3) Roof Live Loads

a. Design roof structures for applicable roof live load or for snow load, whichever is greater.

b. Minimum design roof live load is 20psf.

c. For concrete buildings, roof live load shall not be less than typical floor live load.

d. Roof beams and open web trusses that support a tributary area of 100 square feet or greater shall be designed for an additional point load of 2,000 pounds located at any location along the top of the beam to accommodate potential future equipment.

4) Snow Loads

a. Minimum design roof snow load is 25psf

b. Live load reduction may not be applied to snow loads

c. Evaluate roofs for drifting snow, including snow drifting against rooftop projects and roof-mounted equipment. Drifting snow may be evaluated as a separate design case from the minimum 25psf requirement.

5) Soil Loads

a. Maximum settlement
   i. Differential settlement of $\frac{1}{2}$” over 30ft
   ii. Total settlement of 1”

b. Below-grade structures shall be designed for hydrostatic pressures and/or buoyancy per the requirements of the geotechnical report.

6) Wind Loads

a. Reference the section on Deflection Limits for wind loading.

7) Earthquake Loads

a. For seismic mass calculations, include 10psf for framed partitions. This is in addition to the added reserve dead load in the table above.
b. Reference the section on Deflection Limits for seismic loading.

8) Deflection Limit

a. Vertical serviceability and deflections
   i. Elevator/Escalator Support Beams L/1000
   ii. Supports of Vibrating equipment L/800
   iii. Live load on floors in wood, steel, or concrete buildings
       Office and fitness/exercise rooms L/480
       Other rooms L/360

Note: L = Clear Span between supports

b. Lateral deflections (horizontal deformations) of the exterior wall shall meet the requirements of the IBC. All KCMT Facilities fascia deflections shall be limited to L/360 under wind and seismic unless approved otherwise.

9) Floor Vibration Requirements

a. Coordinate floor vibration limits with King County.

b. Parking Structures shall accommodate damping for expected service vibrations exceeding the comfort zone. This to be determined based on applied design span for the structure case by case. Analysis shall prove the vibrations are within an acceptable range. Designer shall submit proposed vibration design and acceptance criteria for King County review and approval at the start of the design phase.

10) Miscellaneous loads

Structures shall be designed to support load from other building components including, but not limited to:

a. Elevators
b. Escalators
c. Tooling
d. Cranes
e. Lifts
f. HVAC and mechanical or electrical equipment
g. High density filing systems
h. Window washing equipment
i. Fall protection
j. Cladding

C. Structural Criteria: Elements & Materials Guidelines

1) Concrete

k. Mix design

Use a waterproofing admixture for building slabs and walls below the water table or exposed to the elements, and parking garage decks exposed to the weather.

l. Reinforcing steel

Generally use 60ksi steel. Higher strength steel such as 75ksi or 80ksi may be used to reduce congestion in heavily reinforced members.

m. Material and Minimum Thickness

i. Minimum concrete slab on grade thickness shall be 6” reinforced concrete with minimum strength of $f'_c=4,000$ psi. Maximum concrete water/cement ratio shall be 0.45 for all structural concrete. Maximum spacing of slab reinforcing shall be 12”.

ii. Post-Tensioned concrete slab thickness for parking structures shall be 8-inch minimum. Provide 1.5-inch concrete cover at top of PT slab for added durability.

iii. Concrete floors in shop areas shall have a troweled in non-metallic surface hardener applied.

iv. Concrete exposed to freeze / thaw shall contain 5% air entrainment.

v. King County approved epoxy type bonding agent shall be used at all cold joints unless otherwise approved.

n. Structural Slab on Grade

i. Use 3” clear cover at the bottom of slab.

ii. Use 2-1/2” clear cover if slab is placed over a rigid surface.

iii. Use 1” clear cover to the bottom of slab cuts at top.

iv. Apply semi-rigid filler at joints exposed to vehicle traffics.

v. Minimum slab reinforcing bar is #4.

vi. Use minimum of (2) # 4 x 3’-0” reinforcing dowels at anchoring spots on the slabs each direction at the center of slab.

vii. Use minimum of (2) # 4 diagonal reinforcing at corners of openings. Provide references on structural details for size and locations.

viii. Provide pigmented, mineral dry-shake floor hardener in areas subject to frequent wear and tear. Hardener product shall be MasterTop 100 by BASF or approved
equal. Floor hardener should be applied to all work and maintenance floor surfaces. This would include all maintenance bays, steam bay, plus the parts, mechanical tool cage, KC shared tool area, machine shop and brake shop areas. The bottom of inspection pits are not subjected to heavy vehicular traffic, heavy carts etc. so does not need the surface hardener,

o. Non-Structural Slab

i. Provide reinforcing bars. Use of fiber reinforcement or welded wire reinforcement requires King County approval.

ii. Provide pigmented, mineral dry-shake floor hardener in areas subject to frequent wear and tear. See above for specification and locations.

p. Spread Footings

i. Self-weight of footing may be neglected for downward loads unless noted or advised otherwise by a Professional Geotechnical Engineer.

ii. Apply a minimum temperature reinforcing of .0018 in both directions at all spread footings unless noted otherwise by the Engineer of Record.

iii. Verify minimum footing size requirements with Professional Geotechnical Engineer.

q. Pile Foundations

i. Make sure 10% of total gravity loads are applied as a lateral load into the pile systems for pile foundation systems.

ii. Provide grade beams to structurally interconnect and lock the pile caps together. Provide thickened slab over the grade beams as part of this connectivity.

iii. Coordinate the design assumptions with a Professional Geotechnical Engineer to validate the design approach. Select pile foundation systems as appropriate for the anticipated soil conditions per the geotechnical report.

iv. Pile caps shall be designed to accommodate a 3” minimum misplacement of the pile in plan.

r. Basement Walls

i. Use 12-inch maximum center to center rebar spacing for vertical reinforcing bars.

ii. Use #5 rebar size as a minimum size for vertical reinforcing bars.

iii. Use 1-inch minimum cover at interior face (not exposed to water, moisture, or earth).

iv. Use 2-inch minimum cover at exposed face.
v. Use 3-inch minimum cover if cast on earth without any vapor barriers or exposed to water / moisture.

s. Anchorage to Concrete:
   
i. Post-installed anchors shall be accompanied with a current ICC-approved evaluation report. Anchors must be approved for use in cracked concrete in Seismic Design Categories D through F.

   ii. Provide continuous special inspection during installation of all adhesive anchors regardless of the orientation.

t. Rebar Doweling into Concrete
   
i. Post-installed rebar dowels shall be accompanied with a current ICC-approved evaluation report. System must be approved for use in cracked concrete in Seismic Design Categories D through F.

   ii. Provide continuous special inspection during installation of all adhesive anchors regardless of the orientation.

2) CMU
   
a. CMU block shall not be used for load carrying structure or members, and should be avoided for use in non-structural areas, if possible. If the use of CMU for non-structural application cannot be avoided, it shall be over-reinforced, with a maximum reinforcing steel spacing of 24 inches vertical and horizontal, and all cells shall be grouted solid.

b. The applied strength shall be not less than $f'm = 2000$ psi.

c. Provide vertical control joints in CMU walls at the lesser of 40ft spacing or 3*wall height.

d. Anchorage to Solid Grouted Masonry:
   
i. Post-installed anchors shall be accompanied with a current ICC-approved evaluation report. Anchors must be approved for use in cracked masonry in Seismic Design Categories D through F.

   ii. Provide continuous special inspection during installation of all adhesive anchors regardless of the orientation.

e. Anchorage to Hollow / Multi-Wythe Masonry:
   
i. Post-installed anchors shall be accompanied with a current ICC-approved evaluation report. Anchors must be approved for use in Seismic Design Categories D through F.

   ii. The appropriate size of screen tube shall be used per adhesive manufacturer’s recommendation.

3) Steel
a. Steel members shall satisfy the following material specification.

<table>
<thead>
<tr>
<th>Type of Member</th>
<th>Fy (ksi)</th>
<th>ASTM Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolled wide-flange shapes</td>
<td>50</td>
<td>A992</td>
</tr>
<tr>
<td>Square and rectangular HSS sections</td>
<td>46</td>
<td>A500, Grade B or C</td>
</tr>
<tr>
<td>Round HSS sections</td>
<td>42</td>
<td>A500, Grade B</td>
</tr>
<tr>
<td>Steel pipes, unless noted as A572 Fy = 50ksi</td>
<td>35</td>
<td>A53, Grade B</td>
</tr>
<tr>
<td>Plates, channels, angles</td>
<td>36</td>
<td>A53, Grade B</td>
</tr>
<tr>
<td>Threaded rods</td>
<td>36</td>
<td>A36</td>
</tr>
<tr>
<td>Anchor rods (hooked, headed, threaded, nutted)</td>
<td>36</td>
<td>F1554, Grade 36</td>
</tr>
<tr>
<td>Structural framing bolts</td>
<td></td>
<td>A325, Type 1</td>
</tr>
<tr>
<td>Hex nuts</td>
<td></td>
<td>A563</td>
</tr>
<tr>
<td>Flat circular washers</td>
<td></td>
<td>F436</td>
</tr>
<tr>
<td>Compressible-washer type direct-tension indicators</td>
<td></td>
<td>F959</td>
</tr>
</tbody>
</table>

b. Bar grating with frequent exposure to corrosive materials shall be molded FRP grating, not steel.

c. KCMT Engineering prefers Steel Braced Frame (SCBF / SBF) systems with steel stud and steel siding wall systems located outside of the main steel structure. This provides maximum flexibility for any future tenant improvements as well as ease for repairing the structural damages after an earthquake. In areas of vehicle or equipment traffic, reinforced concrete precast wall panels 4’ in height located outside the main steel structure shall be used to protect the building walls / structure from vehicle and equipment damage.

d. Braces shall be capable of carrying tension and compression. Tension-only bracing requires King County approval.

e. Bracing / lateral system shall have redundancy in major lateral directions, so a single failure does not result in a catastrophe or subsequent failures within overall structure.

f. Provide adequate baseplate geometry to allow for field tolerance of anchor bolt installation. Maintain clearances, including:

i. Minimum edge distance from anchor rod to edge of base plate per AISC 360 Chapter J3. Account for the effects of oversized holes per AISC Steel
Construction Manual Chapter 14. Edge distance shall not be less than twice the anchor rod diameter.

ii. Adequate clearance from anchor rod and plate washer to clear the face of column and its weld to the baseplate.

iii. Minimum anchor rod spacing per AISC 360 Chapter J3.

G. Main structural steel shall be ASTM A992 for rolled shapes, ASTM A500 Grade B for steel tubing.

H. Metal roof decking shall be welded to the steel roof structure. Shot-in or powder actuated fasteners shall not be used.

I. Structural connection bolts shall be ASTM A325 or ASTM F1852.

J. Anchor bolts shall be ASTM F1554, or ASTM A36 threaded rod, unless otherwise approved by the County.

K. All welds to the steel lateral resisting system shall be MT or otherwise inspected.

4) Timber, Cold-Formed Steel, and Finishes

A. Interior wall steel studs shall be a minimum of 33 mils (20 gage) steel, and top & bottom tracks shall be a minimum of 54 mils (16 gage) steel. Maximum stud spacing shall be 24 inches.

B. Exterior wall steel studs shall be a minimum of 43 mils (18-gauge) steel, and top & bottom tracks shall be a minimum of 54 mils (16-gauge) steel. Maximum stud spacing shall be 16 inches.

C. The top of interior GWB / steel stud walls shall be laterally supported at not more than 12’ on center.

D. GWB shall have a minimum of 5/8” thickness.

E. Exterior metal siding and roofing panels shall be a minimum of 22-gauge steel.

F. Concrete pavement shall be used in all fueling areas.

G. Exterior metal doors shall be insulated and shall have insulated metal frames.

H. There shall be roof access from a steel stair assembly located at an exterior wall of the building, or interior stair tower with penthouse.

I. Exterior roof edges, and edges of raised roof sections shall be provided with an OSHA approved fall protection railing system.

J. Stairs shall be capable of accommodating two times the maximum building seismic deflection without loss of vertical support. This is in addition to the requirements of ASCE 7 Chapter 13. This provision is intended to minimize damage to egress stairs following a seismic event.
k. At building or fascia joints where substantial lateral movements are expected, apply proper seismic joints detailing to accommodate the inelastic movements as prescribed per International Building code.

D. Structural Criteria: Facility & Design Guidelines

1) **General Requirements**

a. Mechanical rooms and equipment housekeeping
   
i. For Housekeeping Pads, verify if concrete damping pads are required.

ii. Provide curbs for containing the industrial spills.

iii. Control vibrations during operations.

iv. Any floor penetration locations to be coordinated with Engineer of Record.

v. Arrange supports to properly distribute the operational loads over the structural floor system.

b. Fall Protection

   i. Adequate factors of safety to be built into the connections and fasteners that are designed to attach to the main structural elements for the required suspension and impact loads as defined in International Building Code. Calculations to be provided by the contractor or the consultant responsible for the design and submitted to King County Engineering for review.

2) **Additional Requirements by Building Type**

a. Structured Parking

   i. Post-Tensioning Requirements

      a) Provide 150 psi minimum precompression for typical floor slabs and beams. Provide minimum 200psi precompression at roof slab to added durability.

      b) Slab Tensile Stresses:

         Top and Bottom Stresses to be Less than $6f'_c$

      c) Beam Tensile Stresses:

         Top Stresses to be Less than $6f'_c$

         Bottom Stresses to be Less than $7.5f'_c$

         Bottom Stresses with Snow Loading to be Less than $7.5f'_c$

      d) Bottom Clear Covers to Reinforcement:

         Clear Covers for post-tensioning cable to be established for restrained and unrestrained bays. Provide cover for a 3 hour fire rating for structures
without sprinklers, and a minimum of a 1 hour fire rating for other structures. In no case shall the clear cover be less than 1-inch for the restrained (interior) bays nor less than 2” for unrestrained (exterior) bays, unless noted otherwise by the Engineer with adequate justification (as open structure, not critically exposed to fire).

e) Clear Covers for Rebar (mild reinforcement) shall not be less than ¾” and not less than 1-1/4” (based on 3 hours of fire rating) for bottom of slab, unless noted otherwise by the Engineer of Record with adequate justification (as open structure, not critically exposed to fire).

f) Top Clear Covers to Reinforcement:

Reference Bottom Clear Covers. Except provide 1-1/2” cover for protection against vehicle traffic.

g) Where fire rating differs across a floor, consider using the most conservative clear cover throughout

ii. Slope floors to drain. Provide an average slope of 1/4” in 12” slope with 3/16” in 12” as absolute minimum. Provide one drain for every 6,000SF – 8,000SF (i.e. approximately one drain for every two framing bays.)

iii. Slope of ramps with parking stalls is preferred to be 5%. Maximum allowable slope is 6%. Parking floor shall meet ADA requirements, where applicable.

iv. Truck Loading Consideration

This is to address the ability of pavers and slabs to withstand fire or heavy truck loading. This is due to the extremely high axle weights expected to exert high loads on structural slabs and paving elements.

Interlocking concrete pavers have been proven to provide a durable system. ASCE / T& DI and AASHTO is a proper resource for design and loading criteria of pavers.

Wheel and Axle Loading Conditions and Configurations from AASHTO are shown below for reference as an example. The Lid of concrete vaults, elevated or flat slabs, pavements need to be designed to sustain these anticipated loads. When the stabilizer outriggers are in place, a point load of as much as 45,000 lbs. This can be applied to the surface and distributed over an unfactored surface area of almost 0.97 square feet (10-inch x 14-inch) area or conservatively over 64 square inch area that equates to an additional imposed pressure of 322 psi to 700 psi over the surface which designer needs to take into account in addition to what it is normally designed for.
v. Top Level Considerations

The following options shall be considered to account for added thermal loading and moisture at top levels exposed to weather.

a) penetrating sealers
b) additional air entrainment
c) reduced water/cementitious material ratio
d) higher concrete compressive/tensile strength
e) Apply better curing procedures.
f) Provide waterproofing admixture

vi. Special Considerations

a) Long span slabs and beam to be designed by EOR. But keep a Minimum Slab Thickness of 5 inch as part of design:
• Typical Beam Width shall never be less than 16 inch wide. In the case of using a waffle or tapered beam system, a minimum of 15 inch width at the bottom of the beam is acceptable.

• Typical Beam depth shall never be less than 16 inch deep

• Minimum Column Width (Perpendicular to beam span direction) = Nominal Beam Width + 2" on each side of the beam at the widest point (typically the top). Example: 16" nominal width beam is approximately 18" wide at top; 18" + 2" + 2" = 22" minimum column width perpendicular to the beam span direction.

b) Check Column Ties at Crossing or Splitting Ramps. Tie spacing of columns at these locations shall not be less than 5-inch on center.

c) Depressed slabs at entries and water closets

d) Account for any additional mechanical unit loads imposed on the surfaces.

e) Account for any special truck loading required to travel over the surfaces during and after construction. The conditions to be reviewed by Engineer of Record (EOR).

f) Vibrations to be checked at large mechanical units under continual operations.

g) Large escalator reactions and associated vibration issues

h) Large mechanical duct depths that may affect structural member depths and floor clear heights

i) Additional heavy load requirements for move-in and stock areas

j) Heavy exterior cladding systems

k) Heavy, expensive crack sensitive floor coverings and topping slabs

l) Provide tendon marking at bottom of P/T slabs.

m) Consider the use of bonded cable to allow for future penetrations. Investigate cost differences carefully.

n) Future penetration problems can be minimized by bundling post-tensioning tendons and spacing the bundles as widely as possible.

o) Provide waterproofing above rooms containing electrical equipment or similar. Extend waterproofing membrane or traffic coating a minimum of 10ft in plan beyond the extents of the room being protected.

b. Bus Maintenance Facility
i. Structure shall be designed to support hose reels considering hoses are full with fluid. Provide adequate lateral bracing.

ii. Provide waterstops at concrete construction joints in all pits.

iii. Utilidor trench covers shall be removable with cast-in-place inserts for lifting. Provide steel edging within the removable panel and at the exposed edge of the receiving slab/wall to resist concrete chipping.

iv. Design floor slabs to support forklifts and mobile lifts that will be used in the shop floors.

v. Coordinate support requirements for overhead cranes with the crane manufacturer requirements.

c. Tilt-Up Construction

i. Tilt-Up Construction shall not be used unless specifically approved by King County Engineers.

ii. Provide wall panel-to-panel connections at outside corners to help prevent thermal bowing.

iii. Lap splices are not permitted for vertical wall reinforcement.

iv. Concrete cover on wall reinforcement shall consider the impact of reveal strips.

d. Modular Wood Structures

i. Modular building design shall be in conformance with the IBC, including loading per ASCE 7.

ii. Deflection limits:
   a) L/360 for live load of vertical and horizontal elements
   b) L/240 for total load of vertical and horizontal elements

iii. Use i-joists for buildings more than two stories high.

iv. Use engineered lumber for rim boards and solid blocking at bearing walls.

v. Provide redundancy for the lateral resisting framing system in main directions.

vi. Provide adequate tiedown anchoring systems for the lateral resisting shear walls.

vii. Do not allow horizontal joints in plywood sheathing for the 4 feet from ground to help the lateral loads to properly transfer to the foundation supporting elements. This ensures load path continuity at the critical parts of the structure through joints and connections.

viii. Clarify Nail Types and applied locations for skirting walls.

ix. Avoid Toe-nails when elements are expected to be in tension.
x. Account for uplift for vertical upward load of floors and roofs. Provide hurricane clips where each roof truss connects to the vertical studs below to secure and resist anticipated wind suctions at or along perimeters, corners, and eaves of the building.

xi. Indicate how modular units attach to one another side by side and demonstrate the load path for lateral and vertical components are maintained.

xii. Account and resolve eccentricities associated with one sided sheathing that is supporting exterior studs.

xiii. Provide clear details for tie-downs, drive-pin washers, or hold-downs at foundation.

xiv. A direct load path continuity shall be maintained from roof to the foundation.

xv. Allowable soil bearing pressure shall not exceed 1,500psf if a geotechnical report is not available. Otherwise, use the recommended values and parameters per the geotechnical report.

xvi. Helical pile anchors are preferred for resisting uplift. King County approval is required to use other foundation anchors, including drive pins. Provide allowable uplift and shear capacities of the foundation anchoring system along with stamped calculations showing that the provided anchor components have adequate capacity.

xvii. Detail the support and their connections to resist uplift and overturning forces. All supports must be able to carry tension loads all the way down to the surface of the pavement.

xviii. Bottom of modular unit framing must be at least 2’-6” clear above grade to provide adequate crawl space for future maintenance of the structure as needed.

xix. Designer to coordinate with other disciplines for any additional attachments to the structure as needed.

xx. All computer aided calculations shall be clear and legible, shall have joint and membe number key diagrams and load idagrams, and shall have proper references to the plans for designated elements shown in the calculation for the given design.

xxi. Provide a signed cover letter indicating that a quality check on the calculations as well as third party hand verifications have been conducted on the processed information prior to submitting them to King County.

e. Pre-Engineered Metal Building

i. Deflection limits:

   L/360 for live load of vertical and horizontal elements
L/240 for total load of vertical and horizontal elements

ii. Use $F_y = 50$ ksi or better for elements.

iii. Use $F_y = 36$ ksi for Fascia and Exterior Decking’s.

iv. Base plates shall be ASTM A36 ($F_y = 36$ ksi).

v. HSS shall be ASTM A500 Grade B ($F_y = 46$ ksi).

vi. Structural steel bolts to be ASTM A325.

vii. Anchor rods shall be stainless steel headed bolts with a minimum diameter of 1 inch. Acceptable grades include ASTM F593 and ASTM A193 Grade B8 with stainless steel nuts per ASTM F594 and stainless steel washers. Provide separation between dissimilar metals to prevent galvanic corrosion.

viii. Fully develop anchor rods into the foundation.

ix. Structural steel welding shall be per AWS D1.1 with E70XX at minimum.

x. Brace all Exterior Walls on all four sides of the structure.

xi. Provide redundancy for the lateral resisting framing system in main directions.

xii. Provide adequate tiedown anchoring systems for the lateral resisting shear walls and braces.

xiii. Do not allow horizontal joints in exterior metal sheathing for the 4 to 6 feet from ground to help the lateral loads to properly transfer to the foundation supporting elements. This ensures load path continuity at the critical parts of the structure through joints and connections.

xiv. Clarify Screw Types and Locations.

xv. Provide continuous C-shaped track at top and bottom of metal stud wall frames. Furnish ICC report for each type of anchor. The interior partition studs shall be non-bearing walls with deflection gap to allow for floor or roof deformations without loading the walls.

xvi. Account for uplift for vertical upward load of floors and roofs.

xvii. Indicate how modular units attach to one another side by side and demonstrate the load path for lateral and vertical components are maintained.

xviii. Account and resolve eccentricities associated with one sided sheathing that is supporting exterior studs.

xix. Provide clear details for tie-downs, drive-pin washers, or hold-downs at foundation.
xx. Contractor must furnish ICC test report for each type of anchor proposed for use. Wedge anchors cannot be removed once installed. Top portion may be cut off, but the rest of the anchor remains.

E. Structural Plan Standard Requirements

In addition to the requirements of the IBC Chapter 16, the following structural design criteria shall be listed in the structural drawings:

1) Building Category
   a. Structural Risk Category

2) Roof Loads
   a. Roof live load

3) Roof snow load
   a. Importance factor for snow
   b. Roof superimposed dead load
   c. Roof reserve dead load

4) Floor loads
   a. Floor live load
   b. Floor superimposed dead load
   c. Floor reserve dead load

5) Wind loads
   a. Basic design wind speed, $V_{ult}$
   b. Allowable stress design wind speed, $V_{astd}$
   c. Importance factor for wind
   d. Exposure category
   e. Internal pressure coefficient, $C_p$
   f. Topographic factor, $K_t$
   g. Directionality factor, $K_d$
   h. Enclosure classification
   i. Guest effect factor, $G$

6) Seismic loads
   d. Importance factor for seismic
e. Site Class
f. Design spectral accelerations, Sd₁ and Sd₂

g. Seismic design category

h. Seismic force resisting system

i. Response modification coefficient, R

j. Seismic response coefficient, Cₛ

k. Seismic analysis procedure with ASCE 7 reference

7) Other loads

a. Operating weight of mechanical equipment and its location

8) List the following concrete mix design criteria in the structural drawings or specifications:

<table>
<thead>
<tr>
<th>Mixed Material Type</th>
<th>Specification Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland Cement</td>
<td>Type 1 – ASTM C150</td>
</tr>
<tr>
<td>Fly ash (as applicable)</td>
<td>ASTM C618 Class F or C</td>
</tr>
<tr>
<td>Slag cement (as applicable)</td>
<td>ASTM C989</td>
</tr>
<tr>
<td>Light weight aggregate</td>
<td>Light weight aggregates shall not be used without prior approval of King County</td>
</tr>
<tr>
<td>Normal weight aggregate</td>
<td>ASTM C33</td>
</tr>
<tr>
<td>Sand</td>
<td>ASTM C33</td>
</tr>
<tr>
<td>Water</td>
<td>Potable per ASCM C94</td>
</tr>
<tr>
<td>Air entraining admixture</td>
<td>ASTM C260</td>
</tr>
<tr>
<td>Chemical admixture</td>
<td>ASTM C494</td>
</tr>
<tr>
<td>Flowable concrete admixtures</td>
<td>ASTM C1017</td>
</tr>
</tbody>
</table>

F. Structural Specifications Standard Requirements

KC Metro Transit Guide Specifications are the current subscription to Master Specifications. A current copy from MasterSpec shall serve as the starting point for Structural Specifications for individual projects, as appropriate.

- It is critical that each design project be thoroughly considered in detail. Specifications applicable to the constraints of the project shall be chosen for use, evaluated and edited to produce Contract Documents that are current with quality assurance standards, available materials, manufacturers and methods of execution suitable for efficient bidding and construction.
• Special Note: Specify floor flatness and levelness. Shop areas shall have specified overall values of flatness, F(F) 45; and of levelness, F(L) 35; with minimum local values of flatness, F(F) 30; and of levelness, F(L) 24.

• Final copies of the construction specifications shall be submitted to KCMT Design and Construction for reference and review, prior to construction. The specifications shall be in both paper form, and electronic form (Microsoft Word format).
04 ARCHITECTURAL

A. Architectural Requirements Introduction

The King County (KC) Metro Transit Engineering design standard herein presents standardized design guidelines and materials specification guidance for Architectural systems and configurations. This design standard provides for consistent application throughout KCMT facilities and projects involving building-related systems. This includes new facility design or modifications to existing facilities, site, access features, and equipment systems. These standards represent current minimum design standards determined by King County Metro Transit to meet the Agency's long-term requirements and goals. Compliance with these standards does not relieve the user of responsibility for due diligence and the application of professional judgment.

Codes, Regulations, Authority Having Jurisdiction

Projects shall conform to the requirements of State, Local and Federal regulations as applicable to their program and locations, and as enforced by the Authorities having Jurisdiction. This may include, but is not limited to Local Municipal/Zoning and Building Codes, Washington State Labor and Industries requirements, Federal ADA and ANSI 117 requirements.

B. Architectural Criteria: Facility-Specific Program and Design Parameters

1) General Architectural Criteria: Common to all project types

   a. Architectural design shall be determined by Transit Stakeholders. Stakeholders will typically be identified by KCMT Management during the Planning phase, and may include representatives of the facility occupants and system users, Department/Division leaders, funding authorities, Engineering and Architecture subject matter experts, and Safety/Security professionals. Coordination and integration of new facility designs with neighborhoods, communities, partner agencies and infrastructure authorities is required, and starts during the Planning phase.

   b. Durability and maintainability of facilities and improvements, and compliance with and support of King County and Metro Transit's sustainable construction goals shall be prioritized.

   c. Coordination with other disciplines to encompass a well-rounded consideration of safety, security, and hazards specific to Transit Maintenance, Operations, Passenger and other facilities is required. CPTED design principles shall be considered early in the Design phase.

2) Architectural Design Criteria for Site

   a. Requirements for vehicular and pedestrian site access shall be coordinated with Civil Design during the Planning phase, and considered in both site and building programming. Site design shall prioritize durability and maintainability; refer to Section 02 CIVIL of this document for further guidance.
b. When locating building on site, consideration shall be given to passive ventilation, passive solar for lighting and heat gain, and optimal placement of on-site solar generation. Per SCAP 2020, Strategy APX8:

“For new construction, on-site solar generation shall be installed to meet the equivalent of the City of Seattle code requirements below

Construct all new buildings according to sections C411 and C412 of the 2018 City of Seattle code requirement of 0.25 watts of on-site solar photovoltaic power generation per conditioned square foot, or to any higher-level solar code that is established by a jurisdiction in King County

All new construction building projects shall evaluate solar system sizes beyond this standard, and install the largest-sized system that is life cycle cost-effective over a 20-year system life”

3) Design Criteria Specific to Comfort Stations

Function, type, and program of comfort station shall be determined with King County during the Planning phase. Programmed requirements vary and will be determined by King County prior to commencement of design. Existing facilities and those nearing construction as of September 2020 include:

a. Freestanding single occupant restroom facility
b. Freestanding double-occupant restroom facility
c. Single-occupant restroom in a new facility with adjacent break/work room
d. Multiple single-occupant restrooms in a new facility with adjacent break/work room, IT room, lactation room, and custodial room
e. Added single-occupant restroom facility within an existing building

4) Design Criteria Specific to Design of New or Modifications to Existing Transit Maintenance, Operations, or other Facilities

Discussion with King County prior to the design phase is required for specific program requirements of every project. Programming of requirements is a part of the Planning phase, subject to refinement by subject matter experts and Design Engineers and Architects during the Design Phase. This Document addresses Standards and Guidelines for the Design phase.

Regarding security, the interior layout of a multi-function Transit support building typically can identify three “security zones”:

a. Areas open for common use during usual hours of operation
b. Secured areas and rooms restricted to certain personnel or accessible at certain times
c. Dedicated rooms for access only to assigned personnel. KCMT facilities’ key plan and electronic access control system are based on these zones. Changes to the key and/or
electronic access are to follow KCMT security protocols. Confirm current protocols with King County Metro Transit and coordinate with other disciplines as required.

Per the KC 2020 SCAP, maximize construction and demolition materials diverted from landfills from all projects.

Consideration shall be given to designing for disassembly.

C. Architectural Elements: Material Guidelines and Performance Requirements

1) General Criteria for Material Selection

Materials selected shall be durable, easily maintainable, suitable to their intended environment, and have an expected 50 year lifespan.

Material selection shall comply with the KCGBO and KC SCAP. Notably, where design considerations have been vetted, and applicable to the Work, Construction Documents shall:

a. Minimize use of concrete where suitable alternatives exist. Specify suitable and vetted admixture types to reduce the concrete's carbon footprint.

b. Require Forest Service Council certified lumber.

c. Increase Compost use.

d. Use LEED-certification specific language in Submittal requirements, including requirement for Environmental Product Declarations (EPD's).

e. Limit VOC's.

f. Avoid or limit the use of materials on the Red List published by International Living Future Institute (ILFI).

g. Use KCMT CPD Engineering Section's approved *Standard Division 01 Specifications* templates as editing start points for Sustainable Construction Requirements and Construction & Demolition Waste Diversion Sections.

2) Exterior Paving Materials

a. Paving systems are designed in collaboration with and in deference to the Civil design authorizers of KC projects. In general, all walking surfaces shall be slip resistant and ADA compliant.

b. Exterior paving materials shall comply with the general selection criteria outlined above.

3) Interior Floor Materials

a. The selection of flooring material for any space shall be 1) appropriate for the planned or expected use or activity, 2) consistent throughout the defined space and 3) shall comply with the general selection criteria outlined above. Materials shall not require specialty equipment or tools to maintain.

b. All walking surfaces shall be slip resistant and ADA/ANSI compliant. Flooring systems shall
support the Selection Criteria Standards outlined above, including alignment with and in support of KC SCAP and KC GBO. Technical Specifications shall be written to enforce those selections, and support KCMT's need for expected useful life, minimal maintenance, and ability to be repaired.

c. Comply with the requirements of the Structural Design Standards of this document.

4) Exterior wall assemblies

a. Priority shall be given to durability, maintainability, and designed for a 50-year life of building. Design shall comply with the Structural Design Standards of this document.

b. Fire-rated assemblies shall meet the requirements established for their specific locations.

5) Interior Walls

a. Office area wall systems shall consist of 6” studs with 5/8” gypsum wall board, at a minimum. Fire-rated and sound-proofing assemblies shall meet the requirements established for their specific locations.

b. In Vehicle Maintenance and other industrial work areas, wall systems shall be durable and impact-resistant under highly corrosive conditions.

c. Comply with the requirements of the Section 03 STRUCTURAL of this document.

d. Provide fire-resistant systems where required by use, occupancy and AHJ.

6) Ceiling Systems

a. Ceiling systems shall be suitable to their environments, and support the sustainability and durability Selection Criteria outlined above.

b. Provide fire-resistant systems where required by use, occupancy and AHJ.

c. For acoustical ceiling tiles coordinate direct-hung metal suspension system with Structural seismic restraint systems. Acoustical panels shall be specified for maximum light reflectivity and acoustical buffer. Color shall be white. Acoustical ceiling tiles shall be installed in conditioned spaces only.

7) Paints and Coating Systems

a. Interior and exterior applications shall be specified to meet their respective requirements as defined in standard Division 01 Guideline Specification section Sustainable Design Requirements, and/or LEED-specific criteria in LEED-criteria-specific technical specification sections.

b. Criteria includes low-VOC content and environmental ratings for specific products as defined by the Master Painter's Institute.

c. Material and color selection Submittals shall require approval by King County's Project Representative for the Work, including coordination with facility and project stakeholders.
8) Roofing Systems

a. Vapor Retarder
   i. Concrete Deck: Vapor retarder is hot mopped over an asphalt primed concrete deck.
   ii. Metal Decking: Vapor retarder is hot mopped over the first layer of mechanically attached rigid board insulation.

b. Insulation
   i. For new construction built-up roofing systems, use rigid mineral wool if able to meet current Energy Code. If not feasible, rigid polyisocyanurate can be used. Minimum R-value to meet most stringent in County.
   ii. For metal deck without concrete fill, the insulation shall be hot mopped over the vapor retarder.

c. Flat Roof System
   i. Shall be a hot mopped polymer-modified asphalt built-up roof system
   ii. Parapet wall coping shall be a modular coping system

d. Sloped Roof System
   i. Shall be standing seam metal

e. HVAC and other Rooftop Equipment
   i. “Crickets” shall be placed on the uphill side of all roof equipment curbs.

f. Roof Drains
   i. There shall be a sump area around each drain.
   ii. The designer should avoid placement of the drain(s) near columns or structural supports which may end up as high points when structures deflect or sag.

g. Roof Glazing Units
   i. Skylights, smoke-venting skylights and light tubes shall meet OSHA and WISHA fall protection standards or come equipped with OSHA approved fall guards (see Fall Protection).

h. Roof Penetrations
   i. Minimize the amount of penetrations through the roof. When possible, design penetrations to occur inside curbs for roof top equipment. When not possible, design the penetrations to stay at least 12 inches away from curbs, walls, and other building elements to allow the penetration to be properly flashed.
   ii. Keep penetrations away from drainage valleys.
i. Rigid Flashings
   i. Rigid metal flashings shall be stainless steel.

j. Fasteners
   i. All fasteners shall be corrosive-resistant grade stainless steel. Provide metal separation where dissimilar metals are used.

k. Fall protection shall be in compliance with OSHA, WISHA, WAC Chapter 296-24, and local jurisdictional authorities.

l. Smoke-venting skylights exist on KCMT vehicle maintenance facilities as a part of fire suppression systems under previous Codes. These originally constructed systems remain in service, with the smoke-venting skylights protected by wire cage systems where WA State fall protective impact weight is not achieved by the fixture alone.

m. KCMT flat-roofed facilities predating code-required fall-protective parapet heights are protected by a removable rail system procured through Operating or Building Envelope Program-Specific funding.

n. Walk pads
   i. Walk pads shall provide access to HVAC units and other equipment to facilitate maintenance activities on the roof. Walk pads should be kept out of the drainage sump areas and should not obstruct drainage paths. Provide enough spacing to allow storm water to flow freely between walk pads.

9) Openings

The design of facility windows must consider location, amount, height, complexity and special features required. In order to reduce reliance on electric lighting, design of windows, skylights, and other glazed elements shall maximize daylighting and visual comfort.

a. Door and frame types may include
   i. Hollow metal doors and frames
   ii. Overhead coiling doors and grilles
   iii. Wood doors with metal frames

b. Window and curtain wall types may include
   i. Anodized aluminum framed windows

c. Door Hardware

The facility standard for door hardware applies to the lock cylinders. Master lock sets shall follow KCMT transit-wide facility cut-key system.
   i. Security
Coordinate Architectural requirements with Electrical design for secured entry card-reader systems and security camera installations.

10) Elevator and Escalator systems
   a. Coordinate vertical access Architectural requirements with Mechanical systems design. Elevators and Escalators are maintained by an ongoing service contract.

11) Design Criteria for signage
   b. Customer signage mounting locations

   c. Regulatory signage as required by code

12) Miscellaneous design elements
   a. Handrails and guardrails
      i. Handrails and the horizontal rail portion of guardrails shall be stainless steel railing
      ii. The use of galvanized materials at KCMT Bases and other locations in or near sensitive watershed areas shall be minimized to reduce impacts to water quality.

13) Room and Equipment Naming Convention
   a. Coordinate room naming and numbering with Transit Security standards.
   b. Coordinate Equipment naming with KCMT stakeholder Department personnel.
05 MECHANICAL

A. Mechanical Engineering Requirements Introduction

The KCMT Engineering design standard presents standardized design guideline, installation and materials for fire protection, plumbing, HVAC, process, mechanical lifting equipment and special systems. This design standard has the purpose of creating a consistent application of mechanical systems throughout KCMT facilities.

These standards are the minimum design standards to assist in planning and design. Compliance with these standards does not relieve responsibility of design engineers to apply professional judgement.

Codes, Regulations, Authority Having Jurisdiction

Design codes and other requirements shall be the most stringent and the latest version accepted by the local AHJ. Some of these standards are listed below. Additional standards may be applicable.

- Air-Conditioning, Heating and Refrigeration Institute (AHRI)
- ASHRAE Standard 55 – Thermal Environmental Conditions for Human Occupancy
- ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality
- American Society for Testing Materials (ASTM), including E84
- International Building Code (IBC)
- Seattle Mechanical Code (SMC)
- Seattle Energy Code (SEC)
- Underwriters Laboratories, Inc. (UL) 723
- Uniform Plumbing Code (UPC)
- National Fire Protection Association (NFPA)
- National Fuel Gas Code
- International Fire Code (IFC)
- FM Global
- Municipal code of ordinances
- ACGIH Industrial Ventilation Handbook 28th ED; WA Ventilation Code
- The King County Strategic Climate Action Plan (SCAP) and ME Design
- Leadership in Energy and Environmental Design (LEED)
- OSHA Standard Number 1910.146
Automatic Lift Institute (ALI)
WAC 173-360A “Washington Department of Ecology Underground Storage Tank Regulations”
40 CFR 112 and EPA SPCC – Environmental Protection Agency Spill Prevention, Control, and Countermeasure Plan
All other requirements of AHJ

B. Mechanical Engineering Criteria - General

1) Submittals

Present information in a clear and thorough manner to aid orderly review. Alternatives Analysis (AA) Requirements for Mechanical Design

a. Life Cycle Cost Analysis (LCCA) Requirements for Mechanical Design

b. Mechanical load and energy calculations that include input parameters and output reports. Indoor design temperature shall be based on space function and designed to comply with energy code requirement and ASHRAE Standard 55.

c. Ventilation calculations:

Design shall provide indoor air quality in compliance with the Seattle Mechanical Code and local AHJ and requirements in ASHRAE 62.1

d. Mechanical equipment noise criteria:

Design in accordance with noise and vibration chapter in ASHRAE guideline for noise sensitive indoor zones. Exterior noise criteria shall conform with local AHJ requirements.

e. Drawings per KCMT Capital Division CAD Standards

f. Other calculations (i.e. domestic water sizing calculation, hot water sizing calculation, pump calculation, and etc.)

g. Specifications in Construction Specifications Institute (CSI) format

h. Equipment cut sheets

2) Design Requirements

a. Sustainable Design Practices

King County has a desire to design and construct sustainable buildings and facilities. Sample sustainable design opportunities are provided in the KC SCAP, which details priorities and commitments for reducing greenhouse gas emissions. These strategies will impact mechanical engineering design and system selection.

i. Alternatives Analysis (AA) Requirements for Mechanical Design

   o The alternatives shall include an electric-only option as appropriate.
o Compare natural gas vs electric systems and refrigerant vs non-refrigerant options as applicable.

o For each alternative, perform a building energy analysis to predict energy cost impact and to form basis of the life cycle cost analysis (LCCA) as described in the next section.

o Any mechanical systems that include hydrofluorocarbons (HFCs) must include demonstration of conformance with KC SCAP policy, and budget for proper disposal at the system’s end of life replacement or decommissioning.

ii. Life Cycle Cost Analysis (LCCA) in accordance with Section 01 GENERAL.

b. FM Global Review and Implementation

i. FM Global review of 100% documents is required on all projects with elevated physical risk, such as but not limited to:

o Underground fire protection mains

o Fire pumps/ tanks

o Fire detection systems

o Fixed fire protection systems

o Fuel-fired equipment

o Flammable and combustible liquid use and storage (i.e. hydraulic presses, solvent storage, etc.)

o Dust collection systems

o Emergency generators

ii. King County is self-insured so review comments are recommendations rather than requirements. However, dismissing a comment requires written engineering justification from licensed Professional Engineer.

c. Commissioning

i. Project Manager shall hire a third-party commissioning agent for the following projects:

o All mechanical projects over $250,000

o All mechanical projects of any size for buildings located in City of Seattle jurisdiction.

o Generator, automatic transfer switch and fire control panel projects

o Mechanical projects of any size that involve environmental risk and/or life safety systems, including but not limited to:
- Underground fuel tanks
- Fueling systems

ii. Commissioning agent shall also commission special systems, such as but not limited to:
   - Compressors
   - Fluid systems
   - Cranes
   - Lifts

iii. Commissioning agent qualifications for LEED projects shall be in compliance with LEED requirements.

C. Design Criteria for Fire Protection, Plumbing, HVAC and Mechanical Systems

1) Fire Protection

a. Design Engineer shall be providing performance specifications and licensed Fire Protection Contractor shall be providing a final design and hydraulic calculation.

b. Design Engineer shall provide contract documents including but not limited to the following:
   i. Fire protection system type
   ii. Hazard classification
   iii. Riser location
   iv. Riser detail
   v. Fire Department Connection (FDC) and Post Indicator Valve (PIV) locations
   vi. Indicate critical or congested areas
   vii. Intended fire sprinkler head type to be used based on Architectural reflective ceiling plan.

c. Implementation of review comments by KC Mechanical Engineers and amendments of local AHJ requirements. If there is any conflict between the requirements of the referenced standards, the most restrictive shall take precedence. Design Engineer shall consult with local Fire Marshal for interpretation of the fire code.

d. It shall be the responsibility of the contractor to obtain FM Global acceptance of plans for all elements of fixed automatic fire protection prior to fabrication. Installations of such systems shall be made up of FM Approved equipment and components. Installations shall be subject to field acceptance by FM Global following completion. Design these installations, based on proposed occupancy, and rulings obtained from FM Global prior to
system design. Upon completion of fire protection installations, one copy of the Contractor's Materials and Test Certificate shall be forwarded to FM Global for their records.

e. Fire protection system materials shall be performance basis of design Viking.

2) **Plumbing**

a. Insulation and Painting
   
i. Domestic water piping shall be insulated in accordance with Seattle Energy Code regardless of project location. All piping systems with surface temperature below the average dew point temperature of the indoor ambient air and where condensate drip will cause damage should be insulated with a vapor barrier.
   
ii. Painting is not required to piping that is exposed and not required to be insulated.

b. Natural Gas System
   
i. Interior: Design to NFPA code and FM Global requirements. Steel pipe, welded joints (per FM Global).
   
ii. Exterior: System shall be designed in compliance with NFPA code and FM Global and local utility requirements. HDPE for natural gas application shall be used and installed below grade in PVC sleeves.
   
iii. Install seismic shut-off valve at gas meter.
   
iv. Shut-off valve size shall be based on total gas demand in lieu of pipe size. Basis: Pacific Seismic Valves
   
v. Any project requiring connecting to facility's existing natural gas system shall include testing and exercising existing valves, regulators, and related appurtenances that will be salvaged. The operation and required performance of these components shall be confirmed during pre-design. If confirmation cannot be performed prior design phase, project shall include contingency for repair or replacement of these existing components.

c. Emergency Plumbing Fixtures
   
i. Emergency plumbing fixtures shall be provided where required by code including battery room. Tempered water and properly pipe size shall be provided to the emergency fixture. Design shall comply with WAC and ANSI Z358.1

3) **HVAC**

a. Insulation and Painting
   
i. Ductwork shall be insulated to comply with Seattle Energy Code regardless of project location. All ductwork systems with surface temperature below the
average dew point temperature of the indoor ambient air and where condensate
drip will cause damage should be insulated with a vapor barrier.

ii. Painting is not required to ductwork that is exposed and not to be insulated.

b. Cooling Towers

i. Open circuit coolers shall not be used in the design.

ii. Closed circuit coolers may be used only when other alternatives are not feasible.

c. Boilers

i. Boilers shall be condensing boilers with distribution pumps.

ii. Boiler flue connector shall be cast aluminum.

iii. Porcelain coated connectors shall not be used as they may cause pinhole damage
and causing premature boiler failure.

d. Building Management System (BMS)

i. Buildings shall be equipped with BMS that has the capability of controlling all
HVAC systems. The system infrastructure shall be BACnet based and be open-
protocol. No proprietary systems should be allowed. The BMS interface shall be
accessible through web-based platform from any computers.

ii. Control vendors shall provide a complete design, component selection,
installation, programming, startup, testing, training, and warranty service.

iii. When providing additional controls in a building that has an existing DDC system,
specify additional controls shall be the same as the existing DDC system. More
than one control vendor in the same building is not acceptable.

iv. Refer to System-Wide Standardization Plan report for the preferred BMS vendor.

D. Design Criteria for Occupied Zones

1) General Office and Conference Rooms

a. General office HVAC system shall consist of variable refrigerant flow (VRF) systems with
heat recovery. The system shall be coordinated with a full control system that is BMS
compatible. Basis: Mitsubishi.

b. Ventilation shall be provided by dedicated outside air Unit (DOAS) equipped with an
energy recovery, complying with the local energy code. The system will be equipped
with variable speed supply and exhaust fans.

c. Incorporate Variable Air Volume (VAV) units in areas that require Demand Control
Ventilation (DCV). DCV shall be controlled using Carbon Monoxide (CO2) sensor.

d. High efficiency VAV system may also be used when VRF system is not applicable. Provide
VAV system with rooftop air handler with electric or hydronic reheat.
2) Remote IT/Telephone Rooms
   a. HVAC system shall be split heat pump units. HVAC units shall be sized based on the stored equipment heat rejection and recommended temperature requirements by equipment manufacturer.
   b. Packaged terminal air conditioning (PTAC) units shall not be used in projects.

3) Restrooms, Lockers, and Kitchen
   a. Dedicated ventilation systems shall be provided to these spaces to ensure the space is completely isolated from other zones. Ventilation exhaust shall be routed via DOAS units.

E. Design Criteria for Vehicle Maintenance and Industrial Zones
1) Vehicle Maintenance (VM) Bay
   a. HVAC: HVAC systems shall be air handling unit (AHU) with hydronic coils and heat recovery. Include door switches to set back heating temperature setpoint when roll up doors are open. Radiant heating system that include gas-fired heating tubes shall be used to provide freeze protection for areas that are not conditioned. Indicate provided heating system is intended for heating or freeze protection.
   b. Vehicle Exhaust System (VES) standard: dedicated vehicle exhaust fan with hose reels and snorkels. Common variable speed centrifugal roof fan with vacuum pressure control. Diesel operated engine pre-heaters for hybrid buses have separate exhaust at floor level, which must be directly connected to VES in addition to bus engine exhaust; provide floor stand as required.
      i. VES Secondary Standard: VES as described above with hose reel mounted switch to operate fan.
      ii. Snorkel fabrication design is customized based on fleet type at facility.

2) Vehicle Maintenance Steam Bays/Steam Clean Room
   a. Makeup air unit (MAU) with a heating coil shall be used to deliver tempered make-up air to the space. The heating coil shall be sized to limit the leaving air temperature to the design indoor air temperature. MAU shall be independent from VM bay. Provide door switches to set back heating set point when roll up doors are open.
   b. Ventilation: Provide a dedicated exhaust fan.
   c. Special Equipment: Steam cleaning and part cleaning equipment shall be sized based on the number of bus served at the facility. Basis of design: Whitco for steam cleaning equipment and Alkota for part cleaning equipment.

3) Paint Booth
   a. The ventilation system supporting the painting process will include the following:
i. Tempered MAU with cure cycle recirculation to booth.

ii. Variable speed axial fan exhausters to maintain laminar flow.

iii. Two-speed make up air handler supplying minimum velocity air, 10 fpm at 10 ft above object being painted.

iv. Exhaust fans providing laminar air flow at 100 fpm.

v. Cure cycle shall be capable of maintaining 140F with recirculation.

vi. Booth pressure must be entirely negative (\textasciitilde0.2 \text{ in. WG}) relative to the adjacent building spaces.

vii. Pressure sensor to control exhaust fan to maintain laminar flow throughout the booth. There must be no transition zones. Exhaust duct mounted zero velocity VOC sensor with filter.

b. Provide independent, mobile breathable air systems for paint booth operators. Do not integrate breathable air system with compressed air system.

c. Selected HVAC and ventilation equipment installed in classified area shall be in compliance with Class 1, Division 1. Confirm with Electrical Engineer for area classification.

d. Special Equipment: Automatic shutoff valves shall be provided in compressed air lines providing pressure to painting equipment. These valves shall be interlocked with the ventilation system such that no compressed air is available for paint equipment when the ventilation is turned off. Provisions for this interlock system shall be coordinated with the applicable Mechanical sections and the Fire Alarm system.

4) Confined Spaces

a. Confined space as defined in OSHA 1910.146 shall be ventilated continuously. The ventilating system may be either a supply or exhaust type. If supply air directly from outdoor is not tempered, the un-tampered air shall be included in heating and cooling load calculation if the confined space is located in conditioned space.

b. Sensors shall be installed to continuously monitor air quality inside confined spaces.

5) Battery Room (Spent Hybrid Bus Battery Storage)

a. The battery room must be ventilated/exhausted directly to the outside at a rate calculated to be in compliance with code and equipment manufacturer’s recommendation. The ventilation system shall be monitored and shall initiate audible and visual alarms when hydrogen concentrations in the space exceed allowable limits.

b. Battery room must be equipped with an emergency eyewash and shower equipment. Floor drain in the room shall be routed to an acid neutralization tank prior to discharge to the building sanitary system.
6) Garage

a. Ventilation system shall be designed to incorporate “push-pull Method”.

b. Axial fans with variable speed drives, controlled by contaminant sensors (CO, NO2, and VOC’s). NO2 is the highest concern followed by CO and particulate. Additional sensors shall be added to the project based on the project requirements.

c. Sensors are not allowed to be installed in ductwork.

d. Sensors shall be located in all floor areas and installed based on radius coverage recommended by the manufacturer’s recommendation and in the breathing zone (3-7 ft).

F. Design Criteria for Special Equipment

1) Compressed Air System

a. Shop Air System

Compressed air system shall include a liquid separator between compressor and wet air receiver, and a particulate filter after the dryer. An additional filter before the wet receiver is recommended if the receiver is not galvanized or internally coated.

b. Paint Booth Spraying System

Compressed air system shall include a liquid separator between compressor and wet air receiver, oil coalescing filter after the dryer. An additional filter before the wet receiver is recommended if the receiver is not galvanized or internally coated.

c. Tire Shop System

i. Compressed air system shall include an aftercooler and cycling refrigerated dryer between the compressor and the 1000-gallon receiver. The aftercooler and dryer are in lieu of providing an internally coated receiver tank. The designer shall evaluate the benefits and costs associated with the alternate aftercooler and dryer and report to the stakeholders.

ii. At a minimum, the compressed air system in Transit Vehicle Maintenance buildings will include:

   a) Three 7.5 hp, fixed speed, air-cooled rotary screw compressors, with two duty compressors, and the third providing backup
   b) Two air dryers.
   c) One 500-gallon receiver tank

iii. Receiver tanks and other system component standards shall be detailed separately.

iv. The mechanical designer shall verify the specific requirements for each facility.

v. To minimize dissipated heat and noise inside the building, locate compressor...
system outside whenever possible. If it is not feasible to install compressors outside the main building, compressors shall be installed in a dedicated compressor room with insulated walls.

d. Compressed air working pressures shall be confirmed with KCMT Engineering. Typical compressed air pressures:
   
i. Minimum Vehicle Maintenance shop working pressure is 130 psig.
   
ii. Tire Shop working pressure requires 150 psig.

e. A separate dedicated air compressor system for tire shop is preferred. If a dedicated compressed air system is not possible, the system shall be designed to handle the different pressure demands.

f. Implement single speed compressors. Benefits of variable speed drive compressors for transit vehicle maintenance have not been proven. Installing air receivers in the system was found to be the most cost effective to meet vehicle maintenance requirements.

g. Systems shall be designed to meet more than one working pressure, with the following equipment:
   
i. Equipment: Quincy QP Series Industrial Grade Compressor, or approved equal. The Quincy QP series includes “Pro Units” and “Max Units”, where the Max units have aftercoolers built in to all of the units as well as other features.
   
ii. Compressor type shall be selected as appropriate for the system and project.

h. Dryers: Each of the two duty compressors to have a dedicated air dryer (do not manifold to a single dryer). The dryers will be thermal mass cycling refrigerant air dryers.
   
i. Equipment: ZEKs, Sullair, Kaesar, Ingersoll Rand or approved equal
   
ii. Engineer shall explore other possible options as applicable to the projects.

i. Air Receivers:
   
i. Standard: ASME pressure vessel, 200 psig minimum working pressure. 1000 gallons @ 175 psig per 200 buses at maintenance base.
   
ii. Secondary standard: 2000 gallons @ 150 psig per 200 buses at maintenance base

j. Air Filters:
   
i. Determine appropriate air filter classification based on the application. Filter ratings are based on the three categories: solid particles and dust, humidity and liquid, and total oil.
   
ii. Vehicle Maintenance General Shop Air Tools require a 3, 4, 4 filter: 3 for Particles/Dust, 4 for Humidity and Liquid Water, and 4 for Total Oil. Paint Booth Spraying Systems require a 2, 4, 2 filter. Specialty systems to be determined based on each system requirement.
k. Pressure reducing valves (PRVs) should only be used at point of use.

l. Other parts: Install long-nose double-seal quick disconnects. Compressed air systems shall also include separators, condensate drains, and pressure flow control valves. Components shall be standardized for the entire base and consider standardizing transit-wide.

2) **Interior Cleaning Systems**

   a. Updated system Alternative Analysis is in progress.

3) **Exterior Cleaning Systems**

   a. System shall be a “hybrid” system with customized six brush bus wash system including the following features:
      
      i. 2 partial (½ length) brushes in front to avoid conflict with bike racks  
      ii. 2 full size side brushes  
      iii. 2 full size rear brushes  
      iv. “Knock Away” brushes (single hung)  
      v. Wash water reclaim system  
      vi. Light indicator system for speed control during wash cycle.
      
      vii. The “hybrid” function allows use of a high-pressure water spray without brush action, when buses do not require brushes to remain relatively clean and to clean the front of the buses behind the bike racks.

   b. Ensure new/replacement equipment does not include features that change existing discharge permit conditions.

   c. Basis: “Hybrid” Ross & White 6x4 HPF-OM Brush System (Customized)

4) **Fuel System**

   a. New base construction standard for fuel storage is Aboveground Storage Tanks (ASTs); UL 142 double wall at minimum, with additional UL 2080 listing for fire resistance and UL 2085 for vehicle impact and firearm resistance in outdoor applications. Historically sized at 15,000 gallons diesel per 100 buses, confirm new requirements based on planned conversion to fully electric fleet. Conform to NFPA 30 and 30A and FM Global recommendations, and requirements from the AHJ Fire Marshall.

   b. Underground Storage Tanks (USTs) may be used for retrofit projects at existing bases where ASTs are not feasible for fuel storage due to site constraints.
      
      i. Standard UST construction is UL 1316 fiberglass, and independently piped to an above-grade manifold with isolation valves (no manifold piping below grade) such that each UST can be shut down for maintenance or inspection without
ii. Design shall conform to WA Department of Ecology (DOE) regulations, NFPA 30 and 30A, FM Global recommendations, and requirements from the AHJ Fire Marshall.

iii. Tank basis: ACE Tank US 1316 fiberglass

c. Pump Types:


ii. Gasoline Fueling: Suction submersible turbine pump

5) VM Fluid Storage Systems

a. ASTs located in Fuel/Wash building or Vehicle Maintenance building as needed. AST type shall be double-wall steel. Conform to NFPA 30 and 30A and FM Global recommendations, and requirements from the AHJ Fire Marshall.

b. The pump type for maintenance fluids shall be an air powered stub pump. Basis: Graco Fireball, Graco LD series, or equivalent.

c. The pump type for solvents, petroleum waste, and diesel exhaust fluid (DEF): air powered diaphragm pump. Preferred connection size is 1-1/2”.

d. Manual hand pumps can be used for low usage fluids. Consult with KC Mechanical Engineers on fluid consumption and use of hand pumps where applicable.

e. Automatic shutoff valves shall be provided in compressed air lines (or electrical lines) providing pressure to flammable vehicle maintenance fluids. These valves shall be interlocked with the fire alarm system such that no compressed air is available for vehicle maintenance fluids when the fire alarm system is in alarm. Provisions for this interlock system shall be coordinated with the Electrical Engineer.

6) Fluid Monitoring System

a. Fluid management system (FMS) shall be provided for AST and UST systems. FMS with pulse transmitters shall be actively tracking fluid tank levels and dispensed fluids. The system shall be a stand-alone system with tank level probes at each fluid storage tank. The system shall have a capability to communicate with BMS. Basis: Veeder-Root.

b. A separate FMS shall be designed to track and monitor gasoline use for non-revenue vehicles. Basis: FuelCare.

7) Industrial Waste System (IWS)

a. The IWS system will consist of two vaults piped in parallel. Industrial waste water will be directed to the first vault until it reaches maximum capacity. The industrial waste water flow will then be directed to the second vault while the first tank is in retention to settle out sediments and oil. When the fluid level in the second tank almost reaches 100%, the
first tank is drained to the sanitary system. Once the tank is completely drained, the waste water flow is directed back to the first tank while the second tank is in retention.

b. Drains from steam cleaning, floor drains from custodial spaces, hoist drain, part washer equipment, and bus wash are typically the primary sources of industrial waste. The industrial waste is typically in the form of oil, sands, and sludge. Bus wash overflow does not need to be sent to the IWS system as the waste water from the overflow is considered clean.

c. Industrial waste drainage from inspection pits shall be designed to include depressed slab extends the long sides of the inspection pit with floor drains installed at an increment. The increment of floor drain shall be determined by project requirements.

d. Each vault shall have a minimum treatment volume 2000 gallon with vault cover size 24” diameter. The storage/treatment capacity of each tank is based on the number of buses to be serviced at the facility. Final storage capacity shall be reviewed and approved by the KCMT Environmental Compliance Team.

e. Downstream of the dual vault treatment, discharge water drains to sanitary system. Discharged water pH level, oil/sediment and heavy metal concentrations shall be in compliance with King County Industrial Waste Water limits.

f. Preferred sump pump type is electric powered submersible sump pump.

g. KCMT Environmental Compliance Manager applies for permits. Permitting process will require an estimated of daily volume discharge to KC waste water system. Overestimating daily discharge number does not cause extra treatment fees.

h. IWS system shall have a control panel with visual indicators tracking the process and visual and audible alarms. The panel shall have indicator to show the following minimum treatment volume levels:
  i.  Tank #1 Level at 80%
  ii. Tank #1 Level at 100%
  iii. Tank #1 Level at 120%
  iv.  Tank #1 Fill valve open
  v.   Tank #1 Fill valve closed
  vi.  Tank #2 Level at 80%
  vii. Tank #2 Level at 100%
  viii. Tank #2 Level at 120%
  ix.  Tank #2 Fill valve open
  x.   Tank #2 Fill valve closed
i. The control panel shall annunciate alarm condition and provide visual indicator when the following conditions occur:
   i. Level sensor failure
   ii. Valve failure
   iii. Tank 1 Flooded (120% of treatment volume capacity limit)
   iv. Tank 2 Flooded (120% of treatment volume capacity limit)
   v. Tank 1 Emergency (130% of treatment volume capacity limit)
   vi. Tank 2 Emergency (130% of treatment volume capacity limit)
   vii. Control panel failure

j. Control panel shall send email indicating alarm fault and tank number to Building Operator. Additional control panel features and alarms shall be integrated to provide a fully functional system.

k. IWS systems serving existing bases utilize float levels. Design Engineer is encouraged to explore other sensor options that are reliable and robust.

l. Passive skimmers shall not be used. This method has been proven unreliable.

m. System shall integrate multiple points for solids settle out of wastewater prior to getting to the dual vaults:
   i. Grit sumps under man covers
   ii. API separators (3x5 some bigger)
   iii. Catch basins for passive grit accumulation
   iv. Need focus on more active grit accumulation past high waste water generating areas vs low volume generating areas

n. KCMT has established contracts to clean bottom sludge and remove accumulated oil every two years.

o. All piping shall be designed to avoid stagnant water in the pipe. To avoid sludge build up, pipes shall be oversized (minimum pipe diameter is 4”). Clean-outs for sediment removal and flushing from basin and piping shall be provided.

p. When fluid is retained inside the vaults, the pH level will need to be maintained by using a chemical treatment.
   i. Design Engineer shall route 2” diameter CPVC pipe from inside the building to each vault.
   ii. A 55-gallon chemical tank with a manual hand pump will be provided by KCMT.
   iii. Chemical tank location shall be reviewed and approved by the PM and KC
Environmental Compliance Team.

G. Design Criteria for Mechanical Lifting Equipment

1) Cranes and Hoists
   a. Cranes: Refer to Structural
   b. Hoists: Electric only hoists with powered trolleys, hoist and boom swing with lightweight remote controls. Hoist mounted pendants are not allowed. Air or hydraulic powered hoists may be considered for NEC Class 1, Division 2 or higher restricted environments as required.

2) Hydraulic Lifts
   a. VM Running Bay Hydraulic Lifts
      i. Transit proprietary custom design hydraulic post lifts: refer to Ryerson Base Lift Replacement Project - drawings, specifications, O&M manual, lessons learned (KPFF EOR).
      ii. All lift designs must have non-catastrophic failure modes. All posts for the hydraulic lift rated for rear axle load capacity requirements. The rear axle typically carries the most weight, and bus sizes and orientation in the maintenance bay can result in any of the posts carrying a rear axle.
      iii. The current design standard based on the existing fleet is a minimum 30,000 lb capacity per post and post superstructure, however load capacity requirements must be re-evaluated as new coaches are purchased. Rear axle weights for the existing fleet are typically 22,000 lbs on a 40 ft bus and 20,000 lbs on a 60 ft bus; the rear axle load for one possible new electric coach model was estimated at 26,000 lbs and the model Transit will purchase is still unknown. The required capacity may change after design review of the new future fleet.
      iv. All lifts shall be designed to support the lifted load (operating load) when subjected to ASCE 7 level seismic loads per ASCE chapter 15.
      v. Basis: Custom design post lifts.
   b. VM Steam Bay Bus Fleet Hydraulic Lifts
      i. Same standard as the Vehicle Maintenance Running Bay Bus Fleet Hydraulic Lifts
      ii. In addition, components must be made of corrosion resistant material. Galvanize the post platforms, chrome pistons, and stamp or permanently indicate the load rating and fabrication date on the underside of the platform.
      iii. Basis: Custom design post lifts.
   c. Non-Revenue Vehicle (NRV) Hydraulic Lifts
      i. “Off the shelf” commercial maintenance garage vehicle lift.
ii. All lifts shall be designed to support the lifted load (operating load) when subjected to ASCE 7 level seismic loads per ASCE chapter 15.

iii. Design all lifting posts working capacity to exceed the highest vehicle axle weight by approximately 50%.

iv. All lift designs must have non-catastrophic failure modes.

v. Basis: No existing equipment manufacturer standard

d. VM Running Bay Pit Jacks

i. Rail mounted, dual ram design with lifting pistons fixed in all axes of rotation.

ii. Ensure that pit rails can accommodate coach weight distributed across the pit jack’s four (4) roller bearings.

iii. Basis: Stertil Koni PJ200-2 or approved equal

H. Mechanical Engineering Standard Plans

   KCMT Standard Mechanical Details [TBD]

I. Mechanical Engineering Guideline Specs

• DIVISION 01
• DIVISION 02 – EXISTING CONDITIONS
  o 024119 SELECTIVE DEMOLITION - Mechanical Design Engineer shall edit this section when the projects consist of primarily mechanical work
• DIVISION 21 – FIRE SUPPRESSION
  o 210500 GENERAL MATERIALS, METHODS AND REQUIREMENTS (FIRE SUPPRESSION)
  o 210529 HANGERS AND SUPPORTS
  o 210553 IDENTIFICATION
  o 210610 FIRE SUPPRESSION PIPING AND SPRINKLERS
  o 210800 FIRE SUPPRESSION SYSTEMS COMMISSIONING
  o 21131X [WET-PIPE OR DRY-PIPE] SPRINKLER SYSTEMS
  o 211XXX [CENTRIFUGAL, TURBINE, OTHER TYPE] FIRE PUMP
• DIVISION 22 - PLUMBING
  o 220500 GENERAL MATERIALS, METHODS AND REQUIREMENTS (PLUMBING)
  o 220529 HANGERS AND SUPPORTS
  o 220600 PLUMBING PIPING AND FITTINGS MATERIALS
  o 220800 PLUMBING SYSTEMS COMMISSIONING
  o 223X00 [ELECTRIC OR FUEL-FIRED] DOMESTIC-WATER HEATERS
• 224200 PLUMBING FIXTURES AND EQUIPMENT

• DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING, OTHER INDUSTRIAL
  o 230500 GENERAL PROVISIONS
  o 230510 BASIC MATERIALS AND METHODS
  o 230513 ELECTRICAL PROVISIONS FOR MECHANICAL WORK
  o 230520 MECHANICAL DEMOLITION
  o 230593 TESTING, BALANCING AND ADJUSTING
  o 230700 HVAC INSULATION
  o 230800 MECHANICAL SYSTEMS COMMISSIONING
  o 230810 SYSTEMS TRAINING
  o 230820 SYSTEMS O&M MANUALS
  o 230900 HVAC INSTRUMENTATION AND CONTROLS
  o 231123 NATURAL GAS PIPING SYSTEMS
  o 232113 HYDRONIC PIPING
  o 232300 REFRIGERANT PIPING
  o 233100 AIR DISTRIBUTION DUCTWORK
  o 23XXXX [SPECIFIC HVAC AND/OR INDUSTRIAL EQUIPMENT TO BE REPLACED/INSTALLED]
06 ELECTRICAL

A. Electrical Engineering Requirements Introduction

This Section defines minimum requirements to be adhered to by the Designer.

Guidelines are NOT to be used as-is for construction specifications for equipment requirements, installation or contractor testing and commissioning.

A 15% Submittal a Basis of Design and Understanding of Scope is a required Deliverable, providing the scope and foundation for work. Changes to Basis of Design subject to KCMT Engineering approval.

Codes, Standards and Authority Having Jurisdiction

The design shall conform to the latest adopted editions of the following applicable standards and codes. Latest version of the Codes and Standards to apply. Codes version that is applicable is when Design Contract is executed unless overridden by King County Project Electrical Engineer.

The criteria and guidelines set forth in this design standard are not intended to include or repeat code requirements that apply to the electrical design. Where the requirements of more than one code or standard are applicable, the more restrictive shall govern.

- NEC National Electrical Code (NEC)
- ANSI American National Standards Association (ANSI)
- NEMA National Electrical Manufacturer Association (NEMA)
- IEEE Institute of Electrical and Electronic Engineers (IEEE)
- ISA Instrument Society of America (ISA)
- ICEA Insulated Cable Engineers Association (ICEA)
- OSHA Occupational Safety and Health Act (OSHA)
- WISHA Washington Industrial Safety and Health Agency Regulations - All current rules and regulations
- ASTM American Society for Testing Materials (ASTM)
- UL Underwriters Laboratory (UL)
- WAC 51-11 Washington State Energy Code

City of Seattle Energy Code

City of Seattle or city of project or State Electrical Code Supplement

The King County Strategic Climate Action Plan (SCAP) and ME Design
Leadership in Energy and Environmental Design (LEED)
OSHA Standard Number 1910.146
All other requirements of local utility companies having jurisdiction

**Inspection Authorities**

The local AHJ shall have responsibility for the 'code' correctness of the electrical installation. Document any clarification or communication with the agencies having jurisdiction during design. Resolve the topics listed below at the beginning of the design work.

**Electrical Inspector:**
- Applicable state and local codes
- Third Party listing requirements (UL, CSA, ETL, or other Nationally Recognized Testing Laboratory (NRTL) recognized in Washington State)
- Plan review requirements

**Building Inspector:**
- Exit signing
- Emergency egress lighting
- Emergency lighting power supply
- ADA Regulations

**Fire Marshall:**
- Hazardous area determination

**King County Insurance companies:**
- As determined to be applicable by the King County Project Manager

B. **Electrical Engineering Criteria - General**

1) **Submittals**

All submittals listed below shall be labelled and tagged.

1. Alternatives Analysis (AA) Requirements for Electrical Design
2. Life Cycle Cost Analysis (LCCA) Requirements for Electrical Design
3. Electrical load and energy calculations that include input parameters and output reports. Indoor design temperature shall be based on space function and designed to comply with energy code requirement and ASHRAE Standard 55.
4. Electrical equipment noise criteria
5. Design in accordance with noise and vibration chapter in ASHRAE guideline for noise
sensitive indoor zones. Exterior noise criteria shall conform with local AHJ requirements.

6. Drawings per KCMT Capital Division CAD Standards

7. Specifications in (Construction Specifications Institute) CSI format

8. Equipment cut sheets

2) Sustainable Design Practices

1. The KC SCAP details priorities and commitments for reducing greenhouse gas emissions, these strategies will impact Electrical Engineering design and system selection. See also Section 01 GENERAL.

2. Alternatives Analysis (AA) Requirements for Electrical Design:

   a) For each alternative, perform energy analysis to predict energy cost impact and to form basis of the Life Cycle Cost Analysis.

   b) Electrical systems that include hazardous content must include demonstration of conformance with KC SCAP policy, and budget for proper disposal at the system’s end of life replacement or decommissioning.

3. Life Cycle Cost Analysis (LCCA) per Section 01 GENERAL.

   a) The Social Cost of Carbon (SCC) shall be used in LCCAs when evaluating equipment that produces carbon emissions (including diesel generators).

3) Witnessing

For purpose of electrical work, a Witness shall be either a) design consultant, b) King County inspector, c) Third Party Testing agent or d) Commissioning Agent. Determination of who provides witnessing inspection services made by King County Project Manager and verified by KCMT Engineering.

4) Commissioning

The following projects require a third-party commissioning agent:

1) All Electrical projects over $250,000.

2) All Electrical projects of any size for buildings located in City of Seattle jurisdiction.

3) Generator, automatic transfer switch and fire control panel projects.

4) Any Electrical projects of any size that involve environmental risk and/or life safety systems, such as but not limited to:
• MV switchgear
• MV and LV switchboards
• Motor control centers
• Diesel generators and MTS/ATS
• Static Uninterruptible Power Supplies
• MV Power factor correction

C. Electrical Engineering Criteria by CSI Specification Sections

The following criteria is organized by the following CSI Division 26 technical specification sections:

26 00 20 General Electrical Engineering Criteria
26 05 13 Medium-Voltage Cables
26 05 26 Grounding and Bonding for Electrical Systems
26 05 29 Hangers and Supports for Electrical Systems
26 05 33 Raceway and Boxes for Electrical Systems
26 05 36 Cable Trays for Electrical Systems
26 05 43 Underground Ducts and Raceways for Electrical Systems
26 05 53 Identification for Electrical Systems
26 12 00 Medium Voltage Transformers
26 22 00 Low Voltage Transformers
26 25 73 Power System Studies
26 13 00 Medium-Voltage Switchgear
26 23 00 Low-Voltage Switchgear
26 24 19 Motor-Control Centers
26 25 00 Low-Voltage Enclosed Bus Assemblies
26 24 13 Low-Voltage Switchboards
26 24 16 Panelboards
26 27 13 Electricity Metering
26 27 26 Wiring Devices
26 28 13 Fuses
26 28 16 Enclosed Switches and Circuit Breakers
26 29 13 Enclosed Controllers
22 33 53 Engine Generators
26 33 53 Static Uninterruptible Power Supply
26 35 33 Power Factor Correction Equipment
The contents of each Section address some or all of the following standards and criteria specific to that element of the electrical work:

0.1 Areas of Concern and Lessons Learned from Similar Projects
0.2 Drawings
0.3 Specifications
0.4 Calculations
0.5 Documentation Procedures
0.6 Standards and Codes
0.7 Inspection Authority
0.8 Utility Services
0.9 Load Analysis
0.10 Efficiency
0.11 Warranty
0.12 Testing

26 00 20 General Electrical Engineering Criteria

0.1 Areas of Concern and Lessons Learned from Similar Projects

Refer to individual Design Standard for concerns and lessons learned for the Designer.

Of major concern to King County are:

a) Existing systems are delineated.

b) Point of Connection interface with the servicing utility on Point of Connection.

c) Determination who provides MV transformation and cable plant.

d) Perform 30-day metering for existing facilities to determine existing load. Repeat with 7-day metering within 45 days of Bid Set Submittal.

e) There shall be only one Main Service Disconnect at the site of facility.

f) Power Studies are performed and updated throughout the design process to determine equipment sizing, space allocation, conduit entry and exit routes, top hats. When design reaches 100%, the Power Study calculation shall represent the full One-Line Diagram.

g) Provide adequate space in electrical rooms and closets for equipment, clearances, additional (Future) equipment, potential future growth and maintenance space allowance for shelving, tables, and workspace.
h) All over current protective equipment and motor controllers shall be by one manufacturer.

i) Coordinate with architect to ensure adequate switchgear room floor space and head room for equipment and connections.

j) Coordinate with mechanical engineer to ensure switchboard rooms shall be ventilated and dehumidified.

k) Be concerned with constructability when preparing design. Consider: opening in structural members, floor and wall sleeving and reinforcement, anchorage, suspension weight limits of hanging items.

l) Coordinate layout and installation of electrical equipment including switchboards and components with other construction that penetrates walls or is supported by them. Including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.

m) Coordinate door height and widths for equipment entry.

n) Coordinate ingress pathway integrity so flooring loading is below safe requirements, beam/ joist/ ceiling/ HVAC duct work obstructions are mitigated in the design.

o) Maintain required workspace clearances and required clearances for equipment access doors and panels.

p) Early installation of large equipment items may be required for schedule and constructability. Assure Bid documents have requirements for protection from elements until room dry-in.

q) Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete. Consider project conditions. Such as:

r) Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

s) Environmental Limitations - Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   Ambient Temperature: Not exceeding 104 deg F.
   Altitude: Not exceeding 1000 feet.

t) Indicate in Bid Set is special conditions for delivery, storage, installation in indoor dry conditions, work above electrical equipment, construction temporary environmental restrictions (i.e., heating, humidity, and air circulation).

u) Designer Inspection requirements for delivery and storage per-installation.
v) Use of permanent equipment (i.e., lighting) during construction. Whether replaceable items (i.e., lamps) need to be installed prior to Substantial Completions.

w) Consistency within the drawing set.

x) Drawing set matches specified equipment.

y) Bid set provides clarity of requirements and installation so all bidders have the same interpretation.

z) Bid Set is biddable within Standards of Care and existing equipment availability.

aa) Long lead equipment items are delineated and distinguished.

bb) Show full pathway from new work (equipment or devices) to panel for all new homeruns.

cc) For major equipment, the vendor shall have a local service organization within 50 miles of the installation to support the County and provide training, parts and emergency maintenance and repairs.

0.2 Drawings

Refer to General drawing requirements in Section 01 GENERAL.

Note: Imperative that specifics on equipment, feeders, ancillary equipment be shown once on either the one-line diagram, schedules or in the plans. In other locations, identify the item by ID tag.

a) Electrical Legend Sheet
   i. The standard King County - Metro Transit legend sheet of electrical symbols is to be used without exception on all design drawings; this legend is available through KCMT Project Engineer assigned to the project.
   ii. The electrical legend sheet is a general symbol list and may be edited for individual contract drawing sets. In cases where special symbols are required, they shall be used universally throughout the entire project.
   iii. Distinguish between New Work and Existing Work.

b) Abbreviation Sheet
   List all electrical abbreviations and acronyms used in the electrical sheets. Refer to General, Architectural or Civil Master sheets for common project-wide abbreviations and acronyms.

c) Electrical Site and Major Area Plans
   i. Standard electrical site and area drawing format for KCMT title and border
   ii. Include in all plans, sections, elevations and details: Grid lines, floor designation, Room number
(i) Major equipment plans and elevations to be reviewed by approved manufacture for placement of compartments, dimensions and weights.

(ii) FOB site delivery location (if not covered in Architectural or Civil general sheets)

(iii) Utilities point of service

(i) Major equipment and switchgear yards

Note: Coordinate with servicing utility on Point of Connection. Specifically, where interface exists between utility and King County project. Determine who provides MV transformation and cable plant.

Note: Frequently the Project installs MV duct bank system and manholes, and transformer pad. Utility installs MV cable and transformer.

Note: Coordinate with servicing utility on power factor correction used at service entrance for MV connection.

(ii) Exploded view site and area drawing format for King County - Metro Transit title and border, including:

1) Maximum scale 1” = 60-feet

2) Electrical site and area plans will use architectural or civil backgrounds

3) Area plans will also show facility designs where the facility does not require a separate drawing.

4) Outdoor switchgear, outdoor substations, and indoor substations.

5) Below grade ground ring

6) Ground risers to lightning arrestor system on roof and connected roof appurtenances

7) Grounding arrangement of separately derived systems

8) Duct banks, hand holes, manholes

9) Outdoor street and area lighting

10) Generator plans to include: dimensions, conduit and bus duct penetrations, enclosure details, door swings, housekeeping pad, and fueling locations.

11) UPS plan views with incoming, maintenance bypass switch, battery section, converter, battery section, out-going distribution compartment or panelboard. Housekeeping pad.

12) Power factor correction plan views with incoming, capacitor bank, maintenance bypass switch, out-going distribution compartment, and controls.
d) Expanded Area Plans
   i. Include: Floor designation, Grid lines, Room number, Equipment sizing and location, conduit and/or bus duct routes to scale, front, side and back designation, door swings, housekeeping pad with dimensions and height.
   
   1) Power and facility plans are to show the location of, and connection to, all equipment that requires raceways or conductors.
   
   2) Spare raceways for future equipment shall also be shown, where appropriate.
   
   3) Separate lighting and power plans will generally be prepared.
   
   4) All normal, emergency, and special egress lighting shall be shown and identified on the "Lighting Plan."
   
   5) Show receptacles, vendor rough-in, HVAC, wiring to all equipment and power feeders on the "Power Plan."
   
   6) Depending on complexity of projects, separate specialty system in vertical space arrangement: Below grade; 0’ to 5-feet AFF; Above 5-feet AFF – Show the raceway size and routing.
   
   7) The drawings are to show the actual conduit routing for all major power loads.
   
   8) Home run designation may be used for lighting and general-purpose receptacle circuits.
   
   9) Installation in horizontal and vertical planes of bus duct, cable tray and conduit runs greater than 8 conduits. Include location of pull boxes with sizing, door swings and orientation. Include bending radius of conduits greater 4 conduits in array or 3” diameter. Provide elevation marker (Above Finished Floor or From Top of Ceiling). Indicate expansion joints.
   
   10) For bus duct, indicate where bus ampacity reduction is permitted.
   
   11) Fuse cabinet location.

e) Single Line Diagram (One Line Diagram)
   i. Single line diagram: show the entire electrical distribution system from the incoming utility service line to the utility service entrance, to switchgear and down to the distribution level. All equipment and feeders to have Identification tags.
   
   ii. Reference to Power Systems Study with author, date and version defined.
   
   iii. Information on the diagram shall include equipment rating (continuous and short circuit duty), bus ampacity, engineer calculated fault duties, utility metering,
owner metering, overcurrent devices, type of connection (i.e., draw-out, bolted, solid), fuse cartridge and ampacity rating, ground fault, surge protection, protective relays and relay setting, blown fuse alarm, and instrument transformers (show tap setting and maximum tap), surge suppression and lightning arrester class.

iv. All required over-current coordination elements shall be identified on the Single Line Diagram.

v. Bus to cable transitions, bus taps and disconnects.

vi. Include device name, ID tag, Ampere Trip and Ampere Frame, metering, and relays. Include relay setting information.

vii. Three phase power transformer’s information shall include primary and secondary winding connections, kVA, calculated fault duty at incoming lugs, type of connection to the transformer (i.e., flexible braid, bus, cabling).

viii. Engine generator information to include: kW rating, output voltage and amperage, generator main ampacity (AF/AT), type of main (i.e., draw-out, solid bolted connection), calculated fault duty at generator, device by description, connection point to portable load bank, ancillary equipment including battery charger and heaters.

ix. Transfer Switch information to include: Ampacity, voltage, type of main (i.e., MTS, ATS), calculated fault duty at ATS, device by description.

x. Static Uninterruptible Power Supply information to include: Input and output voltage and amperage, type of main, calculated fault duty at input, battery capacity, type and rating, and ancillary devices.

xi. Power factor correction equipment information to include: kVAR rating, ampacity, voltage, type of main, calculated fault duty at incoming, device by description.

f) Grounding Riser Diagram: Include ground sizes and ground bus locations

i. Wiring Diagrams to include

1) Power, signal, and control wiring

2) Termination block diagram

3) Controls explanation

4) Bus transfer controls

5) ATS transfer controls and setting.

g) Elevation Views
i. Front elevations shall be shown for all switchgear, switchboards, unit substations, and motor control centers. Show mimic bus.

ii. Elevations to be drawn to scale but will show the relative locations of compartments, overcurrent devices, metering, and conductor entrances. Show top hats where required. Show breaker hoist is needed.

iii. Show Motor Control Center units with extra height where required for relays. Switchboard and switchgear elevations should be informally reviewed by an approved manufacturer for placement of units and overall dimensional accuracy.

iv. Note depths of assemblies.

v. Show arrangement of top and bottom feeds for incoming and out-going feeders.

vi. Conduits, wireways, and top hats to be drawn to scale. Bending radius, spacing, stacking and array layout to be to scale.

vii. Show housekeeping pads with dimensions and embeds for equipment anchorage.

viii. Cooling fan locations on MV transformers.

ix. Transformer mounting.


xii. Power factor correction equipment with interior and exterior shown. Top hat. Housekeeping pad.

xiii. Other equipment mounting provided by Div 26.

xiv. Major equipment plans and elevations to be reviewed by approved manufacture for placement of compartments, dimensions, and weights.

h) Section Views

i. Include: Floor designation, Grid lines, Room number, Equipment sizing and location, conduit and/or bus duct routes to scale, front, side and back designation, door swings, housekeeping pad with dimensions and height.

i) Details

i. Details are generally to be selected King County - Metro Transit standard `details. Modification of the standard details must be approved, and the standard modified for everyone's use. Special details will be developed as needed for the project for clarity. Details to be to scale.
ii. Bus to cable transitions.

iii. Frame mounting assembly for equipment independently mounted.

iv. Cross section of duct banks

v. Cross sections of cable arrays on support hangers.

j) Schedules

Minimum schedules include:

i. Duct bank, manhole and handhole

ii. MV and LV switchgear, LV switchboards, ground fault, surge and lightning protection, bus transfer controls, grounding and testing, utility and customer metering of accessories, alarms, heaters, spares, overhead and portable cart, extra materials (i.e., fuses, touch-up paint, indicating lights), and maintenance tools.

iii. Generator information not identified on the one-line diagram including minimum run time at 100% rated load. Weight restriction.

iv. ATS information not identified on the one-line diagram.

v. MV and LV feeders. Cable, Splice and Racking Schedule

vi. Grounding and bonding

vii. Raceway and boxes, pull boxes, cable tray

viii. Hanger and supports, wall and floor penetrations and sleeves, weather and fire seals, wall and floor embed anchorage, anchorage, vibration, and seismic bracing,

ix. Power factor correction equipment if stand-alone

x. Motor Control schedules including buss ampacity, voltage, and phases, controller NEMA rating, motor horsepower, circuit breaker AT/ AF, control scheme.

xi. Enclosed circuit breaker and/ or fuse schedules

xii. Interior luminaries and exit signage

xiii. Exterior luminaire. Pole types, height and wind resistant bracing defined

xiv. Panelboard including:

1) Reference to Power Studies Report author, date, version

2) Panel identification and location

3) Feed From information; MLO or Main breaker, ampere frame and trip rating

4) Neutral bus rating
5) Surge protection device (interior or exterior mounted, single use or regenerative)

6) Ground fault

7) NEMA enclosure rating and cover specifics. Keying.

8) Breaker number, breakers spares and spaces;

9) Load designation, type (i.e., lighting, receptacle, motor, computer/IT, heating, other), VA rating, load tabulation by phase, total panel load in VA and conversion to amperage.

10) Accessories, heaters, extra materials (i.e., touch up paint, fuses, indicating lights, cover keys)

11) Connected equipment (if electrical connection by other disciplines)

12) Electric vehicle charging

13) Photovoltaic

14) Identification designations of all electrical feeders and equipment. details of meaning of ID tag to be in Cable, Splice Schedule, and Racking Schedule.

k) Switchover plans

i. Submit recommended switchover and outage plan as part of Bid Set. Indicate sequence of switchover.

ii. Switchover to address outages impact of personnel and operations in the facility.

iii. Ductwork and cable must be installed before switch to new cable. Outage for switchover must be kept to a 4-hour minimum at existing facilities.

0.3 Specifications

a) Refer to Section 01 GENERAL for specifications requirements.

b) For smaller projects (Under $250,000 in electrical content of work), refer to KCI Electrical Mini Specifications. KCMT Project Engineer shall confirm when appropriate to use mini specifications.

c) Designers to become familiar with the applicable sections prior to start of design. Including installation and testing requirements.

0.4 Calculations

a) All calculations are to be prepared in accordance individual Design Standards section and prepared in accord with accepted general practice.

b) Calculations are to be numbered, indexed, and cataloged for ease of reference.
c) The calculations shall be delivered to King County Metro Transit Capital Project Delivery, Engineering Section for Review and Approval per the Design Standards.

d) All final calculations shall be included in the Operations and Maintenance manual.

e) Calculations shall be performed with the approved software, the following represent the software for Lighting, Short Circuit and Arc-Flash calculations:

f) Lighting Calculations: AGI32 Lighting Design software by Lighting Analysts.

g) Electrical Engineering Calculations: SKM Power Tools for Windows, for Short Circuit, coordination study, Arc-Flash, surge etc., voltage drop.

h) Cable pulling tension and bending radius calculations

i) Agency calculations: To be submitted with the Permit set to the AHJ, and Load analysis to utility for service connection.

0.7 Utility Services

a) Seattle City Light (SCL) is the electric utility providing electric power to the Seattle area. For information contact the Account Executive Office at SCL, 700 Fifth Ave, Suite 330, Seattle, WA 98104.

b) Puget Sound Energy provides electrical power service to all other areas in King County outside the City of Seattle. Contact Puget Power at phone number 206/454-6363.

0.8 Load Analysis

a) Prepare a preliminary load survey at the beginning (15% Design Phase) of every project for power distribution system planning. Maintain and update continuously through the design phases. Since detailed load data is not available during the early part of the design, base preliminary load values on square foot averages and preliminary motor lists. Exclude any redundant or standby units from the total connected load to establish the critical load requirements.

b) Designer to expect major loads are fixed in mechanical, vertical transportation, IT/communication systems by the 60% Submittal.

c) Inform King County Project Manager of significant changes to the Load Analysis specifically as it affects the Basis of Design.

d) Identify and locate major loads on a general layout drawing to establish load center location and size. Include both connected load values, estimated peak demand, and average demand for each building or process area.

e) Tabulate the load requirement in the following categories for main distribution system calculations.
<table>
<thead>
<tr>
<th>Load</th>
<th>Connected Load kVA</th>
<th>Demand Factor</th>
<th>Avg. kVA</th>
<th>Peak kVA</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>XXX</td>
<td>1.25</td>
<td>XX</td>
<td>XX</td>
<td>Sq. Ft.</td>
</tr>
<tr>
<td>HVAC</td>
<td>XXX</td>
<td>1.0</td>
<td>XX</td>
<td>XX</td>
<td>Mech. Info.</td>
</tr>
<tr>
<td>Vertical transportation</td>
<td>XXX</td>
<td>1.25</td>
<td>XX</td>
<td>XX</td>
<td>VT Info.</td>
</tr>
<tr>
<td>Other Motor</td>
<td>XXX</td>
<td>1.25</td>
<td>XX</td>
<td>XX</td>
<td>Other Info.</td>
</tr>
<tr>
<td>Major equipment (non-motor)</td>
<td>XXX</td>
<td>1.25</td>
<td>XX</td>
<td>XX</td>
<td>Info.</td>
</tr>
<tr>
<td>General Building</td>
<td>XXX</td>
<td>1.0</td>
<td>XX</td>
<td>XX</td>
<td>Sq. Ft.</td>
</tr>
<tr>
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<td>XXX</td>
<td>X.X</td>
<td>XX</td>
<td>XX</td>
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* Plus, other loads as required by the National Electrical Code (NEC)

f) Prepare a final load analysis at completion of design using load analysis option of "DAPPER", SKM Power Tools for Windows. Files are required once the project is complete.

g) Use the same breakdown and detail given for the preliminary analysis.

h) Base final computations on actual loads shown on the drawings. Compute lighting load based on the number of luminaires shown on the drawings, HVAC load on actual motor horsepower, process load on actual motor horsepower, general building load on number of receptacles, and the actual connected load of special appliances.

i) New systems shall include a minimum allowance for 30%+ growth for capacity and physical space.

j) Existing systems may be loaded to 80 percent of load and space capacity without approval from the King County Capital Project Delivery Electrical Engineering Section.

k) Loading more than 80 percent must be approved by King County Metro Transit’s Electrical Engineering Supervisor.

l) Produce all computer output listings and place in the project documentation.

0.10 Efficiency
This section establishes the standards for the design of electrical systems for the KCMT Operations and Maintenance Facilities.

a) Energy Efficient Materials: Throughout the electrical system, Energy Saving equipment shall be used, wherever feasible. These systems shall include but not be limited to lighting, lighting controls, transformers, motors, etc.

b) New transit facilities shall have an Energy Management System (EMS) incorporated into their design. EMS shall include controls for lighting and HVAC systems.

c) Minimum requirements shall be established for energy saving devices in the sections that follow.

d) This section also establishes the standards for sustainability of the design of the electrical systems for the KCMT Operations and Maintenance Facilities.

e) Sustainable: Products and materials exceeding useful life defined below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Sustainable Period</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>MV Switchgear, switchboards, MCC</td>
<td>25 years</td>
<td></td>
</tr>
<tr>
<td>MV transformers</td>
<td>30 years</td>
<td></td>
</tr>
<tr>
<td>Medium Voltage Cable, Splices.</td>
<td>Not less than 40 years</td>
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<td>Terminations and ancillary equipment</td>
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<tr>
<td>LV Switchgear, switchboards, MCC</td>
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<td>LV transformers</td>
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<td>Panelboards, circuit breakers, disconnect</td>
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<td>switches</td>
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<td>Electrical portion of vertical transportation</td>
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<td>Electric Power Generator</td>
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<td>Uninterruptible power supplies and batteries</td>
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<td>Computerized controls for electrical equipment</td>
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<td>Metering</td>
<td>10 years</td>
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<td>Emergency lighting</td>
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</tr>
<tr>
<td>LED drivers</td>
<td>Not less than</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 years</td>
<td></td>
</tr>
<tr>
<td>LED lamps</td>
<td>Minimum 40,000-hour</td>
<td></td>
</tr>
</tbody>
</table>
### Item | Sustainable Period | Comment
--- | --- | ---
Lighting Poles | Not less than 30 years | Downward compatible
Vehicle charging systems | Not less than 10 years | Downward compatible
Photovoltaic equipment and metering | Not less than 20 years | Downward compatible
Software for electrical equipment | 10 years | Downward compatible

### 0.11 Warranty

Unless specifically identified in the specification or as follows, the warranty period shall be for one year from the date of “Final Acceptance.” (KC General Terms and Conditions 00700-7.9B).

### 0.12 Testing

Section includes requirements for electrical system testing. Testing for each piece of equipment or system shall be spelled out in the specification, which shall callout as a minimum the requirements of the latest edition of the “ANSI/NETA ATS- Standard.

Witness that the following are performed:

- a) Accelerometers have not tripped during shipment of major equipment.
- b) Equipment has been safely stored before bringing to site.
- c) Pre-setting the frame, the housekeeping pad is inspected for compliance.
- e) Certify compliance with test parameters.
- f) Identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- g) Power-Circuit Conductors: Assure labeling is at accessible locations including each termination or interconnection of wiring.
- h) Arc-flash label installed for all electrical equipment.
- i) Confirm instructional signage installed including the color code for grounded and ungrounded
- j) Confirm warning, caution and instruction signs installed ensure safe operation and maintenance.
k) Confirm Operating Instruction Signs installed facilitate proper operation and
l) Emergency Operating Signs have been installed
m) Equipment Identification Labels on each unit of equipment.

n) Confirm that all test instrumentation has certification within 90 days of test
o) Megger test insulation resistance for each panelboard bus, component, connecting
supply, feeder, and control circuit.
p) Verify continuity and tightness of ground connections.
q) Start up by manufacturer’s representative performing the following:
   i. Inspect wiring, components, connections, and equipment installation.
   ii. Megger test power and control wiring and hi-pot medium voltage cables prior to
energization. Submit test reports.
   iii. Metering and Instrumentation: Perform inspections and tests stated in NETA
ATS, Section 7.11.

r) Field adjustment
   i. Field-adjustable switches, auxiliary relays, time-delay relays, timers, and
overload-relay pickup and trip ranges.
   ii. Trip settings of MCPs and thermal-magnetic circuit breakers with adjustable,
instantaneous trip elements.
   iii. Program microprocessors in VFCs for required operational sequences, status
indications, alarms, event recording, and display features.
   iv. Set field-adjustable circuit-breaker trip ranges

s) Infrared Scanning: Two weeks after Substantial Completion, prior to Final Acceptance,
and one week before warranty expiration.

26 05 13 Medium-Voltage Cables

0.1 Areas of Concern and Lessons Learned from Similar Projects
a) The designer should evaluate the space in each existing vault or manhole. Include a
service loop in the design in all vaults and manholes to provide a service loop of MV cable
for future splices.
b) All MV cable and equipment to be identification tag labeled; details of meaning of ID tag
to be in MV Cable, Splice Schedule, and Racking Schedule.

0.2 Drawings
a) Details: Manhole fold out drawings showing entry, exit; routing of cable in the vault; splice;
existing and new cable racks; ground rods and vault ground ring.
0.4 Calculations

a) Perform pulling tension calculations, side wall pressure and bending radius calculations when determining manhole, handhole layouts. Calculations to be in both horizontal and vertical directions. Determine direction of pull. Use a nominal coefficient of friction (COF) value of 0.5. Include in pulling calculations any bends that the cable must traverse at the pulling location.

b) Identify in Plans (or specifications) Expected and Maximum pulling tensions permitted. Indicate minimum pulling lubricant required. For long runs, indicate take-up and pass thru reel location.

c) Provide calculations as Bid Set Appendix for referral by the contractor and King County Resident Engineer.

0.6 Standards and Codes

a) Specify that installer engage an experienced and certified cable splicer to install terminations and connectors for medium voltage cable.

b) Specify that Cable splicer shall have manufacturer’s certification on specific cables used on project and shall have affected utilities medium voltage cable splicing certification.

0.7 Inspection Authority

a) Consultant to witness MV cable installation. Individual must be present on site. Individual to have worked on at least three medium voltage installations.

b) Items inspected include the following:

1. First cable pulls and 10% of subsequent pulls
2. Die crimps to connector
3. Megger Readings
5. Engineer to Stop Pull when pulling tensions exceed manufacturer’s recommended maximum pulling tensions Signature sign off on Witnessed events
6. Verify that identification tags are to be visible from grade level opening of manhole.

0.8 Utility Services

a) Coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project. Determine who provides MV transformation and cable plant.

b) Frequently Project installs MV duct bank system and manholes, and transformer pad. Utility installs MV cable and transformer.
c) Gather utility Fault Duties and Short Circuit data to perform Coordination and Short Circuit Studies.

0.9 Load Analysis

a) Perform Load Analysis on MV cable system. Limit load on new construction to 60% of Calculated Worst-Case Loads. Limit new added load on existing systems to maximum of 70% of cable rating.

0.12 Testing

a) Test and inspect cables according to ICEA S-93-639 before shipping.

b) New Medium Voltage cables will have documentation of VLF, and Insulation Resistance testing performed at the factory. Documentation will be delivered to the KC Construction Manager for review and acceptance prior to shipment to project.

c) Witness that following minimum tests are performed:
   1. All measuring equipment has calibrations within 90 days.
   2. Visual and mechanical inspection.
   3. Perform direct-current High Potential test
   4. Shield Continuity Test
   5. Insulation Resistance Test
   6. Partial Discharge Test
   7. Perform Dissipation Factor Test
   8. Thermographic surveys of bolted connections on energized and loaded cables

26 05 26 Grounding and Bonding for Electrical Systems

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) A grounding system shall be designed such that the OHMIC value of the Electric Service Entrance "grounding electrode" does not exceed 10 ohms. Field measurements shall be made utilizing the Fall Potential Method, with industry standard equipment.

b) Existing facilities: Determine through As-built documents or field testing the existing ground ohmic value to Earth.

c) New facilities: Request soil resistivity data for the site.

d) Ground bonding common with lightning protection system.

e) Ground connections to be exothermic welds outdoors and in underground in in-slab installations. All other ground connections shall be compression connections.

0.2 Drawings
a) Details to include:
   • Grounding buses in electrical and IT/communication rooms
   • Ground connections
   • Ground rod and ground measurement test well
   • Manhole ground ring and bus
   • Equipment grounding typical
   • Isolated ground details including cabinetry where needed

b) Grounding Bus: Provide 12” long bus bar in small electrical and telecom rooms and closets. Provide minimum 20” long bus bar in large electrical and telecom equipment rooms.

0.4 Calculations
   a) Provide grounding system as required to obtain the resistance noted in NEC Article 250 as a minimum.
   b) A grounding system shall be designed such that the OHMIC value of the Electric Service Entrance "grounding electrode" does not exceed 10 ohms.

0.6 Standards and Codes
   a) Comply with UL 467 for grounding and bonding materials and equipment.
   b) Comply with IEEE C2 grounding requirements.
   c) Concrete-Encased Grounding Electrode (Ufer Ground) to comply with NFPA 70.
   d) Fall-of-potential testing: Conform to IEEE 81.

0.7 Inspection Authority
   Consultant to witness main service ground installation. Individual must be present on site. Individual to have worked on at least three main service ground installations.
   Items to witness include the following:
   a) Field measurements shall be made utilizing the Fall Potential Method, with industry standard equipment.
   b) Certification of measuring equipment within 90 days of test
   c) Acceptance of testing procedure

0.8 Utility Services
a) Coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project. Determine who provides MV transformation and grounding system.

b) Frequently Project installs MV grounding system. Utility connects to ground for transformer ground connection.

0.9 Load Analysis

a) Perform Ground Resistance Analysis to determine grounding design. Specifically, if multiple ground rods and ground plant required, or UFER ground system warranted.

b) A grounding system shall be designed such that the OHMIC value of the Electric Service Entrance "grounding electrode" does not exceed 10 ohms.

0.12 Testing

a) Fall-of-potential testing to be per IEEE 81.

b) Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.

26 05 29 Hangers and Supports for Electrical Systems

0.1 Areas of Concern and Similar Projects

a) Consultant to access routing of conduit/ cable tray and method of attachment. Evaluate changes of elevation due to aberrances (i.e., beams).

b) Locate and dimension penetrations in walls and floors. Determine and design reinforcing.

c) Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

d) Hangers and support systems shall not be designed to support maintenance staff using as work platforms.

e) Wind-Restraint Loading:

f) Basic Wind Speed: 85mph.
g) Building Classification Category: [I] [II] [III] [IV], depending on project parameters

h) Seismic-Restraint Loading:
   1. All equipment shall be seismically rated for the applicable conditions.
   2. Include in project specifications requirement for static capacity testing if King County requires.
   3. Aluminum RMC limited to 400Hz, grounding and special applications. Aluminum conduit, boxes or fittings shall not encounter concrete. Provide non-metallic sleeve where aluminum conduit passes through concrete structure.
   4. Boxes and Enclosures, Aboveground: NEMA 250, Type 4x.

0.3 Specifications
   a) Include in project specifications requirement for static capacity testing if required by KCMT Project Engineer.

0.4 Calculations
   a) Consultant to design seismic-restraint device not defined by details and charts on the drawings.
   b) Drawings and Schedules to be provide for conduit runs and/or cable tray of greater than 30 pounds per linear foot. And 60 pounds per square foot.
   c) Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Determination shall be weight of supported components plus 20 pounds per linear feet or 50 pounds per square feet.
   d) Unless required or designated for equipment servicing, hangers and support system should not include added weight of maintenance personnel in design assumptions.
   e) Design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data.
   f) Evaluate adequacy of Static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and vibration isolation bases.

0.5 Documentation Procedures
   a) Coordination Drawings: Plans and sections drawn to scale which show the coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
   b) Signage: Include DO NOT USE FOR MAINTENANCE USE signage if a concern.
c) Product Certificates: Signed by manufacturers of seismic restraints’ professional engineer certifying that products furnished comply with requirements.

d) Field quality-control reports.

0.6 Standards and Codes

a) Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

b) Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70 (NEC).

c) Sheet Metal Pull and Junction Boxes: NEMA OS 1, galvanized steel.

d) EMT: Use steel compression fittings only. NO SETSCREW TYPE FITTINGS ALLOWED. Comply with NEMA FB 2.10.


f) Comply with SCTE 77 for fiberglass boxes.

0.12 Testing

Witness that the following are performed:

a) Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Examine that corrosion protection mitigation measures are per specification.

b) Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

c) Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

d) Location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork

e) That raceways shall not be supported from ducts, pipes, or other systems foreign to the electrical installation.

26 05 33 Raceway and Boxes for Electrical Systems

0.1 Areas of Concern and Similar Projects

a) Consultant to access routing of raceway systems and method of attachment. Evaluate changes of elevation due to obstructions (i.e., beams).

b) Locate and dimension penetrations in walls and floors. Determine and design reinforcing.
c) Provide in-line pull boxes where transitions exceed 270-degrees of bending radius.

d) For all pull boxes 2’x2’x6” or larger, design engineer shall indicate size and locations on drawings. Pull boxes shall be sized to comply with NFPA 70.

e) Wherever rigid galvanized steel conduit is specified, intermediate metal conduit is permitted unless noted or required otherwise.

f) Locate any watertight seals in the plans.

g) Separate power conduits from Specialty Systems by 24”.

0.4 Calculations

a) Consultant to calculate fill for all feeder conduit greater than 2” in diameter and/or #2AWG conductor size.

0.5 Documentation Procedures

a) Coordination Drawings: Plans and sections drawn to scale which show the coordination of penetrations, and seals for electrical raceways.

0.6 Standards and Codes

a) Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

b) EMT: Use steel compression fittings only. Comply with NEMA FB 2.10.


d) GRC: Comply with ANSI C80.1 and UL 6.

e) ARC: Comply with ANSI C80.5 and UL 6A. For use with 400 Hz systems only.

f) PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

g) Sheet metal: UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70 (NEC).

h) Boxes and Enclosures, Aboveground: NEMA 250, Type 4x.

i) Pull boxes: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70 (NEC).

j) Sheet Metal Pull and Junction Boxes: NEMA OS 1, galvanized steel.

k) Comply with SCTE 77 for fiberglass boxes.

26 05 36 Cable Trays for Electrical Systems

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Examine drawings and existing conditions below ceiling spaces and include bends and offsets to avoid ducts, pipes, conduits, etc., in the bid price.
b) Locate and dimension penetrations in walls and floors. Determine and design reinforcing.
   1. Locate any fire seals in the plans.
   2. Indicate tray dividers where tray used for power and specialty systems.
   3. Minimum tray width of 24”, ladder bottom, rack type.
   4. Tray to be labeled that “NOT DESIGNED FOR MAINTENANCE ACCESS OR SUPPORT”.

c) On-site fabricated transition shall not be accepted.

d) Hangers and support systems shall not be designed to support maintenance staff using as work platforms.

0.4 Calculations
   a) Consultant to calculate fill for cable tray and limit to 40% capacity fill.
   
   b) Structure of trays shall be suitable to support a continuous loading of cables weighing 75 lbs. per linear foot, when supported on 12’ centers, without any deflection exceeding 1/100 of the span, with a safety factor of 1.50.

0.5 Documentation Procedures
   a) Require Contractor to walk project on-site to develop scaled Submittal Drawing.
   
   b) Coordination Drawings: Plans and sections drawn to scale which show the coordination of penetrations, and seals for cable tray.

0.6 Standards and Codes
   a) Comply with NEMA VE-1

0.12 Testing
   Witness that the following are performed:
   
   a) Examine areas and equipment for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Examine that corrosion protection mitigation measures are per specification.
   
   b) Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
   
   c) That cable tray shall not be supported from ducts, pipes, or other systems foreign to the electrical installation.
      1. Cable tray supported on 4-foot centers. Additional brackets on ends, tees and corners installed.
      2. Cable tray seismic bracing supported on 12-foot on centers.
3. Finished tray shall be located below ceiling and shall have a minimum clearance of 8" above and to the open side of the tray.

4. In the communications rooms, tray is mounted at 8'-6" above the floor and parallel to the wall not less than 4" and no more than 6" of space between tray and wall around the circumference of room.

5. Cable tray shall not closely parallel high voltage electrical power.

6. Cable tray electrically bonded at all joints.

7. Installation of cable tray provides 2 feet minimum clearances access near mechanical ductwork and sprinkler system piping.

26 05 43 Underground Ducts and Raceways for Electrical Systems

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Under roadways: Galvanized rigid steel conduit.

b) Runway areas: Galvanized rigid steel or PVC Schedule 80.

c) All underground conduit shall be 2” diameter minimum or shall be Schedule 80 PVC encased in concrete.

d) Conduits to be filled from the bottom up or center to the outer edges

e) Assume handholes and manholes are not watertight. Coordinate with civil engineer to ensure sufficient ballast to not lift structures.

f) Coordinate with civil and mechanical engineer if temporary or permanent de-watering scheme is required.

g) Assume no interior operating equipment. Coordinate with King County if interior lighting or power is required.

h) County preference for pre-cast handholes and manholes.

i) Manhole floor and side wall ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

   1. Insert bolts tested Ultimate Pullout Strength: 12,000 lbf minimum.
   
   2. All anchors and attachments in manholes to drilled.
   
   3. Curves and Bends: Use manufactured galvanized rigid steel elbows for stub-ups at equipment and at building entrances with minimum radius of 36 inches.

0.2 Drawings

a) Drawings to include:

   1. Duct bank route, to scale dimensions if greater than 6 conduits wide or tight radius elbows
2. Manhole fold out drawings showing entry, exit; routing of cable in the vault; splice; existing and new cable racks; ground rods and vault ground ring; ladders, sumps, covers, riser spacers

3. Sectional views of elevation, grading, sloping, and top and bottom elevations. Show conflicts and crossing with other below grade utilities and obstructions. This work may be part of the civil engineering package.

b) Schedules to include:

1. Duct bank ID number, conduit array, conduit type, spacing array if non-standard, conduit sizes, conduit fill by ID tag, SPARES.

2. Handhole ID number, dimensions, side wall weight limits, standard and non-standard equipment, traffic rating on cover rating, (i.e., H20, H40), manufacturer model number, survey marker location

3. Manhole ID number, dimensions, side wall weight limits, top weight limits, riser quantity and size, standard and non-standard equipment, number and size of knock-out panels, number, and manufacturer model number, Survey marker location

4. Cover ID tag, type, hinges, tamper proof and security features, traffic rating on cover rating, (i.e., H20, H40)

c) Details to include:

1. Conduit penetration at manhole and expansion joint

2. Cross sectional views where duct bank array changes

3. Road crossing details

4. Manhole cable racking sectional and elevation views, including dimensions, rack to rack spacing, wall attachment details, and rack arms

5. Cover ID tag

0.4 Calculations

a) Consultant to calculate fill for all conduits more than 2” diameter and #2AWG conductor size.

b) Consultant to determine cable bending radius to assure minimums are not exceeded.

c) Consultant to evaluate spoil bearing load and use to establish manhole structural requirements.

d) Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment.

e) Review Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
0.6 Standards and Codes


a) RNC: NEMA TC 2, Type EPC-40-PVC or Type EPC-80-PVC, UL 651,

b) RNC fitting: NEMA TC 3 and UL 514B.

c) Handholes and Boxes: Comply with SCTE 77.


f) Precast concrete utility structures according to ASTM C 1037.

g) Highway H-20 structural load rating according to AASHTO HB 17.

h) Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77.

i) Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

0.8 Utility Services

Coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project. Determine who provides MV transformation and cable plant.

Frequently Project installs MV duct bank system and manholes, and transformer pad. Utility installs MV cable and transformer.

0.12 Testing

Witness that the following are performed:

a) Confirm layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities.

b) Confirm that pre-finish elevation has sufficient tolerances to match finish site grading, and surface features.

c) Notify King County Construction Manager if there is a conflict between areas of excavation and existing structures.

26 05 53 Identification for Electrical Systems

0.1 Areas of Concern and Lessons Learned from Similar Projects.

a) Each electrical circuit, cable, and equipment item to have separate, unique identification number.
b) Identification tags and locations per King County Specifications, Section 26 05 53 Identification for Electrical Systems for detailed requirements.

c) Contract drawings shall include schedule showing complete text for all phenolic label required on project for all switchboards, distribution boards, circuit breakers panelboards, transformers, ATSs, lighting cabinets, MCCs, meter cabinets and meters on project.

d) In addition to identification, identify and design Warning labels, Safety signage and areas where maintenance staff cannot step.

e) All ID tags to be durable, corrosion resistant, UV resistant and permanently secured.

0.2 Drawings

a) Details to include:

1) Indicate placement of ID tag on enlargement details of equipment

2) Typical of various configurations of ID tags showing sizes, attachment location, and attachment method.

b) Schedules to include:

Identification naming for all MV cabling and electrical equipment

Identification type, color, material

0.6 Standards and Codes

a) Raceways and cables: Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

b) WARNING LABELS AND SIGNS: Comply with NFPA 70 and 29 CFR 1910.145

c) UNDERGROUND-LINE WARNING TAPE Comply with ANSI Z535.1 through ANSI Z535.5.


26 12 00 Medium Voltage Transformers

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Survey area assigned for physical conditions: sufficient area for transformer, housekeeping pad, working clearance zones, fencing and security gating.

b) Define path of ingress and egress. Specifically, since truck mounted delivery and second vehicle for crane. Delivery weight to be without oil.

c) Ensure crane certification has been provided for loading weight.

d) Ensure connections from incoming line side and outgoing load side are compatible.

e) Provide flexible MV cabling in line side-transformer throat connection.
f) Provide accessible grounding connection point.

g) Use precaution on type of winding selection. The two King County utilities differ in output voltage and phase rotation.

h) Provide connections for cooling fan even if current load analysis does not require. Determine source of power.

i) Evaluate transformer weight and center-of-gravity and design housekeeping pad to avoid rotation, turning over or de-coupling in event of seismic event. Housekeeping pad to be integral with incoming section-transformer-outgoing section and future outgoing expansion sections.

j) Design oil containment barrier. Slope housekeeping pad to sump pit area sized to 50% of transformer oil requirements.

k) Transformer oil to be drained for shipment and refilled on site. Insulating Liquid: Less flammable, silicone-based or hydrocarbon mineral oil dielectric. Liquid shall have low toxicity and be nonhazardous.

l) Minimum clearances around MV transformer: 10-feet with operable or accessible areas, 6-feet at fin locations.

m) Require shipping accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

n) Anchor transformer designed embedded anchors in concrete base and attach by bolting.

o) Recommend to King County on Cost-Benefits for oil filled, dry type or epoxy impregnated transformer coils.

0.6 Standards and Codes

a) Class AA/AA/FA for 1500kVA and greater.

b) Comply with IEEE C2.


d) Comply with NFPA 70.

e) Finish: Painted ANSI 61 olive green color

f) Oil: Tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.

g) Energy efficiency shall comply with NEMA TP-1.

h) Signage shall comply with ANSI Z35.1.

i) Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and

j) Outdoor Enclosure Material: Galvanized steel, NEMA 3R.
0.8 Utility Services

Coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project.

0.9 Load Analysis

a) Conduct load analysis. Provide 30% spare capacity above connected loads requirements.

0.10 Efficiency

a) Losses to be less than published standards.
b) Winding Material: Copper with Class H insulation.
c) Sound Level Standards: Sound level standards as defined in NEMA and ANSI OR Low sound level rating of 3dB minimum less than NEMA TR standard sound levels in noise sensitive areas.
d) Outdoor transformers to be bio-oil filled.

26 22 00 Low Voltage Transformers

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Determine installation method: floor mount, wall mount, ceiling hung. Limit wall mount to 30kVA and below. Limit ceiling hung to 112.5kVA and below. Floor mount preferred for sizes greater than 15kVA.
b) Survey area assigned for physical conditions: sufficient area for transformer, housekeeping pad, working clearance zones.
c) Define path of ingress and egress. Specifically, flooring loading on transformers above 225kVA.
d) Provide accessible grounding connection point.
e) Minimum clearances around LV transformer: 4-feet in front, 2-feet on side.
f) No oil filled transformers to be located interior to buildings.
g) Insulation Class: 185 deg C up to 15kVA rating, 220 deg C above 15kVA rating, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
h) Taps: (2)-2-1/2% FCAN, (4)-2-1/2% FCBN
i) Recommend to King County on Cost-Benefits for dry type or epoxy impregnated transformer coils.
j) Evaluate usage requirements and provide K-factor transformers. Select K13 for 100% harmonic generating load (electronic ballasts, computers, data racks, etc.). Select K4 or K7 for loads that are half harmonic generating. For unique applications such as a
transformer dedicated to a single harmonic load, K20 or K30 transformers may be appropriate.

k) Isolation transformers: Use for x-ray equipment and copier loads where surges occur. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.

l) Noise attenuation: Provide noise attenuation in areas designated by King County. In general occupancy above 2 stationary persons.

m) Noise Sensitive Areas: Minimum of 3 dBA less than NEMA ST 20 standard sound. Common-Mode - Minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz. Normal mode - Minus 52 dBA at 1.5 to 10 kHz.

n) Determine installation method: floor mount, wall mount, ceiling hung. Limit wall mount to 30kVA and below. Limit ceiling hung to 112.5kVA and below. Floor mount preferred for sizes greater than 15kVA. Enforce areas of anchorage.

0.3 Specifications

a) NEC Article 250-30.

b) IEEE C57.12.91.

c) Enclosure: Ventilated, NEMA 250, Type 2.
   a) Comply with NEMA ST 20 and list and label as complying with UL 1561.
   b) Comply with NEMA Standard TP-1 for transformers rated 15kVA to 1000kVA.
   c) Indoor: Ventilated.
   d) Outdoor – Ramp and Airfield: NEMA 3R Vacuum Pressure Insulated (VPI) with openings facing toward building, away from airfield.
   e) Outdoor, other unconditioned locations: Ventilated, raintight NEMA 3R.

0.8 Utility Services

Where required, coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project.

0.9 Load Analysis

Conduct load analysis. Provide 30% spare capacity above connected loads requirements.

26 25 73 Power System Studies

0.1 Areas of Concern and Lessons Learned from Similar Projects
a) Power System Studies must be performed by the engineer of record. Engineer to use for determination of equipment sizing and selection. Study to be Basis for Design. Contractor bidding to recalculate the study for the equipment bid.

b) In compliance with NFPA 70 or NEC emphasis on Arc Flash and NFPA 70E emphasis on safety, performing the Power Systems Studies is the nexus and most important design role to perform. The selection and sizing of electrical equipment, electrical room dimensions and safety exiting are fundamental to personnel and equipment safety and sustainable design.

c) “Not on my watch” needs to be the adopted mantra to each Engineer of Record on a County project.

d) Coordinate with KCMT Project Engineer at the beginning of the project to determine which studies are required. Obtain information on existing conditions that can be used for the study.

e) Section includes computer-based studies to determine the following:

f) Minimum interrupting capacity of circuit protective devices.

g) Arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

h) Overcurrent protective devices and overcurrent protective device settings for selective tripping.

i) Study results shall be used to determine coordination of series-rated devices.

j) Provide Arc Flash, Short Circuit Current and Overcurrent Protective Device Coordination study for the electrical distribution. Studies to be Basis for Design and incorporated as Addendum to the Bid Document set.

k) Use SKM Power Tools for Windows for Power Studies

l) Contractor to re-perform the Studies based on equipment selected for the project. In-field relay settings to be determined by the contractor’s studies.

0.4 Calculations

a) Short circuit and overcurrent protective device coordination study software, certifying compliance with IEEE 399.

b) For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

0.6 Standards and Codes

a) The study shall be in accordance with latest applicable NFPA 70E, OSHA 29-CFR, Part 1910

b) Sub part S, IEEE 1584, and NESC Standards
0.8 Utility Services

a) Coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project.

b) Existing Facilities: Prior to 15% Submittal, request from King County and/or serving utility: X/R ratio, z%, fault duty, define point of service, manufacturer, brand and model of SPARE breakers, breaker spaces, define who installs duct bank, transformer and cabling, and MV cable.

c) New Facilities: Prior to 15% Submittal, request from utility: X/R ratio, z%, fault duty, define point of service, define who installs MV duct bank, transformer and MV cable.

d) Gather utility Fault Duties and Short Circuit data to perform Coordination and Short Circuit Studies.

26 13 00 Medium-Voltage Switchgear

0.1 Areas of Concern and Lessons Learned from Similar Projects.

a) All medium voltage switchgear shall be labeled with Arc Flash Hazard level, NEC 110-16.

b) Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchgear, including motor contribution.

c) Working Space: Provide at least 10 feet front and 6-feet side working clearance for 4kV and higher switchgear.

d) Conduit Access: Provide knockouts for a minimum of (2) 6-inch conduits top and bottom.

e) Provide buss connection and added room space and housekeeping pad for one added cubicle.

f) Ratings: Main-Bus Rating: Minimum 1200 A, continuous; Momentary (10 cycles) Current Rating: 40,000 asymmetrical rms amperes; 2-Second Current Rating: 40,000 symmetrical rms amperes.

g) Interior bussing to meet Section 26 05 48 Seismic Controls for Electrical Systems.

h) Recommend to King County on Cost-Benefits for draw-out devices, vacuum breaker, fusible breakers.

i) King County does not recommend fusible main or branch devices.

j) Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

k) Coordinate with architect to ensure adequate switchgear room floor space and head room for equipment and connections.

l) Coordinate with mechanical engineer to ensure switchboard rooms shall be ventilated and dehumidified.
m) Require shipping accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

n) Anchor switchgear assembly to 4-inch, channel-iron floor sill embedded in concrete base and attach by bolting.

o) Recommend to King County on Cost-Benefits for draw-out devices, vacuum breaker, fusible breakers

0.3 Standards and Codes

a) Comply with NFPA 70, ANSI C2, NESC, ANSI/IEEE C37.20.2 “Metal Clad and Station Type Cubicle Switchgear”

b) Comply with ANSI/IEEE C37.20.3 “Metal Enclosed Interrupter Switchgear

c) Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type 1.

d) Power Fuses: Comply NEMA SG 2:

e) Protective Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs

f) Instrument Transformers: Comply with IEEE C57.13. Provide devices compatible with EATON PXM series meters.

g) Relays: Where required, comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.


i) Indoor Enclosure Material: Steel, NEMA 1.

j) Outdoor Enclosure Material: Galvanized steel, NEMA 3R.

k) Finish: Manufacturer’s standard ANSI 61 gray finish

0.8 Utility Services

a) Coordinate with servicing utility on Point of Connection. Specifically, where interface between utility and King County project

0.12 Testing

a) Start up by manufacturer’s representative performing the following:

1. Inspect switchgear, wiring, components, connections, and equipment installation. Perform inspections and tests stated in NETA ATS Section 7.1. Test and adjust components and equipment.

2. Megger test power and control wiring and hi-pot medium voltage cables prior to energization. Submit test reports.

3. Interrupter switches: Perform inspections and tests stated in NETA ATS, Section 7.5.
5. Protective Relays: Perform inspections and tests stated in NETA ATS, Section 7.9.
6. Instrument Transformers: Perform inspections and tests stated in NETA ATS, Section 7.10.
7. Metering and Instrumentation: Perform inspections and tests stated in NETA ATS, Section 7.11.
10. Surge Arrestors and Capacitors: Perform inspections and tests stated in NETA ATS, Section 7.19 and 7.20.
11. Arc-flash label installed for all electrical equipment.

26 23 00 Low-Voltage Switchgear

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) All low voltage switchgear shall be labeled with Arc Flash Hazard level, NEC 110-16.

b) Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchgear, including motor contribution.

c) Working Space: Provide at least 6 feet front and 4-feet side working clearance for 208V to 600V switchgear.

d) Conduit Access: Provide knockouts for a minimum of (2) 6-inch conduits top and bottom

e) Provide buss connection and added room space and housekeeping pad for one added cubicle

f) Ratings: Main-Bus Rating: Minimum 1600A to 5000A, continuous; Momentary (10 cycles) Current Rating: 40,000 asymmetrical rms amperes; 2-Second Current Rating: 40,000 symmetrical rms amperes. 100% phase bus capacity rated neutral.

g) Consider the possibility of future increases in available fault currents due to upsizing of utility transformers. Specify switchgear with adequate AIC rating to accommodate some future increase in available fault current.

h) Size switchgear to allow for minimum 30% spare capacity and 30% spare breaker capacity.

i) Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks where required by project parameters.

k) Provide 25% SPARES of each breaker frame size used or a minimum of (1) SPARE breakers of each size used.

l) For existing switchgear, perform 30-day metering of panelboard loads prior to start of design. Follow up with 7-day metering 60 days prior to issuance of Bid Document issuance.

m) Coordinate with architect to ensure adequate switchgear room floor space and head room for equipment and connections.

n) Coordinate with mechanical engineer to ensure switchboard rooms shall be ventilated and dehumidified.

o) King County does not recommend fusible main or branch devices.

p) For double ended switchgear, the typical configuration is main-tie-main with mechanical interlock of mains and tie.

q) Interior bussing to meet Section 260548.16 “Seismic Controls for Electrical Systems.

r) Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

s) Require shipping accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

t) Anchor switchgear assembly to 4-inch, channel-iron floor sill embedded in concrete base and attach by bolting.

u) b. Recommend to King County on Cost-Benefits for draw-out devices and fusible breakers

0.6 Standards and Codes

a) Comply with NFPA 70, ANSI C2, NESC, ANSI/IEEE C37.20.1

b) Comply with ANSI/IEEE C37.20.3 “Metal Enclosed Interrupter Switchgear

c) Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type 1.

d) Power Fuses: Comply NEMA SG 2:


f) Protective Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs

g) Instrument Transformers: Comply with IEEE C57.13. Provide devices compatible with EATON PXM series meters.

h) Relays: Where required, comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

j) Indoor Enclosure Material: Steel, NEMA 1.
k) Outdoor Enclosure Material: Galvanized steel, NEMA 3R.
l) Finish: IEEE C37.20.1, manufacturer's standard ANSI 61 gray finish
m) Comply with applicable portions of NECA 400.

26 24 19 Motor-Control Centers

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) All low voltage Motor Control Centers shall be labeled with Arc Flash Hazard level.
b) Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchgear, including motor contribution.
c) Working Space: Provide at least 6 feet front and 4-feet side working clearance for 208V to 600V switchgear.
d) Conduit Access: Provide knockouts for a minimum of (2) 6-inch conduits top and bottom
e) Provide bus connection and added room space and housekeeping pad for one added cubicle
f) Main-Bus Rating: Minimum 600A Horizontal, 300A vertical, continuous; Momentary (10 cycles) Current Rating: 65,000 asymmetrical rms amperes; 2-Second Current Rating: 40,000 symmetrical rms amperes.
g) 100% phase bus capacity rated neutral.
h) No aluminum buses permitted.
i) Adjustable magnetic settings up to 1300% of motor FLA.
j) Consider the possibility of future increases in available fault currents due to upsizing of utility transformers. Specify switchgear with adequate AIC rating to accommodate some future increase in available fault current.
k) Size Motor Control Center to allow for minimum 30% spare capacity.
m) Fused switches are allowed where available fault current exceeds 65,000 amps symmetrical, or for coordination reasons.
n) Two normally open and two normally closed reversible auxiliary contacts minimum.
o) Equip units in Type B and Type C MCCs with pull-apart terminal strips for external control connections.
p) Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter.
q) Interior bussing to meet Section 260548.16 "Seismic Controls for Electrical Systems.

r) Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

s) Require shipping accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

t) Provide Service Entrance labeling if installation requires.

u) Anchor MCC assembly to 4-inch, channel-iron floor sill embedded in concrete base and attach by bolting.

0.2 Drawings

a) Motor control schematic diagrams are to be done in a standard style and format. One standard diagram may apply to more than one motor with the same requirements. They are to include all control circuit devices supplied as part of the motor control center equipment. The following control devices are to be shown on the motor control schematic diagrams:

1. Elapsed time meters
2. Ground fault relays
3. Instruments
4. Motor heaters
5. Motor winding temperature detectors and relays
6. Motor safety shutdown features
7. Motor control features

b) Motor control schematic wiring diagram for each type, size, and variant of motor, to include:

1. Power, signal, and control wiring
2. Termination block diagram
3. Control explanation
4. Bus transfer controls
5. Safety shutdown feature

0.6 Standards and Codes

a) NEMA ICS 18, NEMA ICS 2.3 “Instructions for the Handling, Installation Operation and Maintenance of Motor Control Centers”

b) UL 845.0

c) Comply with NFPA 70, ANSI C2
d) Comply with applicable portions of NECA 400.

e) MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

f) Reduced-Voltage, Solid-State Controllers: Comply with UL 508.

g) Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.


i) MCP Disconnecting Means: UL 489, NEMA AB 1, and NEMA AB 3

j) MCCB Disconnecting Means: UL 489, NEMA AB 1, and NEMA AB 3

k) Molded-Case Switch Disconnecting Means: UL 489, NEMA AB 1, and NEMA AB 3

l) Protective Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs

m) Instrument Transformers: Comply with IEEE C57.13. Provide devices compatible with EATON PXM series meters.

n) Relays: Where required, comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

o) Control-Circuit and Pilot Devices: NEMA ICS 5

p) Wiring: NEMA ICS 18, Class II Type B


r) Indoor Enclosure Material: Steel, NEMA 250m, Type 1A.

s) Outdoor Enclosure Material: Galvanized steel, NEMA 3R.

t) Finish: IEEE C37.20.1, manufacturer's standard ANSI 61 gray finish

### 12. Testing

a) Field adjustment

1. Field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

2. Motor overloads per manufacturer’s tables for actual motor nameplate Full Load Amps.

3. Overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

4. Trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements.
5. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features.

6. Set field-adjustable circuit-breaker trip ranges
   b) Witness test MCC with 1000-Volt Megger for 480-Volt systems and 500-Volt Megger for 208-Volt systems after installation is complete.
   c) Witness Infrared Scanning after Substantial Completion, but not less than two weeks prior to Final Acceptance, perform an infrared scan of each switchgear and Motor Control Center.

26 25 00 Low-Voltage Enclosed Bus Assemblies

0.1 Areas of Concern and Lessons Learned from Similar Projects
   a) Usage of the bus will be permitted only with King County written authority.
   b) The engineer shall design the busway route to ensure that adequate space is provided around the busway for circulation, maintenance and inspection of joints and anchorage.
   c) Multiple busway runs shall be separated by a minimum of 4 inches.
   d) Coordinate with the structural engineer to ensure that the bus withstands a seismic event.
   e) De-rate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 120 deg F.
   f) Busway route will be designed to avoid crossing seismic joints, wherever possible.
   g) Design a 6-inch concrete curb around bus-assembly floor penetrations.
   h) Show Warning signage restricting maintenance personnel from using for support.

0.2 Drawings
   a) Drawings to include:
      1. Scaled plan views. Maximum scale 1/8” = 1’
      2. Detailed installation in horizontal and vertical planes.
      3. Scaled section views where critical interferences with structure, HVAC duct work or other equipment occurs
      4. Bus width and depth.
      5. Scaled off-sets and transitions
      6. Cable to bus transitions
      7. Location of indoor to outdoor transition
      8. Elevation marker (Above finished floor, From top of ceiling)
9. Bus ampacity reductions
10. Taps and disconnects
11. Unused (Future) tap locations
12. Requirements for vibration and seismic bracing
13. Weather and fire seals

b) Details to include:
   1. Cable to bus transitions used
   2. Taps and disconnects
   3. Unused tap locations
   4. Expansion joints
   5. Dimensioned wall and floor penetrations and bracing
   6. Structural anchorage and bracing
   7. Seismic bracing and anchorage
   8. Floor penetration housekeeping curb

c) Schedules to include:
   1. Identification naming, Ampacity, interrupting rating
   2. Locations of non-standard lengths
   3. Wall and floor penetrations
   4. Weather seals
   5. Fire seals
   6. Wet, damp outdoor labeling
   7. Indoor labeling
   8. Identification and warning labels/ signage

d) Review shop drawings for compliance with design documents. Ensure vendor has included “Last Piece” sections to compensate for As-Built conditions.

0.6 Standards and Codes
   a) Comply with NEMA BU 1, "Busways."

0.12 Testing
   a) Witness that the following are performed:
1. Field-torqueing of all bus to bus connections

2. Infrared Scanning after Substantial Completion, but not less than two weeks prior to Final Acceptance, perform an infrared scan of bus connections, transitions, and cable to bus sections

26 24 13 Low-Voltage Switchboards

0.1 Areas of Concern and Lessons Learned from Similar Projects

Refer to King County – Metro Transit Project Manager or Electrical Engineering Supervisor for recent sample Specifications from similar projects.

a) Low voltage switchboards shall be labeled with Arc Flash Hazard level.

b) Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchboards, including motor contribution.

c) Working Space: Provide at least 6 feet front and 4-feet side working clearance for 208V to 600V switchboards.

d) Conduit Access: Provide knockouts for a minimum of (2) 6-inch conduits top and bottom

e) Provide buss connection and added room space and housekeeping pad for one added cubicle

f) Ratings: Main-Bus Rating: Minimum 600A to 3000A, continuous; Momentary (10 cycles) Current Rating: 40,000 asymmetrical rms amperes; 2-Second Current Rating: 40,000 symmetrical rms amperes. 100% phase bus capacity rated neutral.

g) Consider the possibility of future increases in available fault currents due to upsizing of utility transformers. Specify switchboards with adequate AIC rating to accommodate some future increase in available fault current.

h) Size switchboards to allow for minimum 30% spare capacity and 30% spare breaker capacity.

i) For existing switchboards, perform 30-day metering of panelboard loads prior to start of design. Follow up with 7-day metering 60 days prior to issuance of Bid Document issuance.

j) Coordinate with architect to ensure adequate switchboard room floor space and head room for equipment and connections.

k) Coordinate with mechanical engineer to ensure switchboard rooms shall be ventilated and dehumidified.

l) Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks where required by project parameters.

m) Breakers: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I2t operation.
n) Provide 25% SPARES of each breaker frame size used or a minimum of (1) SPARE breakers of each size used.

o) King County does not recommend fusible main or branch devices.

p) For double ended switchboards, the typical configuration is main-tie-main with mechanical interlock of mains and tie.

q) Interior bussing to meet Section 260548.16 “Seismic Controls for Electrical Systems.

r) Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

s) Require shipping accelerometers: 0.3gs in the x, 0.9gs in the y and z direction.

t) Anchor switchboards assembly to 4-inch, channel-iron floor sill embedded in concrete base and attach by bolting.

u) Recommend to King County on Cost-Benefits for draw-out devices and fusible breakers

0.6 Standards and Codes

a) Comply with NFPA 70, ANSI C2, NESC, ANSI/IEEE C37.20.1

b) Comply with ANSI/IEEE C37.20.3 “Metal Enclosed Interrupter Switchboards

c) Comply with IEEE C37.20.7. Provide arc-resistant switchboards, Type 1.

d) Power Fuses: Comply NEMA SG 2:

e) Comply with NEMA PB 2.

f) Comply with NFPA 70.

g) Comply with UL 891.

h) CIRCUIT BREAKERS: Comply with IEEE C37.13.

i) Protective Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs


k) Relays: Where required, comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.


m) Indoor Enclosure Material: Steel, NEMA 1.

n) Outdoor Enclosure Material: Galvanized steel, NEMA 3R.

o) Finish: IEEE C37.20.1, manufacturer’s standard ANSI 61 gray finish
p) Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

q) Comply with applicable portions of NECA 400.

26 24 16 Panelboards

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Low voltage panelboards shall be labeled with Arc Flash Hazard level.

b) Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchboards, including motor contribution.

c) Minimum interrupting rating: 22,000 amperes RMS for 480Y/277V; 10,000 amperes RMS for 208Y/120V.

d) Neutral: 100% phase bus capacity, except 200% neutral bus required for panels serving predominantly computer loads, sensitive electronic loads, lighting with electronic ballasts variable frequency drives and other non-linear loads.

e) When the design includes circuiting to panelboards that are old and in poor condition, panel shall be replaced as part of the design with a new panelboard that meets the requirement for spare capacity and 30% space. New panelboard shall be equipped with a main circuit breaker.

f) Existing panels may be sized for 80% of connected load and 90% of breaker space capacity.

g) New panelboards at existing facilities shall be of the same manufacture and type as the existing panelboards and shall be equipped with covers that are hinged/door-in-door type.

h) For existing panels, perform 30-day metering of panelboard loads prior to start of design. Follow up with 7-day metering 60 days prior to issuance of Bid Document issuance.

i) New panelboards shall have minimum 54 circuits, except for 208Y/120V panels in elevator machine rooms serving only elevator loads.

j) Designer shall submit electronic version of panel schedules to King County at 100% Design.

k) Designer shall include standard panelboard door-in-door detail in project drawings.

l) Main Circuit Breaker is required for all panelboards that are not located in the same room as the source panel or that are serving a specific tenant or user group.

m) Panelboard mains and bus sized for 50% additive load.

n) Panel board shall have a minimum of 30% spare breaker capacity for 480Y/277V panels and 30% for 208Y/120V panels.
o) Arrange breakers with single pole on top third, 2-pole in middle third and 3-pole in bottom third. Spares and spaces to be placed in per 1, 2 or 3-pole thirds.

p) Spare breakers and component parts to be available for 15 years.

q) Panelboards shall have individual feeds. Multiple section panels with feed-through lugs are allowed only with King County approval.

r) Fully rated panelboards are standard. No series rated panelboards are allowed.

s) Circuit breakers are the standard protective device for mains and branch circuits unless fuses are required for interrupting high fault currents.

t) Surge Protective Devices is required for panels serving predominantly computer loads, sensitive electronic loads, and LED lighting loads.

u) For new distribution panelboards, a metering section or separate metering cabinet must be included, with capacity to hold a minimum of 6 meters.

v) Working Space: Provide at least 4 feet front and 3-feet side working clearance

w) Conduit Access: Provide knockouts for a minimum of (2) 2-inch conduits top and bottom

x) Branch Overcurrent Protective Devices: Bolt-on circuit breakers

y) Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one main service disconnecting and overcurrent protective devices.

z) Panel doors shall have a continuous piano hinge for 110 degree opening minimum. Door-in-door construction.

aa) Flush mounted panelboards: Provide six 1-inch empty conduits from top of panelboard into accessible ceiling space for future branch circuit conductors.

bb) Panels located in high bay maintenance areas and other nonconditioned spaces to be considered as Outdoor locations (NEMA 3R).

cc) Panels located in Fuel and Wash facilities and Steam and Brake Bay/ shops shall be rated for hose direct spray and enclosures rated for NEMA 4X.

dd) King County does not recommend fusible main or branch devices.

ee) Coordinate with architect to ensure adequate electrical room floor space and wall space for panelboards and connections.

ff) Coordinate with mechanical engineer to ensure switchboard rooms shall be ventilated and dehumidified.

0.6 Standards and Codes

a) Panelboards: NEMA PB 1, power and feeder distribution type.

c) Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

d) Indoor Dry and Clean Locations: NEMA 250, Type 1.

e) Outdoor Locations: NEMA 250, Type 3R or 4.

f) Corrosive Locations: NEMA 4X.

g) Hazardous Locations: NEMA 7.

h) Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

i) Testing: Comply with UL 67, UL 50 and NEMA PB 1.

0.12 Testing

a) Witness field adjustments:

1. Should contractor elect to pre-delivery panelboard interior cans, assure requirements match delivered product.
2. Megger test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
3. Verify continuity and tightness of ground connections.
4. Trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements.
5. Set field-adjustable circuit-breaker trip ranges
6. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
7. Tolerance: Difference exceeding 10 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum

26 27 13 Electricity Metering

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) The King County requires a power meter on select 480V panels (i.e., lighting, HVAC, process) and above. Typically, the panel is metered at the upstream breaker that feeds it.

b) Consult with King County Project Manager on extent of below service entrance sub-metering such as metering uses defined by asterisk (*) below.

c) Perform field investigation and coordinate with King County to determine which of the following scenarios fits a specific project.

1. * Double ended unit substation – meters are required on both main breakers and all feeder breakers.
Meters for feeder breakers shall be installed in the top row of cubicles which are reserved for metering.

2. * New breakers in existing unit substations:
   i. A meter is required for every new breaker in a unit substation. The meter shall be installed in a top row cubicle reserved for metering.

3. * New Switchboards and Distribution boards:
   i. Provide a meter cabinet adjacent to or contiguous with switchboard or distribution board.
   ii. Provide a meter for every feeder to a panelboard.

4. * New Panelboards:
   i. All new King County and tenant panelboards require a meter

5. * New meter cabinet: if no existing meter cabinet exists, or if meter cabinet is full, a new meter cabinet shall be installed.

6. * Tenant Revenue Meters: Provided and installed by tenant project

7. * New meters:
   i. Install new meter in an existing meter cabinet if possible.
   ii. If no existing meter cabinet with space is available, design shall include a new meter enclosure sized for minimum (4) meters.

d) Metering system includes:
   2. Electricity Meters.
   3. Shorting Terminal blocks – required for all meter CT inputs.
   4. Fused disconnect – required for all meters.
   5. Control Power Transformers.
   6. Power Gateway.
   7. Network Switch.
   8. Communication network and interface modules for Modbus TC/ICP data transmission protocols.

e) Customer revenue meter: Traceable revenue meter and shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy. Accuracy from Light to Full Rating shall meet the following criteria:

f) Power and Energy: Accurate to 0.2 percent of reading.
g) Voltage and Current: Accurate to 0.1 percent or better of reading.

h) The meter shall provide true RMS measurements of voltage, phase-to-neutral and phase-to-phase; and current, per phase and neutral.

i) Power Factor: 0.2 percent of reading.

j) Frequency: Plus, or minus 0.03 Hz.

k) Indicate ratios on one-line; burdened and c-200 minimum accuracy class suitable for connected relays, revenue grade meters, and instruments unless otherwise identified.
   1. Solid core type.
   2. CT output shall be 0-5A proportional to the maximum full-scale amperage rating.
   3. CT shall be minimum 1% accurate from 1% to 100% of the maximum full-scale rating from -15°C to 60°C.

l) The meter shall provide data collection, formatting and web page hosting providing all web data through an HTTP interface. The meter shall directly host the live and saved meter data without the need for any dedicated server software, active X control or Java Applets.

m) The meter shall have two communications ports.
   1. The first King County shall be auto-sensing 10/100 base-T Ethernet with the following capabilities:
      2. Allow the meter to speak with 12 simultaneous sockets of Modbus TCP so that multiple requests for data can be received simultaneously.
      3. Allow auto transmit/receive detection for straight or null RJ45 cables.
      4. The second King County shall provide RS485 communications speaking Modbus ASCII, Modbus RTU or DNP 3.0 protocol through back plate.

n) Communications Card: Standard, plus Ethernet RJ45 (10 Base T).

o) Provisions for flash firmware that can be field upgraded through a communications port, without decommissioning the instrument or de-energizing the circuit or equipment.

p) Environmental Conditions: System components shall be capable of withstanding conditions without mechanical or electrical damage or degradation of operating capability. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

0.5 Documentation Procedures
Software and Firmware Operational Documentation: Require hard copies of manufacturer’s specification sheets, operating specifications, design guides, user’s guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.

0.6 Standards and Codes

a) Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100 and marked for intended use for the location and environment in which they are intended.

b) Comply with ANSI C12.20, Class 0.2% for revenue meters installed.

c) Enclosure: NEMA 12 for indoor applications; NEMA 3R or 4X in indoor or outdoor applications where dust, water or corrosive chemicals are present.

d) Metering cabinet: Assembled in UL certified and labeled by a UL 508 Certified assembly shop

e) Instrument Certifications: UL 22CZ

f) Comply with NFPA 70, as adopted, and administered by the AHJ.

g) Instrument Certifications: Certified to UL 22CZ

h) CABLING: Comply with NECA 1.

0.12 Testing

Witness that the following are performed:

a) Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities.

b) Metering Test: Load feeders, measure loads on feeder conductor with a rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.

c) Support training of King County maintenance personnel to adjust, operate, and maintain systems. Train in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment.

26 27 26 Wiring Devices

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Ground fault receptacles where required by Code

b) Arc fault receptacles where required by Code
c) Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

0.2 Drawings

Layout receptacle to follow guidelines:

a) Coordinate wiring device location with architectural programmed room layout. Avoid placement behind shelves and tables. Locate switches near entry doors.

b) Provide double duplex on wall where likely placement of computer equipment to be located.

c) Coordinate receptacles drops in industrial areas with manufacturing planner. Provide 4-foot slack in ceiling drops. Provide twist lock receptacle in ceiling for future relocation.

d) Minimum one receptacle per 6-linear feet of wall area. Circuiting to alternate within room.

e) Maintenance receptacle within 6-feet of each serviceable equipment item.

f) GFCI maintenance receptacle on roof top areas and adjacent to serviceable equipment.

g) Mounting height for maintenance and service areas: +48” AFF.


i) Use night light indicator feature in maintenance spaces normally unlit and unoccupied.

j) Use isolated ground receptacles for IT/ Communication equipment.

k) Homeruns only required for 90% Submittal.

l) Circuiting required only for 90% Submittal.

m) Provide dedicate circuits (and isolated 1:1) transformer for copy machines.

n) Provide dedicated receptacles for individual shop equipment. Use Twist lock feature.

0.3 Calculations

a) Circuit receptacles at no greater than (8) per circuit for general use, and (6) per circuit for offices.

b) Circuit at anticipated equipment VA load.

c) Circuit all programmed computer locations at 500VA.

d) Percent Voltage Drop: Provide 3 percent or lower VD from device to panel board

0.6 Standards and Codes

a) Convenience Receptacle: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
b) Isolated-Ground, Duplex Convenience Receptacles: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

c) GFCI RECEPTACLES: Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.

d) Surge Suppression Receptacles: Comply with IEEE C62.41.2 and IEEE C62.45, NEMA WD 1, NEMA WD 6, UL 498, UL 1449, and FS W-C-596

e) WALL-BOX Dimmer Switches: Comply with UL 1472.

f) POKE-THROUGH ASSEMBLIES: Comply with UL 514 scrub water exclusion requirements.

0.12 Testing

Witness that the following are performed:

a) For 5% of devices, verify circuit assignment on plate matches continuity at panel.

b) For 5% of devices, measure ground Impedance: Values of up to 2 ohms are acceptable.

c) Check ground fault trip on all GFCI breakers per UL 1436 and UL 943.

26 28 13 Fuses

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Select fuses to provide appropriate levels of short circuit and overcurrent protection for components such as wire and cable, bus structures, and other overcurrent equipment.

b) Select fuses to coordinate with time-current characteristics of other overcurrent protective elements, such as other fuses, circuit breakers, and protective relays. Design system to ensure that device closest to fault operates first.

c) Verify that the let-through current of the selected fuse does not exceed the rating of downstream devices or conductors.

d) Selectively coordinate all protective devices so faults are isolated to the most localized level.

e) On low voltage systems this may occasionally indicate the use of a fuse in series with a circuit breaker.

f) On medium voltage systems, particular care should be given to coordination of pad mount vacuum fault interrupters with upstream feeder fuses and coordination of fuses in series through a transformer (i.e. a 12.47-4.12kV transformer with primary and secondary fuses).

g) Provide fuses from a single manufacturer.

0.3 Specifications

a) Fuses for circuits under 600V shall be UL listed, Class J, Class L, Class R or RK.
b) Fuses for safety switches shall be Class R, intended for use with rejection clips.

c) Use Class L and Class T fuses to protect loads over 600A such as transformer secondaries, switchboard mains, or large feeders.

d) Use Class J, Class K and Class R fuses to protect most feeder and branch circuit applications.

0.12 Testing

a) Approve Fuses shop drawing concurrent with Power Studies.

b) Approve fuse insertion handling procedure shop drawing.

c) Witness that the following are performed:
   1. Correct selection and placement of all fuse per Power Studies
   2. Confirm Blown Fuse indicator has not ruptured.

26 28 16 Enclosed Switches and Circuit Breakers

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Provide communications capability on switches and circuit breakers as required by engineering considerations.

b) Provide fusing on current limiting circuit breakers as required by engineering considerations.

c) The following functions may be required based on specific project parameters. Coordinate use with King County:
   1. Undervoltage Trip.
   2. Auxiliary Contacts.
   4. Electrical Operator.

d) Provide disconnect with sight of any equipment item.

0.5 Documentation Procedures

a) All switches and enclosed circuit breakers to be from one manufacturer.

b) Provide Lock out-Tag Out requirements and placards

0.6 Standards and Codes

a) Switch, Type HD, Heavy Duty, Single Throw, 240V OR 600V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated.
b) Switch, Type HD, Heavy Duty, Double Throw, 240V OR 600V ac, 1200A and Smaller: UL 98 and NEMA KS 1, horsepower rated.

c) Shunt Trip: Comply with UL 50, and UL 98, with 200kA interrupting and short-circuit current rating when fitted with Class J fuses.

d) Enclosed Circuit breaker: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

e) Ground-Fault Protection: Comply with UL 1053

f) Enclosures: Comply with environmental conditions at installed location.
   1. Indoor: NEMA 250, Type 1
   2. Indoor with Dust: NEMA 250, Type 12
   3. Outdoor NEMA @50, Type 3R
   4. Outdoor oil/ dust: NEMA 250, Type 4
   5. Hazardous: NEMA 250, Type 7,8,9 depending on conditions

g) Surge withstand shall conform to IEEE C37.90.1 and ANSI C62.41 (6 kV).

0.12 Testing

Witness that the following are performed, for 25% of enclosed switches and circuit breakers:

a) Verify device matches design.

b) Confirm correct power factor correction capacitor installed

c) Mechanical and visual inspection Proper phase rotation

d) Proper heater elements or CT/ microprocessor overloads are installed

e) Trip setting of breakers conforms to Power Studies

f) Check ground fault trip on all GFCI breakers per UL 1436 and UL 943.

26 29 13 Enclosed Controllers

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Provide reduced voltage starters for centrifugal horsepower motors for voltages and sizes as noted below:

b) 5 HP and larger – 208V, 3 phases.

c) 5 HP and larger – 480V, 3 phases.

d) Positive displacement loads shall have reduced voltage starters.
e) Specify Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays as required by engineering considerations.

f) Provide communications capability on switches and circuit breakers as required by engineering considerations.

g) Provide fusing on current limiting circuit breakers as required by engineering considerations.

h) Preference is to provide enclosed controller within sight of any equipment item.

0.5 Documentation Procedures

a) All controllers to be from one manufacturer.

b) Specify Lock Out-Tag Out requirements and placards

0.6 Standards and Codes

a) Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

b) Fusible Disconnecting Means: NEMA KS 1

c) Reduced voltage magnetic controllers: NEMA ICS 2, general purpose, Class A, UL 489, NEMA AB 1, and NEMA AB 3,

d) Reduced-Voltage Solid-State Controllers: Comply with UL 508.

e) MCCB Disconnecting Means: UL 489, NEMA AB 1, and NEMA AB 3

f) Enclosed Controllers: NEMA ICS 6


h) Surge withstand shall conform to IEEE C37.90.1 and ANSI C62.41 (6 kV).

0.12 Testing

a) Witness that the following are performed for 25% of controllers:

1. Verify device matches design.

2. Confirm correct power factor correction capacitor installed

3. Continuity testing

4. Mechanical and visual inspection Proper phase rotation

5. Proper heater elements or CT/ microprocessor overloads are installed

6. Trip setting of breakers conforms to Power Studies

7. Proper phase rotation

b) Check ground fault trip on all GFCI breakers per UL 1436 and UL 943.
22 33 53 Engine Generators

This Section includes packaged engine-generator sets for emergency and/ or optional standby power at 480VAC with the following features:

a) Diesel engine.

b) Unit-mounted OR Remote-mounting control and monitoring.

c) Outdoor, sound attenuated enclosure where installed outdoors.

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Emergency power is divided into different groups the legally required power, the King County - Metro Transit Required, the basic service element. Anything else would fall into an Optional Standby Group classification

b) Per National Electrical Code (NEC/ NFPA 70), the following definitions are used:

1. Emergency Power Systems: These systems are intended to automatically supply illumination, power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

2. Legally Required Standby Power Circuits. Systems intended to automatically supply power to selected loads (other than those classed as emergency systems) in the event of failure of the normal source.

3. Optional Standby Power Circuits: Optional standby power systems are those systems intended to supply power to public or private facilities or property where life safety does not depend on the performance of the system. Engine generator and transfer switch to be integrated by single installer.

4. Existing Emergency Power System: The existing emergency power system at the transit bases includes the basic minimum of that which was required by code and the local municipality at the time the transit base was constructed. Those circuits defined as standby shall be connected through their own set of power panels and shall abide the code rules for that designation.

c) New facilities: Provide on one ATS the Emergency and Legally Required loads and separate ATS the Optional Standby loads.

d) Engineer to determine if Alternate power source is feasible solution for project meeting NEC 700-4(B) requirements.

e) Codes and AHJ to dictate emergency and Legally Required loads. King County to provide listing of Optional Standby loads. Engineer to coordinate refinement of listing.
f) The equipment supplier shall have a local service organization within 50 miles of the installation to support the County’s Maintenance department and provide training, parts and emergency maintenance and repairs.

g) Designer shall select appropriate input/output voltages based on project parameters. Typical is 480Y/277V, 3P, 4W output.

h) Engine generator to be sized for Prime Power rating. Standby rating shall not be used.

i) Designer shall utilize a generator sizing calculation application program in determining whether block loading will be required for the engineered system.

j) Prioritize Block Loading as:

1. Emergency circuits including:
   i. Egress Lighting
   ii. The telephone system
   iii. Elevator cab lighting
   iv. The Fire Alarm Monitoring system.
   v. All other Fire/Life Safety Systems

2. Mechanical loads for emergency systems including: Air Compressor that feeds the fire protection system for dry pipe system requires constant air pressure, jockey pump for water pressure.

3. Legally required systems including elevators

4. Owner designated Optional Standby loads such as air compressors for vehicle racks, garage door lift openers, and IT/communication room HVAC cooling equipment.

k) Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 4 percent of rated output voltage from no load to full load.

2. Steady State Voltage Modulation Frequency: Less than 1 Hz.

3. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

4. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

7. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

l) Start Time: Comply with NFPA 110 Type 10 system requirements (i.e., 10 second maximum time to start, come up to speed and voltage and connect to load).

m) Rated Engine Speed: 1800 rpm for units rated 750kW or less. 1200 rpm for units rated greater than 750kW.

n) Specify a microprocessor-based control module for operation and monitoring of the unit. It shall also incorporate a communications interface for remote control and monitoring including metering. The module shall incorporate an interactive control panel for unit control, diagnostics, and data inquiry. It shall be housed in an environmentally hardened enclosure.

o) Design the fuel storage and supply, ventilation, cooling, and exhaust systems in accordance with the manufacturer’s recommendations. All electrical equipment for these systems, such as fans, pumps, controls, etc. shall be fed from emergency panels which are energized whenever the specific engine generator is operating.

p) Limit fuel tank capacity to #2 diesel 660 gallons at indoor locations.

q) Design for minimal community and adjacent area impact. Design hospital grade muffler. Provide vibration and shock mounting.

r) The Engineer shall determine the arrangements for fuel storage and supply for each individual installation. The following guidelines shall apply in general:

1. 0-500kW: Units up to 500kW rating shall be provided with an integral base double walled tank provided convenient arrangements for refueling under emergency conditions are available. No day tank is required.

2. Above 500kW: Units above 500kW rating shall be provided with a double walled day tank.

s) All items on the Emergency Power Supply Systems shall be identified; Lighting shall be marked and visible from the floor, convenience receptacles shall be identified with a red cover-plate for fire (WAC 296-46B-700), and all other equipment shall have orange plastic engraved nameplates indicating it as on the EPSS.
0.2 Drawings
   a) Coordinate with Architect to provide adequate space is available at the proposed unit location for the engine generator plus clearances required by NEC, Fire Department, refueling agent, and King County Maintenance.
   b) Coordinate with mechanical engineer to provide adequate ventilation during operating periods and permitting maintenance staff to enter and exit the enclosure or room.
   c) King County to determine extent of Drawing requirements for project

0.4 Calculations
   a) Perform Power Studies per Section 26 05 73 Power Studies with commercial power interruption and generator assuming emergency loads.
   b) Minimum sound attenuation of 12 dB at 500 Hz or as required by the local AHJ.
   c) Outdoor Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
   d) Racks shall be FRP, seismic zone 3.

0.5 Documentation Procedures
   a) Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Section 26 05 40 "Seismic Controls for Electrical Systems."

0.6 Standards and Codes
   a) Comply with ASME B15.1.
   b) Comply with NFPA 37.
   c) Comply with NFPA 110 requirements for Level 1 emergency power supply system.
   d) Comply with UL 2200.
   e) Battery Charger: Comply with UL 1236
   f) Surge withstand shall conform to IEEE C37.90.1 and ANSI C62.41 (6 kV).
   g) Comply with applicable NEMA, ISO and UL standards.
   h) Generator, Excitor, and Voltage Regulator: Comply with NEMA MG 1.
   i) Winding: Class H or F for 480V; Class F with two stators for 4160V.
   j) Battery Charger: comply with UL 1236
   k) Fuel Tank: Comply with NFPA 30
   l) Day Tank: Comply with UL 142
m) Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

0.12 Testing

a) Witness pre-delivery factory testing at \( \frac{1}{4}, \frac{1}{2}, \frac{3}{4} \) for 1 hours, followed by 2 hours at full load, and 1 hour cool down.

b) Witness that:

1. Pre-setting the frame, the housekeeping pad is inspected for compliance.

2. Examine roughing-in of piping systems and electrical connections. Make provisions for load testing the unit. This may include a site to spot a portable load bank and provisions for connection including conductors and switching.

3. Load shed block loading protocol and programming has been provided.

4. Witness on-site testing at \( \frac{1}{4}, \frac{1}{2}, \frac{3}{4} \), and \( \frac{4}{4} \) simulated load bank for 1 hours, followed by 8 hours at full load. After which a 1 hour cool down.

5. Witness full emergency power on-site test. Conduct at night due undue environmental conditions. Witness transfer. Hold for 2 hours at full load, and 1 hour cool down.

c) Witness these performance tests:

1. Voltage and Frequency Transient Stability Tests: Measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.

2. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load.

3. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations and compare measured levels with required values.

4. Coordinate tests with tests for transfer switches and run them concurrently.

26 33 53 Static Uninterruptible Power Supply

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Evaluate the need for a redundant incoming power source (normal or emergency) on a per project basis.

b) Evaluate the need for an automatic transfer switch versus a manual transfer of the loads on a per project basis.

c) Provide fixed or portable unit for the computing and database equipment. The unit shall have adequate capacity to provide continuous power for 30 minutes. Computing equipment including BOSS, MIRS, FMS, Fare Box, telephone.
d) The switchgear UPS shall be supplied power through the Emergency Power Supply System (EPSS) (All non-Life Safety Systems shall be configured as Legally required and/ or Optional Standby Circuits, as defined by the National Electrical Code).

0.3 Specifications

a) Designer shall select appropriate input/output voltages based on project parameters. Typical is 480V, 3P in/480V, 3P out.

b) Provide minimum 30% spare load capacity for future growth.

c) Provide Maintenance Bypass Switch.

d) Provide connection for testing load bank post output section.

e) The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.

2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.

3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.

4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.

5. Load is 50 percent unbalanced continuously.

f) Minimum Duration of Supply: Provide battery supplying rated full UPS load current at 80 percent power factor, duration of supply is 4-hours.

g) Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 20 percent from nominal voltage.

h) Maximum Energizing Inrush Current: 1.5 times the full-load current.

i) Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus, or minus 2 percent over the full range of battery voltage.

j) Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

k) Limitation of harmonic distortion of input current of THD to 2% for 100% linear load and 6% for 100% non-linear load
l) Minimum Overload Capacity: 125 percent of rated full load for 10 minutes, and 150 percent for 60 seconds in all operating modes.

0.6 Standards and Codes


b) EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment. UL Compliance: Listed and labeled under UL 1778 by an NRTL.

c) NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

d) Enclosures: Freestanding NEMA 250, Type 1

e) Surge suppressors: Comply with IEEE C62.41.1 and IEEE C62.41.2, Category B.

0.12 Testing

a) Witness pre-delivery factory testing at ¼, ½ and ¾ rated load for 30 minutes each without battery, followed by 2 hours at full load.

b) Witness that:

1. Pre-setting the frame, the housekeeping pad is inspected for compliance.

2. Witness on-site testing at ½ and ¾ rated load using inductive, resistive load bank for 1 hour, followed by 4 hours at full load.

3. Equalization charging of battery cells

4. Conduct battery functional tests.

5. Confirm test instrumentation has certification within 90 days of test.

6. Load the system using an inductive/ resistive variable load bank to simulate kVA, kW, and PF of load for the unit’s rating.

c) Simulate malfunctions to verify protective device operation.

d) Test duration of supply on emergency, low-battery voltage shutdown and transfers and restoration due to normal source failure.

e) Test output voltage under specified transient load conditions.

f) Test efficiency at 50%, 75% and 100% rated loads.

g) Test remote status and alarm functions.

h) Test battery-monitoring system functions.

i) Witness these performance tests:
1. **Voltage and Frequency Transient Stability Tests**: Measure voltage and frequency transients for 50, 75% and 100 percent step-load increase and decreases using inductive load bank and verify that performance is as specified.

2. **Harmonic-Content Tests**: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load.

3. **Noise Level Tests**: Measure A-weighted level of noise emanating from UPS

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**Power Factor Correction Equipment**

**0.1 Areas of Concern and Lessons Learned from Similar Projects**

a) New projects shall be designed to meet 95% power factor or better.

b) Utility bills of existing facilities shall be monitored to determine compliance with the electric company's required operating power factor. The electric utility company imposes penalty on low power factor and charges are identified on the utility bill.

c) **Minimum Motor Size Application**: Provide power factor correction capacitors on all single speed motors continuously run 25 HP and above to P.F. of 0.95, except two-speed motors and motors fed by variable frequency drives.

**0.4 Calculations**

a) **At Service Entrance**: Determine total power factor without correction summing loads and power factors.

b) Coordinate with King County if fixed or adjustable correction. Determine if automatic or manual correction.

c) **At individual motors**: Determine power factor correction. Specify in motor control or enclosed controller schedule.

d) **Interrupting Capacity**: 200,000 A Designed for 180,000 hours or 20 years of continuous industrial use.

e) **Rupture Protection**: Pressure-sensitive circuit interrupter for each cell. Turns on an amber warning light after action of pressure actuated interrupter.

**0.6 Standards and Codes**

a) **Capacitors**: Comply with UL 810, NEMS CP1 “Shunt Capacitors”, IEEE 18 “Shunt Power Capacitors” and the NFPA 70.

b) **Enclosure**: NEMA 250, Type 12 steel,

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**Surge Protective Devices for Low-Voltage Electrical Power Circuits**

**0.1 Areas of Concern and Lessons Learned from Similar Projects**
This equipment shall be installed between all probable voltage transient sources and voltage sensitive equipment such as computers, microprocessor based and other electronic equipment.

b) Applies to service equipment and branch circuit distribution equipment including panelboards.

c) Provide SPD protection when motor control centers contain voltage sensitive equipment such as Programmable Logic Controllers and Variable Frequency Drives.

d) Two stage coordinated SPD protection is acceptable.

e) Determine surge rating.

f) Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1000 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1000 V for 480Y/277 V, 700 V for 208Y/120 V.
3. Neutral to Ground: 1000 V for 480Y/277 V, 700 V for 208Y/120 V.
4. Line to Line: 1800 V for 480Y/277 V, 1200 V for 208Y/120 V

g) Peak Surge Current Rating: The single-pulse surge current withstand rating per phase shall not be less than 160 kA.

h) SCCR: Equal or exceed 100 kA.

i) The same manufacturer to provide all SPD equipment.

0.6 Standards and Codes

a) Comply with NFPA 75.

b) SPDs: comply with UL 1449, Type 2 or better. Comply with UL 1283.

c) Comply with UL 1283 “Electromagnetic Interference Filters”.


e) Enclosures: NEMA 250, Type 1 or 12.

26 50 00 Lighting

0.1 Areas of Concern and Lessons Learned from Similar Projects

Lighting systems throughout the Transit Facility are to be designed to meet the prevailing 'Energy Code' requirements as applicable to the installations encountered at the facility. Lighting levels, in maintained foot-candles, are to be designed to meet those recommended by the Illuminating Engineering Society (IES) and the guidelines that follow.

0.4 Calculations
The following illumination levels are established as the minimum average maintained lighting level required for the area noted. The only preferred light source is LED.

<table>
<thead>
<tr>
<th>Description of Area</th>
<th>Foot Candle Level (FC)</th>
<th>Unit Lighting Power Allowance (LPD-W/ft²) (Per note ‘a’ below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Offices</td>
<td>50</td>
<td>a</td>
</tr>
<tr>
<td>Maintenance Bays</td>
<td>50 - 100 *</td>
<td>a</td>
</tr>
<tr>
<td>Paint Booth</td>
<td>100 *</td>
<td>a</td>
</tr>
<tr>
<td>Machine shop</td>
<td>50 - 100 *</td>
<td>a</td>
</tr>
<tr>
<td>Storage</td>
<td>20 - 50 *</td>
<td>a</td>
</tr>
<tr>
<td>Fueling Stations</td>
<td>30</td>
<td>a</td>
</tr>
</tbody>
</table>
| Approach and Exit Roadways | 0.6 | a \*
| Parking Areas       | 0.6 ****              | a                                                             |
| Parking Areas with Conflicting Foot-Traffic | 0.8 | a |
| Approach and Exit Roadways with conflicting Foot-Traffic | 0.8 | a |
| Bus Loading Area    | 2.0                    | a                                                             |
| Walkways            | 0.8                    | a                                                             |

* Depending on the complexity of the task
** Task lighting shall be used for detail work in shops and offices.
*** Lamps in explosion proof fixtures or located in wall accessed from back side that is not Class 1, Div. 1 or 2
**** Additional requirements for Maintenance Bases in Exterior Lighting Section 26 56 00.

a) Uniformity ratios shall, in general, be no greater than 3.5:1 with a Max: Min ratio not exceeding 12:1 based upon calculated initial horizontal foot-candle level values.

b) Corners and edges of parking lots abutting private property may be excluded from this requirement. Light spilling onto adjoining properties and sensitive areas shall be avoided/minimized.

c) Uniformity ratio for bus zone flyer stops on or near freeways and ramps shall be no greater than 3:1.

d) All lighting for the site shall rely only upon the light fixtures under the control of the electrical system on the site. Lighting on adjacent properties, including street lighting, shall not be considered when calculating the site lighting.

e) Interior foot-candle levels shall be calculated by the room cavity ratio method and shall use the following reflectance values, unless specific information is available:

<table>
<thead>
<tr>
<th>Surface:</th>
<th>Finished Room Offices</th>
<th>Unfinished Room Shops, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceilings</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>Walls</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Floors</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>--------</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Maintenance Factor(s)</td>
<td>0.8</td>
<td>0.6</td>
</tr>
</tbody>
</table>

0.6 Codes and Standards

a) Lighting on King County Metro Transit Maintenance and Operations facilities shall be designed to meet/exceed WAC requirements (WAC 296-800-21005).

0.11 Warranty

a) Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion.

26 51 00 Interior Lighting

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Such lighting systems shall provide for the safety and security of King County - Metro Transit personnel and property.

b) Electrical Systems Design Principles. All light fixtures serving areas that can also be illuminated by day lighting shall be capable of switching without substantial warm-up.

c) Standardization of lamps is necessary from a maintenance standpoint. All lamps shall comply with the requirements of the National Energy Policy Act (EPACT).

d) Current requirements of King County and King County Metro Transit, state that all lighting shall be transitioned to LED systems. Replacing all Fluorescent, HID (Metal Halide, High Pressure Sodium, Low Pressure Sodium & Mercury Vapor), incandescent and Halogen lighting sources.

e) Existing fixtures: Replacement of lamps in existing fixtures with LED shall be done with King County Engineering oversight to verify that light levels are not negatively impacted. And should be done in such a manner as not to diminish Safety.

f) The color temperature of the LED light source shall be limited to the 3500K to 4500K temperature range.

g) Emergency lighting shall be provided at an adequate level to maintain safe building egress as required by code, to provide life safety, property, and equipment protection.

h) Emergency lighting is to be provided near each motor control center and any other equipment that needs to be monitored continuously.

i) Emergency lighting source shall be LED. All light fixtures on the emergency system shall be marked in such a manner as to be easily identified from floor level. The fixtures shall be painted or marked with Orange in a manner that will not interfere with the illumination of the space the fixtures are serving. (WAC 296-46B-700)
j) Fixture installation shall allow for re-lamping of equipment without the use of specialized equipment, such as scaffolding.

k) Fixtures with replaceable lamps shall only use lamps currently stocked by King County Maintenance shops.

l) Fixture drivers shall be selected to be the most efficient type available for the fixture.

m) Fixture installation shall comply with seismic zone 3 requirements.

n) Accreditation per OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

o) Design Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections. Obtain Architect's approval of fixtures for mockups before starting installations.

p) Evaluate available light fixtures on a life cycle cost basis to determine the most appropriate technology for each application.

q) All materials used for lighting equipment must be capable of being recycled.

r) All material taken from the site for disposal shall be through certified recyclers (county or state).

s) LED fixtures shall be used for artistic lighting and lighting of artwork unless conditions preclude its use.

t) The use of custom or foreign products are not desirable but will be allowed where required with King County approval.

u) Hangers for pendant fixtures shall be rigid type; with not less than five-threaded engagement turns at each end. A safety factor of 4 shall be used in sizing anchors and hangers.

0.2 Drawings

Layout lighting to follow guidelines:

a) Coordinate lighting fixture locations with architectural Reflected Ceiling plans and programmed room layout. Avoid placement so inaccessible due to shelving equipment, HVAC duct work, mechanical equipment and other obstructions.

b) Provide staged light levels per energy code for outside light influence.

c) Coordinate lighting in corridor in industrial areas with manufacturing planner.

d) Provide fixture on roof top areas and adjacent to serviceable equipment.

e) Homeruns only required for 90% Submittal.

f) Circuiting required only for 90% Submittal.
g) Lighting within the transit facility shall be designed and installed to provide sufficient illumination for the tasks outlined for that portion of the facility.

h) All interior luminaires shall be of the type required for the environment in which they are installed, i.e., normal, hazardous (Classified Div. 1 or Div. 2, etc.), damp or wet. Fixtures installed in a damp or wet environment shall be vapor tight as a minimum requirement.

i) High bay Lighting: Luminaires located in a high bay location (shop, storage room, fueling lanes, etc.) shall be LED, cord and twist lock plug/receptacle mounted.

0.6 Standards and Codes

a) Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

b) Exit Signs: Comply with UL 924

0.12 Testing

a) Witness that:
   1. Placement of proper fixture and location per bid documents.
   2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
   3. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.
   4. Occupancy Adjustments: Adjust aimable luminaires in the presence of Architect or lighting designer.
   5. Revisit the site prior to Substantial Completion to ensure that all luminaires are providing illumination to the required areas without obstruction to the ceiling cavity.

26 56 00 Exterior Lighting

0.1 Areas of Concern and Lessons Learned from Similar Projects

a) Lighting systems shall provide for the safety and security of King County - Metro Transit personnel and property.

b) Replacement of Lamps in existing fixtures shall be done with Engineering oversight, to verify that light levels are not negatively impacted.

c) Fixtures with replaceable lamps shall only use lamps currently stocked by King County Maintenance shops

d) Fixture drivers shall be selected to be the most efficient type available for the fixture.

e) Fixture installation shall comply with seismic zone 3 requirements.

g) Design Mockups: Provide module mockups, complete with power and control connections. Obtain County’s approval of fixtures for mockups before starting installations.

h) Evaluate available light fixtures on a life cycle cost basis to determine the most appropriate technology for each application.

i) All materials used for lighting equipment must be capable of being recycled

j) All material taken from the site for disposal shall be through certified recyclers (county or state).

k) Specify vandal resistant fixtures where warranted by specific application.

l) The use of custom or foreign products are not desirable but will be allowed where required with King County approval.

m) Work areas in bus yards around maintenance and operations buildings shall be designed to meet Washington Administrative Code (WAC) requirements for task and non-task lighting.

0.2 Drawings

Layout lighting to follow guidelines:

a) Coordinate lighting fixture locations with architectural and civil plans and programmed use layout. Avoid placement so inaccessible due to shelving, equipment, or other interferences.

b) Coordinate lighting in aisles in industrial areas with manufacturing planner.

c) Provide fixture on roof top areas and adjacent to serviceable equipment.

d) Homeruns only required for 90% Submittal.

e) Circuiting required only for 90% Submittal.

f) Lighting within the transit facility shall be designed and installed to provide sufficient illumination for the tasks outlined for that portion of the facility.

g) Grounding for Exterior Lighting: Provide a handhole adjacent to each light pole, with a ground rod (3/4” x 10’ copper clad steel)

h) Concrete Light Pole Base: Pole base shall be designed and detailed on the drawings, with 30 inches (minimum) above finish grade.

i) Poles in transit yard to be elevated above grade 6-feet. Pole foundation to be protected with 4-foot bollards in 4-corner locations.

j) Coordinate mounting height of fixtures in service yards. Use latch in place lowering ring above 60-feet.
k) Specify that anchor-bolt templates and anchor bolts be shipped independent of pole so pole foundation can be fabricated prior to arrival of the pole.

0.4 Calculations

a) Glare: Luminaires shall be selected and suitably placed to minimize disability and discomfort glare.

b) Light Pollution: Care shall be taken for those situations wherein luminaires are placed near abutting private property.

c) Modifications in the form of shielding, luminaires with revised photometrics, landscaping barriers or other solutions shall be used whenever objectionable light impinges on or near a property not belonging to KING COUNTY - METRO TRANSIT.

d) Pole, pole foundation and anchorage: Design structural pole, foundation, and framing system to withstand 100MPH wind gusts, and 80MPH continuous wind loads.

0.6 Standards and Codes

a) Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

b) Pole and Support Component Certificates: Comply with AASHTO LTS-4-M

c) Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

d) Exit Signs: Comply with UL 924

e) Steel poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

f) WAC 296-800-21005: Provided and maintain adequate lighting.

0.12 Testing

Witness that:

a) Placement of proper location, construction, and anchorage of pole base.

b) Confirm fixture and location per bid documents.

c) Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery or generator and retransfer to normal.

d) Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.

e) Usage Adjustments: Adjust aimable luminaires in the presence of Architect or lighting designer.
f) Lowering device: Cycle up-down lowering 5 cycles without failure under 0-10 MPH wind conditions.
07 TRACTION POWER SUBSTATION SYSTEM (TPSS)

A. TPSS Introduction, Codes, Regulations, Authority Having Jurisdiction

This section, in tandem with Section 08 OVERHEAD CONTACT SYSTEM, provides standards and guidelines for TPSS to design, construct, and operate Metro’s Electric Trolley Bus (ETB) System.

Design Basis Memo (DBM)

A Design Basis Memo will define DC system requirements for the ETB and establish guidelines for load flow studies and design of traction power systems. DC system requirements will include incoming utility interface, DC System data, operational parameters for normal and contingency conditions, ETB vehicle characteristics, utility interface, AC and DC switchgear, protection and controls, grounding, etc.

Codes and Regulations (refer to latest editions)

- AASHTO American Association of State Highway and Transportation Officials
- ASTM American Society for Testing Materials
- APTA American Public Transit Association
- ANSI American National Standards Institute
- AREA American Railway Engineering Association
- ATEA American Transit Engineering Association
- ICEA Insulated Power Cable Engineers Association
- IEEE Institute of Electrical and Electronics Engineers
- KCM King County Metro OCS Standard
- NEC National Electrical Code
- NEMA National Electrical Manufacturer’s Association
- NESC National Electric Safety Code
- SDOT Seattle Department of Transportation
- WSDOT Washington State Department of Transportation
- WE Code State of Washington, Rules & Regulations for Installing Electric Wire & Equipment

Jurisdictional Authorities

- Washington State Department of Transportation (WSDOT)
- King County Metro (KCM or Metro)
• Seattle Department of Transportation (SDOT)
• Seattle Public Utilities (SPU)
• Seattle City Lights (SCL)
• Seattle Fire Department (SFD)

B. TPSS Design Criteria and Performance Requirements

1) Climatic Conditions

   Elevation: 0 – 500 feet
   Latitude: 47° north
   Maximum Recorded Temperature: 103 oF (AMBIENT)
   Minimum Recorded Temperature: 0 oF
   Maximum Normal Temperature: 77 oF
   Mean Normal Temperature: 53 oF
   Minimum Normal Temperature: 35 oF
   Mean No. of Days above 90 oF: 2 per year
   Maximum Wind Speed: 79 mph
   Dominant Direction: SW
   Adverse Atmospheric Conditions: Heavy fog, sun rain, snow and ice

2) Environmental Criteria

   Maximum Ambient Temperature: 120°F
   Minimum wind speed (ft./sec) 2.0 (coincident with max. temp.)
   Maximum wind speed (mph) 85
   Minimum ambient temperature: 0°F
   Ice loading (radial thickness, in.) 0.25 (Operating), 0.50 (Structural)

3) System Voltage

   Substation no load DC voltage: 700 VDC
   Substation nominal DC voltage: 672 VDC
   DC voltage regulation: 4%
   Contingency operating ETB voltage: 450 VDC (minimum)
   Normal operating ETB voltage: 525 VDC (minimum)

4) DC Cables and Feeders
Insulation level: 1.0 kV (Minimum)
Conductor size: 500 kcmil HD Copper EPR (Minimum)

5) Load Flow Calculations

a. Load flow and voltage drop calculations for the system shall be conducted to size substations and the system.

b. Voltage drop calculations may be conducted using two available software programs used in the industry. They are:
   
i. Train Operations Model (TOM) program which is originally developed for light rail systems. Since, it has been refined to adapt to electric trolley bus system operations. It is a simulation program that uses dynamic modeling. TOM takes a snapshot of moving electric trolleybuses and calculates electric trolleybus voltages by solving a set of non-linear equations simultaneously. The process takes time and may experience non-convergence for some cases. Currently, this is the most adopted study tool by the transit industry.

   ii. Personal Simulation Program with Integrated Circuit Emphasis (PSPICE) is an electrical circuit modeling tool developed primarily for use with electronic circuit studies and design. This tool can be used to calculate trolley bus voltages but with limited variables by placing the trolley coaches strategically at critical locations. This program will require the user to determine the placement of trolley buses strategically along the system to evaluate system’s voltage.

6) Criteria for Normal and Contingency Operations

Bus voltages will be considered operating under normal and contingency operations when the following:

a. All mainline TPSS are in service for normal operations.

b. Buses operating at full performance on normal schedule for both Inbound and Outbound routes.

c. Minimum trolley bus voltage for normal operations is as defined in System Voltage Section.

d. One mainline TPSS is out of service for contingency operation. Out of service is defined as no traction power DC supplied by the TPSS in question. However, the TPSS 700V DC bus is assumed to be in use with the feeder circuit breakers closed for feeding through DC power from the adjacent TPSSs, and the out-of-service TPSS will be operating as a DC tie station.

e. Minimum trolley bus voltages for normal and contingency operations are as defined in System Voltage Section.

7) ETB and Battery Operated Bus Characteristics and operating data
The City of Seattle Department of Transportation (SDOT) plans to accommodate the use of the New Flyer Xcelsior XT60 ETBs as the primary electric trolley buses that will operate in parallel on KCM system. To consider the worst-case passenger loading condition, the new 60ft articulated New Flyer Xcelsior XT60 ETB will be used to model load flow simulation study.

**New Flyer Xcelsior XT60 ETB Data**

- Avail. Seats: 48
- Length: 60 Ft.
- Axle Count: 3
- Wheel Diameter: 38.2 inches
- Gear Ratio: 10.49
- Empty Weight (curb): 46,600 lbs. or 23.3 tons
- Normal Weight: 56,200 lbs. or 28.1 tons
- Equivalent Rotating Weight: 4,660 lbs. or 2.33 tons
- Frontal Area: 94.2 sq. ft.
- Aerodynamic drag: .00679
- Flange Coefficient: .108
- Acceleration: 3.7 mph/s
- Deceleration: -2.6 mph/s
- Aux. Power: 20 kW
- Max Design Speed: 39 mph
- Average operating speed: (to be provided by KCM)

**New Flyer Xcelsior XT40 ETB Data**

- To be provided

**Proterra ZX5 Battery Electric Operated Bus**

- Refer to platform specifications for ZX5 with Duopower Drivetrain vehicle
- Refer to platform specifications for ZX5 with Prodrive Drivetrain vehicle
- Design basis for charging battery electric buses shall be meet specifications as defined “Battery Electric Bus Charging Criteria”.

8) **Traction Power Substation type and size**

   a. Substation shall be self-contained fully enclosed building set of concrete footing.
b. Substation enclosure shall be climate controlled and provide dry working space.

c. Substation shall be sized to meet the minimum requirements to supply adequate power to the safe and efficient system operations.

d. Each substation shall be provided with at least one spare DC feeder circuit, for future expansion.

e. Spare conduits and ducts shall be provided to support future expansion.

f. Adequate ductbanks and underground vaults shall be utilized for all incoming utility AC and outgoing DC feeder cables.

9) **Substation site selection**

a. Shall be located in an environmentally acceptable site approved through an environmental vetting process.

b. Refrain from locating in residential areas as much as possible as these sites may be considered environmentally restrictive.

c. Site TPSS in commercial zones on agency owned lands or leased from private owners.

d. TPSS site shall have one dedicated parking stall for maintenance vehicle parking.

e. TPSS should be located in close proximity to the electric trolleybus routes to minimize voltage drops in outgoing DC feeder cables.

f. TPSS should be located in the vicinity of SCL’s 480VAC lines.

g. Siting order of preference shall be as follows: a) Public property, b) City and County R.O.W, c) light commercial areas.

10) **Utility Interface**

a. Shall be close to utility lines to minimize transmission costs

11) **AC and DC Switchgear**

a. The AC switchgear assembly shall be rated for the utility supplied voltage.

b. The assembly shall provide the means to deliver, control, and measure the substation power requirements.

c. The assembly shall be housed in dead-front enclosures containing ac draw-out circuit breaker, relaying, metering equipment, and auxiliary power supply.

d. The design shall be supported by calculations required to complete their electrical design and properly size equipment based on these Criteria and pertinent codes. Designer shall also produce calculations required by the AHJ to document compliance with electrical codes. For example, electrical short-circuit and overcurrent protective devices.

e. The rectifier transformer shall be copper wound vacuum pressure impregnated dry-type
(VPI), self-cooled, with primary voltage to be consistent with utility supply and equipped with appropriate taps. Provisions shall be included for future addition of fans for increasing the output above the specified base.

f. The rectifier-transformer unit shall be traction heavy duty rated per IEEE standards.

g. The transformer rectifier shall have overall regulation not greater than 6% + 0.5% between 1% rated and 100% rated load.

h. Rectifier shall be of conventional diode design and naturally convection-cooled. Provisions shall be included for future addition of fans for increasing the output above the specified base.

i. Each rectifier shall be equipped complete operative assembly consisting of the rectifier elements, heat sinks, internal buses, connections, fuses, and all other necessary components and accessories.

j. The DC switchgear assembly shall form a lineup of dead-front metal enclosures.

k. The DC circuit breakers shall be stored energy, draw-out, single-pole units.

l. Main DC circuit breaker or main positive disconnect shall be provided in each line up. A main DC circuit breaker is required for a large TPSS with multiple DC feeder breakers.

m. Design basis for DC protective relays shall be Siemens Sitras Pro. However, other suppliers meeting the functional design requirements of the Siemens Sitras Pro will also be considered.

n. Negative return shall include negative disconnect switches, negative bus bar, terminations for negative return cables, and other associated equipment.

o. Busbars and bus connections shall be designed to withstand the thermal and mechanical stresses occurring during the specified load cycle and the rated short circuit currents, without damage to the bus, bus supports, or enclosure.

p. Busbars shall be rigid, high electrically conductive copper.

q. Busbars shall be adequately insulated with high-strength insulators.

r. Bus connections shall be bolted and finished with silver-plated surfaces. Each joint shall have conductivity at least equal to that of the busbar. A minimum of two bolts shall be provided for each bus connection, or with four bolts for larger busbar joints.

s. Underground distribution feeders shall be insulated to 1.0 kV minimum and sized according to the System Load Flow Study and shall be no less than 500 MCM CU.

t. Transfer tripping of adjacent substations shall be considered in the design upon early consultation with and approval by KCM.

12) Protection

a. Based on the magnitude of load, overload, and short circuit currents, a comprehensive
b. Protective relays shall be multifunction microprocessor based digital type with a communication port that is capable of sending and receiving digital messages.

c. Relays shall be arranged to be visible, accessible for maintenance, and logically grouped with devices of related functions located in proximity to each other.

d. Programmable Logic Controllers (PLCs) or Industrial PC (IPC) shall be provided with TPSS control.

e. Transfer tripping of substations adjacent to the section where a fault is detected shall be provided where required by KC Metro.

f. Annunciation with acknowledge and reset functions and display of TPSS one-line shall be provided on a HMI touchscreen dynamic color display on the switchgear line up.

g. Each substation shall be equipped with a traction electrification Emergency Trip Station (ETS) and a Substation Shutdown Station (SSS). The ETS shall be mounted outside the entrance door and the SSS shall be mounted inside near the exit.

h. Actuation of the ETS shall trip the incoming ac breaker and dc feeder breakers at the substation, and transfer trip and lock out the dc breakers at the adjacent substation for the associated line sections, thus completely isolating the sections. Activation of the SSS shall trip and lock out the incoming ac breaker and all dc feeder breakers but not initiate transfer trip.

i. Substations shall be equipped with a local control and annunciation system and provision for a remote control and annunciation system through SCADA on the HMI display.

j. Alarm functions shall include at minimum: unauthorized entry, fire and smoke alarms.

k. Each TPSS shall be furnished with a battery charger/eliminator and dc distribution panelboard, which shall be sized to supply all substation control power loads.

l. The voltage for auxiliary equipment shall be 120/240V, 1-phase, 208Y/120V, 3-phase or 480Y/277V 3-phase and shall be the same throughout the project.

13) Grounding

a. Each traction power substation shall be provided with an ac ground mat.

b. The ground mats shall be constructed of bare copper or “Copperweld” conductors and ground rods exothermically welded together. Pressure connected joints will be considered for special applications.

c. Grounding connections shall carry the rated short circuit current. Grounding conductor size shall be minimum 4/0.

d. Ground mat shall be designed to protect personnel from step and touch potentials,
which may arise from substation fault conditions. It shall meet the requirements of IEEE Standard 80. Mat shall be used to solidly ground traction power transformer enclosures, auxiliary power transformer neutrals, building and door frames, AC switchgear enclosure, and low voltage panels. Ground mat shall extend a minimum 5 feet beyond the TPSS building enclosure and metallic fence if provided.

e. DC switchgear enclosures, including rectifier and negative cubicles shall be connected to the substation ground thru a high resistance ground relay for frame fault detection.

f. Grounding grid shall be connected to TPSS ground buses by four individual connections.

14) Coordination with other disciplines

a. All TPSS work shall be coordinated with other disciplines for proper installation of foundation, cable duct banks, and provide adequate circulation and maintenance space for easy maintenance.

C. Standard Plans

Typical TPSS Single Line Diagram (TPSS-STD-01)

Typical TPSS Equipment Layout Plan (TPSS-STD-02)

D. Standard Specs

340010 Med-Voltage Conductors Cables

340020 Traction Electrification System General Specification

340030 Primary Utility Service Med-Voltage ME AC Switchgear

340040 Prefab Traction Power Substation Building

340040 Traction Power Substation Testing
08 OVERHEAD CONTACT SYSTEM (OCS)

A. Introduction, Codes, Regulations, Authority Having Jurisdiction

This section provides standards and guidelines for OCS to design, construct, and operate Metro’s ETB System.

Design Basis Memo

Design Basis Memo will define OCS requirements for the ETB and establish guidelines for design of poles, pole foundations, trolley wire, trolley wire components, and trolley wire special work. Design guidelines will include selection of type of system, define loads and loading criteria, electrical clearances, roadway clearances, DC disconnect switches, feeder poles and feeders, etc.

Codes and Standards (reference latest edition for all)

AASHTO American Association of State Highway and Transportation Officials
AASHTO LRFD LRS LRFD Specifications for Structural Supports for Highway Sings
AASHTO Green Book
ASTM American Society for Testing Materials
APTA American Public Transit Association
ANSI American National Standards Institute
AREA American Railway Engineering Association
ATEA American Transit Engineering Association
ICEA Insulated Power Cable Engineers Association
IEEE Institute of Electrical and Electronics Engineers
KCM King County Metro OCS Standard
NEC National Electrical Code
NEMA National Electrical Manufacturer’s Association
NESC National Electric Safety Code
SDOT Seattle Department of Transportation
WSDOT Washington State Department of Transportation
WE Code State of Washington, Rules & Regulations for Installing Electric Wire & Equipment
WEC Code State of Washington, Electrical Construction Code

Jurisdictional Authorities

- Washington State Department of Transportation (WSDOT)
• King County Metro (KCM or Metro)
• Seattle Department of Transportation (SDOT)
• Seattle Public Utilities (SPU)
• Seattle City Lights (SCL)
• Seattle Fire Department (SFD)

B. OCS Design Criteria and Performance

1) Climatic Conditions

   Elevation: 0 – 500 feet
   Latitude: 47° north
   Maximum Recorded Temperature: 103°F (AMBIENT)
   Minimum Recorded Temperature: 0°F
   Maximum Normal Temperature: 77°F
   Mean Normal Temperature: 53°F
   Minimum Normal Temperature: 35°F
   Mean No. of Days above 90°F: 2 per year
   Maximum Wind Speed: 79 mph
   Dominant Direction: SW
   Adverse Atmospheric Conditions: Heavy fog, sun rain, snow and ice

2) Environmental Criteria

   Maximum Ambient Temperature: 120°F
   Maximum wind speed (mph) 85
   Minimum ambient temperature: 0°F
   Ice loading (radial thickness, in.) 0.25 (Operating), 0.50 (Structural)

3) General Road Clearances

   LATERAL CLEARANCES:
   
a. Edge Of Curb:

   An offset of 4.0 feet from the face of curb to the centerline of pole foundation is the
guideline minimum clearance. Where space is restricted, design deviation must be
obtained to reduce this clearance. (KC Metro Standards)

   b. Driveways:
A 7.5-foot clearance measured along the sidewalk on arterials and in business districts per SDOT standards.

c. Curb (wheelchair) ramps:

One foot of clearance to the side of the ramp and five feet of clearance to the end of the ramp. For this guideline, ramp means only the (scored) portion and does not include the triangular transition area (or wing). Refer to most recent Seattle Right of Way Design Criteria.

d. Fire Hydrant

Five-foot lateral clearance is required.

e. Clearance to a Tree

A 10-foot clearance from center of tree to center of poles. This clearance shall be increased to 20 feet for poles with luminaire attachment.

f. Curb and edge of roadway (shoulder)

No less than three feet of clearance per SDOT standards where new poles are being installed on arterial and business district streets or minimum Metro standard to centerline of pole, whichever is larger.

g. Contact Wire Placement on Roadway:

For placement of contact wires on roadway, refer to Metro standard plans Wire Over Parked Car Illustrations.

4) DC Cables for Parallel Jumpers/Equalizers

a. Feeder jumpers shall be per Metro Standards and insulated, stranded copper conductors with sufficient flexibility to prevent fatigue failure of the cable due to movement and/or vibration of the overhead conductors. Feeder jumpers shall have two clamps when attached to contact wires.

b. Spacing of equalizing jumpers shall be based on required current conductivity, with a minimum of one jumper per Metro Standards.

5) Contact Wire Insulation and Electrical Clearances

a. The following air clearances shall be maintained between live equipment and any grounded fixed structure (per NESC Code 236-1, Table 235-6).

<table>
<thead>
<tr>
<th>Normal</th>
<th>Absolute Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing Static</td>
<td>Passing Static</td>
</tr>
<tr>
<td>4” 6”</td>
<td>3” 5”</td>
</tr>
</tbody>
</table>
b. Passing clearance refers to deflected (or uplifted or deflected) position of conductors or current collectors as the vehicle is passing, and static clearance refers to the normal static position of conductors without a vehicle.

6) Normal Trolley Wire Heights and Position (600 F, no wind and no ice condition).

<table>
<thead>
<tr>
<th>Normal height at support be at a range</th>
<th>18’-9” to 19’-3”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal minimum height at mid-span</td>
<td>18’ – 0”</td>
</tr>
<tr>
<td>Normal minimum height at support mid-span with ¼” ice</td>
<td>As per NESC</td>
</tr>
<tr>
<td>Normal minimum height at support mid-span with ½” ice</td>
<td>As per NESC</td>
</tr>
<tr>
<td>Normal maximum height at support</td>
<td>20’</td>
</tr>
</tbody>
</table>

a. Above tabulated heights shall be adjusted for routes with high gradients to assure the elevated vehicular clearances are met at all inclinations. Multiple span headspans such as “hold up” per Metro standard SA-302 or “hold down” per Metro standard SA-303 shall be employed at grade break locations.

b. Communication wires (telephone, cable TV) including cables and messenger wires shall have a minimum of 5 feet of vertical clearance to the trolley conductors.

c. The horizontal distance between the nearest trolley wire and the face of the curb shall be as specified in KC Metro Standards SA drawings.

7) OCS Poles and Foundations

a. All pole types shall be selected on the basis of their loading capacity requirements demanded by their load applications by the OCS, lighting and signal combinations from KCMT SP-201 Series of standards. The main type of pole to be employed are, galvanized tapered tubular steel, unless otherwise directed by KCMT. Pole capacities shall be as per King County Metro standards. Pole shaft Lengths shall be 25 ft. or 33.5 feet.

b. All poles shall be provided with bolted base connection base plates to fasten to anchor bolt foundations. Joint use poles that require riser shall have reinforced hand holes, luminaire arm connections and signal arm box type fasteners on pole shaft to interface with signal arm length requirements. Pole caps shall be on all poles, removable and are capable of being securely fastened to the top of poles.

c. Poles shall be set per KCMT standards. Offset from center line of pole shall be set to provide a minimum of 5’-0” walking space on sidewalk or platform.

d. Foundations shall be anchor base bolt type per Metro standards. The concrete finish level shall generally be at the same elevation with the roadway, sidewalk, or platform level where installed.

e. Foundation located within 20 feet of a roadway with no curb or a barrier shall be protected from vehicle impacts.
f. Foundations shall be installed with embedded conduits where feeder risers, street lighting, or traffic signal wiring is required. Unless otherwise specified in design, feeder conduit shall be no less than 2-inch dia., and signal wiring conduit shall be as specified in signal design plans.

8) Disconnect Switches and Section Isolators

a. DC No Load disconnect switches shall be used to electrically connect and disconnect line sections. Disconnect switches shall be rated to withstand the system worst-case overload and short circuit conditions without overheating. Switches shall be no-load type and located on feeder poles.

b. Switches provided in insulated enclosures shall be in separate and independent enclosures for positive and negative cables.

c. Section insulators shall be No-Bo type.

d. Protection for the OCS and feeder system shall be provided by installing surge arresters at feeder poles.

e. Surge arresters shall be rated to withstand maximum system voltage regeneration and anticipated voltages induced from parallel high voltage power distribution lines.

f. Surge arrester shall be capable of discharging the energy from lightning strikes or other excessive surges.

9) Grounding

a. Pole shall be grounded to attain 25 ohms or less resistance per NEC requirements.

b. For best performance, separate ground rod shall be embedded in the foundation extending it to a depth 5-foot below the bottom of the foundation.

c. Surge arrester system shall be grounded externally independent of the pole grounding and shall attain resistance from ground electrode or combination of electrodes of 5 ohms or less per NEC requirements.

10) Joint Use Poles

a. Where and when possible, joint use poles combining signal system and lighting provisions shall be combined with OCS poles to reduce pole clutter.

b. Above joint application shall be avoided with feeder poles.

11) Building attachments (eye bolts).

a. Where space is limited or prevented from placement of poles due to utility or other conflicts, eye bolt attachment to new or existing building shall be considered as OCS cross-span support system. Design of eye bolt and its anchoring shall include design loads as determined to be supported by a pole. Eye bolt design shall include structural design for adequate anchoring of the eye bolt to the building structure.
12) Coordination with other disciplines

a. Pole placement and joint use application shall be coordinated with signal and lighting design disciplines to reduce pole clutter along the corridor.

C. OCS Elements & Materials Guidelines

1) Contact Wire and Guy Wire Particulars

<table>
<thead>
<tr>
<th>ASTM</th>
<th>B47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size and type:</td>
<td>No. 4/0 AWG, grooved</td>
</tr>
<tr>
<td>Material:</td>
<td>H.D. Copper</td>
</tr>
<tr>
<td>Allowable wear:</td>
<td>30% (for maximum permissible mechanical stress)</td>
</tr>
<tr>
<td></td>
<td>15% (for electrical average fusing ampacity)</td>
</tr>
<tr>
<td>Tension at 60°F:</td>
<td>4/0 - 2000 lb.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size:</th>
<th>8M Guy Wire</th>
<th>16M Guy Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material:</td>
<td>Copperweld</td>
<td>Copperweld</td>
</tr>
<tr>
<td>Make-up Strand:</td>
<td>7 x 0.092”</td>
<td>7 x 0.128”</td>
</tr>
<tr>
<td>ASTM:</td>
<td>A460</td>
<td>A460</td>
</tr>
<tr>
<td>Overall Diameter (in.):</td>
<td>0.276</td>
<td>0.386</td>
</tr>
</tbody>
</table>

2) Insulators

a. Insulators shall provide electrical insulation in accordance with the system insulation class and shall have the mechanical safety factors specified.

b. The insulators shall have resistance against deterioration from exposure to sunlight and airborne chemical pollutants.

c. Insulator life expectancy shall be compatible with that of the rest of the equipment.

d. There shall be two levels of insulation minimum between the energized parts or structures per GO 95.

3) Cantilevers

a. Cantilevers as OCS support shall be employed only in special circumstances where limitation exist to use cross spans or back bones.

b. When cantilevers are employed, they shall be galvanized steel tubes, schedule 40 at a minimum and designed for gravity and radial loads. Minimum factor of safety for structural strength shall be 2.5.
c. The maximum “reach” of a bracket arm from KC Metro Standards (SA-341 or SA-351) is approximately 19 feet between the face of the pole and the nearest wire.

D. OCS Design Criteria: Loading on Structures

Loads on support structures shall include the following AASHTO or ASD US Standard Specifications:

1) **Dead Load**

   Loads on structural supports due to the weight of conductors to be treated as dead loads for purposes of the design. Ice loading conditions in combination with other load types (see Group Loads below). Dead load due to the self-weight of the structures and equipment shall also be applied.

2) **Live Load**

   Live load as indicated in the AASHTO Standard Specifications must be included.

3) **Ice Load**

   In addition to the requirements of the AASHTO Standard Specifications ice load will include the load of ¼ inch radial thickness of ice for operating loading and conductors. ½ inch radial ice shall be included for structural design for the maximum sag of the OCS. Ice is assumed to weigh 57 pounds per cubic foot.

4) **Wind Load**

   Wind loads shall be based upon a wind speed of 85 mph, the 50-year mean recurrence interval value. Wind loads on wires and conductors will be computed by the method given for structural supports in AASHTO or NESC Standard Specifications. Wind load under iced conditions will include the load due to the increased diameter of ice coated wires and conductors.

5) **Group Loads**

   To account for the effects of wire and conductor variation with temperature, the load groups indicated in the NESC Standard Specifications and applied as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>Applicable Loads</th>
<th>Percent of Allowable Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Dead Load at 0°F</td>
<td>100%</td>
</tr>
<tr>
<td>II</td>
<td>Dead Load at 60°F + Wind Load</td>
<td>133%</td>
</tr>
<tr>
<td>II</td>
<td>Dead Load at 0°F + Ice Load + ½ Wind Load</td>
<td>165%</td>
</tr>
</tbody>
</table>

6) **OCS Configurations**
a. The tangent route is defined as the portion of the route which is mostly straight and does not include any intersection or special work area. It may include slight changes of 10° direction and up or downward profile deviation of the trolley wires, resulting in 70 lb. of radial loads per support.

<table>
<thead>
<tr>
<th>Description</th>
<th>METRO Standard</th>
<th>Change in Trolley Wire Bearing Angle at support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangent Span</td>
<td>Standard cross spans</td>
<td>0° to 10°</td>
</tr>
<tr>
<td>1 Double Curve Hanger/Rail</td>
<td>SA-307.2 (two way) SA-317.2 (one-way)</td>
<td>1° to 2.5°</td>
</tr>
<tr>
<td>2 Double Curve Hanger/Rail</td>
<td>SA-308.2 (two way) SA-318.2 (one-way)</td>
<td>2.5° to 4°</td>
</tr>
<tr>
<td>Curve Segment Span</td>
<td>SA-310.2 (two way) SA-320.2 (one-way)</td>
<td>4° to 7°</td>
</tr>
</tbody>
</table>

b. Slight changes in trolley wire direction (up to 20°) may be constructed without the need for “special work” device. Direct allocation of a curve span from the King County Metro standards SA-161 is employed where appropriate. Curve spans shall be allocated as indicated below.

i. Span lengths are defined as the distance between adjacent trolley wire support clamps. Span length in the design shall be as follows:
   - Normal span: 100 feet
   - Maximum span for new construction: 110 feet
   - Maximum span on either side of a double tangent span: 100 feet
   - Maximum span adjacent to a switch or a curve segment: 100 feet
   - Maximum span with bridle construction: 100 feet
   - Absolute maximum span: 125 feet tangent alignment

ii. Bridle construction shall be employed as necessary to attain conductor alignment. Maximum skew angle of cross-span with respect to the perpendicular to the trolley wires:
   - Tangent span: 30°
   - Equalizer/feeder span: 15°
iii. 90° turns are generally wired using 15° curve segments or break. Where space is restricted, 30° curve segments or breaks may be used. A break shall be either:

- A switch (trailing or facing)
- A curve segment
- A combined curve segment/crossover (normally a left-hand turn)
- On induction control switches, the antenna should precede the switch by a minimum of 25 feet, or as per KCMT Standard SA-165
- Note: if curve segments are used, one 25° and one 35° may be used in place of two 30° curve segments. Refer to KCMT Standards SA-161.

iv. Guying of special work shall be designed to:

- Be structurally fully compliant with the applied load
- Simplified to Facilitate expeditious installation and maintenance

v. The following guidelines shall be used to design the guying for special work.

- If possible, the bridle terminations shall be located on a straight line between poles. This permits single inside and outside guying of the bisector of the angle shall be aligned with guying.
- In double-lane sections, all curves are to have individual high-side pull offs if the trolley wire angle at the supports do not exceed 20.

vi. King County Metro has two types of curve design:

- Using curve segments or rails
- So-called “conventional curve design.”

vii. Curve segments shall be used where the location:

- On sharp curves for very low-speed operations at 15 mph shall use Conventional curve design
- Alternatively, conventional curve design shall be used on all the curves which can be negotiated at speeds up to 30 mph. A conventional curve design shall consist of a series of 20 to 2.50 double curve hanger spans per KCMT Standard SA-307.2 and supported every 5 – 40 feet by a bridle or by a backbone arrangement.

viii. Backbone guying shall be minimized or avoided wherever possible:

- Shall be replaced by adjacent pole located conveniently or placed directly or use of split-guying to the pole Backbone guying shall only be
used where alternative installations cannot be satisfied by direct pole placements locations being employed with poles without resultant complex conditions that affect trolley operations that may cause dewirements of collector shoes.

E. OCS Standard Plans

Metro Transit Division Trolley Standards SP Drawings
Metro Transit Division Trolley Standards SA Drawings

F. OCS Standard Specs

340100 General Requirements for OCS
340110 OCS Metal Poles
340120 OCS Pole Anchor Foundation
340130 OCS System Disconnect Switches
342326 OCS Component and Fittings
342327 OCS Disconnect Switches and Surge Arrester
342330 OCS Metal Fabrications
342331 OCS Installation
342360 OCS Testing and Commissioning
342365 OCS Spare Parts
09 TRAFFIC ENGINEERING

A. Traffic Engineering Requirements Introduction

Deliver traffic engineering work which meets or exceeds the jurisdictional authority’s design standard or guideline applicable to the work to the maximum extent feasible. Provide guidance for local cities and consultants when designing facilities that will be used by Metro transit vehicles.

Traffic Codes, Regulations and AHJ

See Section 02 CIVIL.

B. Traffic Engineering Design Criteria

1) Lane Width for Bus Operations

It is desirable for lanes with transit use to be 12 feet in width. 11 foot widths are acceptable without formal approval.

2) Guidance for Bus Operations with Lane Width narrower than 11 Feet

Metro often provides transit service in local agency right-of-way where lane widths are determined by others, which can at times be narrower than 11 feet.

Metro has a process in place for approving transit operations in lanes with width narrow than 11 feet in width. Materials relevant to this situation include the following:

- Approval Process for Transit Coach Operation in Lanes less than 11’ Wide
- Hazard Risk Analysis for Bus Operations in Lanes Less Than 11’ Wide
- Hazard Risk Analysis Tables 1 – 4

3) Queue Jumps

Queue jumps are physical lanes in a roadway that provide travel time savings to specific vehicles, typically transit, near congested intersections. Queue jump lanes can be restricted to transit only use, but may also include general purpose turning movement traffic. Queue jump lanes are often accompanied by a queue jump signal that provides buses with a head start at a signalized intersection. Queue jump signal displays should be the transit movement only type of display described in the next section. A standard traffic signal display may be used for a queue jump display provided that it is an optically programmed display and is installed with a “BUS SIGNAL” sign below the display.

Operational considerations include:

Receiving Lane: It is desirable, but not required, to have a receiving lane on the far side of the intersection where a queue jump is provided; this allows the bus to merge into traffic after clearing the intersection.

Queue jump signal phase: If the queue jump is on the right side of the roadway, the queue jump phase may be run as an overlap with the adjacent general-purpose signal phase; a
“PROCEED” indication continues to be displayed on the bus signal while adjacent traffic also has a “PROCEED” indication. If the queue jump is on the left side of the roadway, the queue jump phase should not be run as an overlap with the adjacent general-purpose traffic; a “STOP” indication should be displayed while adjacent traffic has a “PROCEED” indication.

Detection Strategies: It is often desirable to install a pair of loop detectors or video detection zones combined with AND logic to activate the queue jump phase. The two detectors should be spaced 30 feet apart so that both detectors are activated simultaneously by a long vehicle (i.e., a bus) but will not be triggered by a shorter vehicle. This arrangement is useful when the queue jump lane is shared with some general traffic.

Metro often works collaboratively with AHJ on Queue jump implementation. Material below is guidance for these discussions.

4) *Transit-Only Movement Signal Head Display Recommendations*

Metro’s preferred Transit-Only Movement signal display style is noted below

![Diagram](image)

Metro’s preferred Transit-Only left Turn Only Movement display style is noted below
Only the three-lens display should be used to control bus movements.

A supplemental “BUS SIGNAL” sign should be installed below the signal display.

The lunar LRT-type displays do not need to be optically programmed.

The diagonal bar indication may be used to control a bus turning movement. When deploying this type of traffic control signal, review potential operator training needs with Metro management.

Note that these types of specialized signal displays often have long lead times from the manufacturer and may require early procurement.

5) **Transit Signal Priority**

Transit Signal Priority ("TSP") investments are one of the most attractive means to reduce transit travel time and increase transit reliability. Both local agencies and Metro are interested in widespread TSP system implementation and continual system improvement.

From a capital project design perspective, the following factors are important for designing an intersection to be TSP compatible:

a. The traffic signal must be connected to the city’s traffic network with reliable, low-latency communication. A fiber connection is preferred, but high-speed copper, cellular, or fixed-wireless connections may be sufficient.
b. The traffic signal controller must be compatible with King County’s centralized TSP system, which requires review and verification an upgrade of the existing traffic signal controller equipment is not required.

See the latest version of King County’s TSP Policies and Strategies document for the latest compatibility list.

6) Traffic Control Devices

Traffic signage and markings shall be designed to the AHJ standard. If Metro is the jurisdictional authority, the design shall use the following guidelines:

- Manual on Uniform Traffic Control Devices (MUTCD)
- WSDOT Design Manual

7) Bus Lane Signing, Striping, and Marking

Bus lane signage defines the legal operating parameters for the lane. Signage will vary depending on whether the lane is a full-time bus-only lane, a part-time bus lane, a Business Access and Transit (“BAT”) lane, or a right-turn-except-bus lane. Signs should be installed wherever a bus lane begins or ends or where regulations change. Signs should be repeated as needed to reinforce the lane’s restrictions and enforceability. While lane striping is beneficial to reinforce lane restrictions, signage is required to make the restriction legally enforceable.

Example Bus Only Sign
Signs designating bus lanes (as well as other signage) should not be installed in the bus mirror strike zone. The mirror strike zone shall be between 6 feet and 8 feet in height measured from the pavement surface and 2’ minimum from the face of curb.

8) **Red Bus Lane Markings**

Red markings can be made of MMA material (preferred) or thermoplastic.

A clean and unworn pavement surface will help ensure longevity of the red marking. Project Team’s should evaluate addressing pavement damage prior to installing red markings.

9) **AutoTURN Guidelines**

See Section 02

10) **In-Lane Bus Stop Guidance**

See [Transit Route Facility Guidelines](#)

11) **Speed and Reliability Guidelines**

Metro has developed [Speed and Reliability Guidelines](#) to support project evaluation and implementation by Metro and local agencies.

This is a guidance document for use on projects with transit speed and reliability improvement goals.

12) **Traffic Control Plans**

The current MUTCD edition shall be utilized for traffic control plan development and execution where King County is the AHJ.


See Section 02 CIVIL.
10 REFERENCES

A. Referenced within this Document

The following Documents are available either online or by request via the Engineering Manager.

[Links to be provided at a future date].

01 GENERAL:
- Design Quality Plan (DQP)
- King County Strategic Climate Action Plan (SCAP)
- King County Green Building Ordinance (KCBGO)
- King County Sustainable Infrastructure Scorecard
- LCCA Tool - KC Dept of Natural Resources and Parks
- COMPUTER AIDED DESIGN STANDARDS Version 2.5.13 – June 2019
  Division 01: General Requirements

02 CIVIL:
- King County Surface Water Design Manual
- King County Stormwater Pollution Prevention Manual
- King County Drainage Maintenance Standards
- King County Site Management Plan (SiMPla)
- KCM Transit Route Facility Guidelines
- King County Industrial Waste Discharge Standards
- Transit Passenger Facilities
- Metro Standard Pavement Details
- KCMT CPD Technical Specification Supplement (TSS)

03 STRUCTURAL:
- Structural CSI Guideline Specs

04 ARCHITECTURAL:
- Architectural CSI Guideline Specs

05 MECHANICAL:
- Ryerson Base Lift Replacement Project - drawings, specifications, O&M manual, lessons learned.
KCMT Standard Mechanical Details [TBD]

Mechanical Engineering Guideline Specs

06 ELECTRICAL:

Electrical CSI MASTERSPEC 2016-CDR
Electrical DESIGN STANDARD
SECTION 260051 - ELECTRICAL MINI-SPEC 2020

07 TPSS:

Battery Electric Bus Charging Criteria
Typical TPSS Single Line Diagram (TPSS-STD-01)
Typical TPSS Equipment Layout Plan (TPSS-STD-02)
TPSS Guideline Specs

08 OCS:

Wire Over Parked Car Illustrations
Metro Transit Division Trolley Standards SP Drawings
Metro Transit Division Trolley Standards SA Drawings

09 TRAFFIC:

Approval Process for Transit Coach Operation in Lanes less than 11’ Wide
Hazard Risk Analysis for Bus Operations in Lanes Less Than 11’ Wide
Hazard Risk Analysis Tables 1 – 4
TSP Policies and Strategies
Speed and Reliability Guidelines
B. Legacy Engineering Documents - For Historical Reference Only

This document was created with the following Reference Materials as the basis. These documents were provided by KCMT Engineering for integration into and compilation of these standards.

These documents may no longer be current, and this list is included for reference only.

**General:**
- DIV 01 Templates-LSA Edit 08-31-20 / DIV 1.pdf

**Architectural:**
- Architectural Design Standards Transit Capital Delivery 06.02.pdf

**Structural:**
- 2020-05-28 KC-SE Design Standards and Specifications - For KPFF.pdf

**Civil:**
- C01381C19 - Metro Standard Plans (not signed).pdf
- C01453C20-Civil Specs 2020 June23.pdf
- KCM_Civil Standard Pavement Details_1-6-09
- TSS 1-15-2020 Rev .doc

**Mechanical:**
- ME Design Guidelines draft 29May2020.docx

**Electrical:**

BASE ELECTRICAL
- Electrical CSI MASTERSPEC 2016-CDR.docx
- Electrical DESIGN STANDARD.docx
- SECTION 260051 - ELECTRICAL MINI-SPEC 2020.docx

LIGHTING
- Basic Lighting Requirements-2020 draft.doc

PARK & RIDE
- PARK&RIDE 2020 DRAFT.docx
- P-n-ride-2007a.doc
- EE Notes.doc

**OCS:**

ELECTRICAL TROLLEY STANDARDS
- LOADFLOW CALCS.xlsx
- Metro OCS Guidelines - Bike-Parking-Loading - June 2020.docx
- Wire Over Parked Car Illustration_07.16.2020.pdf

**Traffic:**

Bus Lanes
• SDOT Standard Plan 717a.pdf
• SDOT Standard Plan 750.pdf
Lane Width Guidelines
• Distribution Memo.docx
• Hazard Risk Analysis Tables (portrait) (1).docx
• Lane Width Criteria - 12-09-19.docx
Queue Jump
• MUTCD LRT Signals Diagram.png
TSP
• TSP Policies and Strategies 10-10-19.docx
• speed-reliability-toolbox.pdf
• transit-facilities-guidelines.pdf
C. Public Access Reference Documents - Available Online

“Capital Delivery Design Standards for CAD, specifications, and other reference files” - current as of 11/10/2020:

https://www.kingcounty.gov/depts/transportation/metro/about/design-construction-standards.aspx

ARCHITECTURAL
- Transit Facility Square Footage (4.7MB PDF) Amount of areas for Transit facility structures and properties.

CAD
- KCMTD Capital Division title and border Updated September 2019. Metro Transit Capital Division .DWG and .DWT title and border files.
- CAD Design Manual CAD.pdf - Metro Transit Capital Division CAD Standards (Acrobat format) Updated June 2019
- Civil Civil pavement details
- CTB.zip Contains Metro standard plot style tables for AutoCAD
- Electrical Electrical blocks and details
- Passenger Facility Guidelines Metro Transit passenger facility design guidelines, updated 2018
- Mechanical Mechanical blocks and details.

TROLLEY STANDARDS
- Trolley Overhead Standards SA dwgs (13.6MB PDF) Updated August 2017. SA-221 OBSOLETED pending new version
- Trolley Standards SP dwgs-Pole Purchase Requirements (1.2MB PDF) Updated June 2016

PASSENGER FACILITIES
- Transit Route Facilities Guideline Metro Transit route facilities design guidelines, updated 2018
- Architectural Plans Plans added & index updated 1/2/2005
- Construction Plans updated 12/5/2017 (site updated April 2018)
- Structural Plans Plans added & index updated 1/2/2005