King County Metro Transit Capital Project Delivery:

Engineering Services
Design Standards and Guidelines

Prepared by:

Metro Transit Engineering Services

March 2024

King County

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Professional Seal

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

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INTRODUCTION

Purpose of Document

This document summarizes Engineering Section Design Standards and Guidelines generally 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 of a capital improvement for Metro Transit.

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

This document 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 Deviation Request in coordination with the Engineering Manager (a.k.a. Managing Engineer) 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 as determined per project 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** require 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, specifications and referenced Standards.

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 11 REFERENCES.

Documents are available by request through the KCMT Engineering Manager.

01 GENERAL

A. Engineering Deliverables Requirements

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

1) Quality Management

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

The DQP addresses processes and requirements internal to the Engineering Services only. The DQP is not intended to replace a Project-specific Quality Management Plan (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 (KCGBO). 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 KCGBO. 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 Services for Review and Approval. LCCAs should be performed by using the LCCA Toolset and the Excel Template created by 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) Basis of Design

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 Basis of Design report to clearly identify applicable codes, design standards, and jurisdictional requirements for the engineering work products. Where code allows for various engineering solutions the Basis of Design shall identify the selected methodology.

The Basis of Design shall include project criteria addressing one or more of the following:

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

6) Calculations

Requirements are discussed in discipline-specific sections:

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

7) A first draft of all calculations shall be completed at 60% design. Critical calculations that are delayed past 60% design risk impacting project cost and schedule.

8) Cost Estimates

Depending on the 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.

9) Geotechnical report requirements

Final copy of geotechnical engineer's report shall be submitted to KCMT CPD Engineering Services for reference and review, prior to construction. The Geotechnical report shall have a coversheet with WA Engineer's stamp and signature.

B. Introduction, Codes, Regulations, Authority Having Jurisdiction

Subsections B through E 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.

Establishing jurisdictional authority and identifying the applicable regulations and design standards and guidelines for all project elements is the responsibility of the individual engineers of record and 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 consultant permit teams (if applicable), KCMT permit specialist(s) and environmental planners early in the planning phase.

(See also Basis of Design.)

FM Global Recommendations:

King County is self-insured and as such FM Global does not dictate design criteria. Certain projects are required to undergo technical and quality assurance review as shown in this FMG Decision Chart. Per FM Global's request, in the past their review was performed at 100% design; however, they currently would like to review as soon as meaningful schematics are available (typically at 60% design). While KCMT takes these recommendations seriously, Engineering Services is not beholden to FM Global review recommendations, however, deviations require justification based on documented engineering and safety analysis.

C. 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.

D. Standard Plans, Standard Drawing Requirements

Design Drawings and Specifications are to be submitted as separate files (see Specification requirements in the section below). Drawing set submittals and review sessions are expected at 30%, 60%, 90% and 100%. Specific review requirements shall be defined within the project design quality management plan.

Lists of code references, standards, symbols and abbreviations on drawings and specifications shall include only those applicable to the project and actively in use. All symbols and abbreviations shall be defined.

Use of standard plans is encouraged by KCMT to address typical construction situations. Use of Standard plans reduces 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 the King County Metro CAD standards for CAD and graphic requirements for all KCMT Engineering drawings. These standards are based on the US National CAD Standards. Where there is deviation, Metro CAD Standards will be used.

E. Standard Contents: Standard and Guideline Specifications

KCMT CPD Engineering Services 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.
- Selected Standard Specifications and Guideline CSI Specifications are provided by individual disciplines as referenced within that section of this document.
- Specifications are to be submitted as a separate package and not included in the drawing set.

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 Specifications, 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 Specifications may be required for a project as determined by the Project Engineer.
- Products, Materials and Equipment shall be specified according to ***King County Procurement Guidelines for Listing Products and/or Equipment on Public Works Construction Contracts***.
- 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.

For Metro-owned facilities, a geospatial survey shall be prepared and provided by a Professional Land Surveyor registered in the State of Washington. The final site survey plan(s) shall be stamped and signed by the said surveyor. Legal descriptions with metes and bounds shall be provided on the site survey map. Geo-spatial survey shall include surface as well as sub-surface features, 2 ft interval contour lines. Symbols and datum shall be in accordance with APWA standards and the requirements of AHJ.

Traffic engineering elements (i.e., lane widths, ITS) are addressed in Section 09 TRAFFIC.

Civil Codes, Regulations and AHJ

The list in this section includes design manuals, 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 ***(PDF)***
King County Site Management Plan (SiMPla)
King County Road Design and Construction Standards ***(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

Manual on Uniform Traffic Control Devices (current edition)

Washington State Department of Ecology (DOE) publications

DOE Stormwater Management Manual for Western Washington

LID technical Guidance Manual for Puget Sound

Local Agency Publications

As relevant to the work

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.

The KCMT Project Engineer shall determine the 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 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. For most transit facilities, add 5 ft to the front of the bus to account for the deployed bus rack. Factor in the side mirrors protruded beyond the 8'-6" wide bus body.

4) Pavement Section

Pavement sections shall be developed to AHJ standards.

It is recommended that Portland cement concrete paving (PCCP) 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. It is strongly recommended a minimum 10-inch thick PCCP be used at transit bases, permanent bus lanes at transit centers and other layover facilities. Follow AASHTO pavement design methods. Bus axle weights shall be 130 percent load based on Metro Fleet Specs published by Metro Vehicle Maintenance.

PCCP panels shall have a maximum 1:1.2 width to length ratio. Maximum panel length shall not be more than 12 ft.

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 and Metro Facilities Division.

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. The 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., corrugated pipes shall not be zinc coated. Use inert materials to the maximum extent feasible, such as HDPE (high density polyethylene) pipes.

See Mechanical Design Standards for Industrial Waste treatment facilities.

C. Civil Engineering Standard Plans

1) Metro Standard and Guideline Plans

Transit Passenger Facilities Standard Construction 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 ***(internal / PDF)***. 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 the responsibility of design engineers to apply professional judgement.

For additional information or questions, please contact KCMT CPD Structural and Architectural Supervising Engineer.

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.

- Draft structural calculations shall be submitted to KCMT CPD Engineering Services for reference and review, prior to construction.
- Structural Calculations sheets shall be formatted, have a coversheet with WA Structural Engineer's stamp and signature. It shall include a table of contents with all pages being numbered and initialized by the designer performing the calculations. All loading assumptions and conditions shall be listed in the Structural Calculations.
- All Computer output 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.

  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.

2) Codes, Regulations, Authority Having Jurisdiction

The list in this section includes design manuals, 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.

These may include, but are not limited to the Codes, Manuals, Standards, Guides, Specifications and Reports published by:

Current edition of the International Building Code (IBC) as adopted by the AHJ.

Current edition of the International Existing Building Code (IEBC) as adopted by the AHJ

American Association of Highway Officials (AASHTO)

American Railway Engineering Association (AREMA)

Aluminum Association (AA)

American Concrete Institute (ACI)

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)

American Society of Mechanical Engineers (ASME)

ASTM International (ASTM)

American Welding Society (AWS)

American Wood Protection Association (AWPA)

Crane Manufacturers Association of America (CMAA)

Code of Federal Regulations (CFR)

Concrete Reinforcing Steel Institute (CRSI)

Department of Ecology (DOE)

Forest Stewardship Council (FSC)

Leadership in Energy and Environmental Design (LEED)

Masonry Standards Joint Committee (MSJC)

Occupational Safety & Health Regulations (OSHA)

Precast/Prestressed Concrete Institute (PCI)

ASTM International/SAE International (UNS)

Washington Administrative Code (WAC)

Pacific Lumber Inspection Bureau (PLIB or WCLIB)

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 operating 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. Roof structures that support solar panel systems shall be designed to resist the dead loads provided in ASCE 7 Section 4.16.

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

Minimum Uniform Reserve Dead Loads for Structures and Facilities		
Location and Type of Building Construction	**Floor Added Reserve Dead (PSF)**	**Roof Added Reserve Dead (PSF)**
Modular – Single Story Metal Structures	5	5[b]
Modular - Single Story Wood Structures	5	5[b]
Parking – Concrete or Post-Tensioned Structures	10[a]	20[b]
Facility - Maintenance or Repair Shops	10[a,b]	30[b]
Facility - 1-4 Story Office / Operation Structures	15[a,b]	30[b]
Facility - Pre-Manufactured Steel & Metal Structures with Roof-Mounted Mechanical Equipment or Built-Up Roofing System	10[a,b]	15[b,c]

Notes:

a: 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.

b: This load is in addition to the weight of roofing material and rooftop equipment.

c: For Gantry Structures use 5 psf added Dead Load as the added mass to the lateral analysis.

2) Live Loads

a. Uniformly distributed and concentrated live loads, including Passenger Vehicle loads and Heavy Vehicle Loads, shall be per the requirements of ASCE 7 Table 43.1.

b. Live load reduction is permitted as provided in ASCE 7 Section 4.7 for Uniform Live loads or Section 4.7.4 for Passenger Vehicle Garages.

c. For parking structures restricted to passenger vehicles, 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 or a 3,000 concentrated load acting on an area of 4.5 inches x 4.5 inches + 25 psf snow load acting simultaneously whichever is more conservative.

d. Structure floors or lids over pits and vaults that are accessible to buses shall be designed for AASHTO Design Tandem Load (two 25 kip axles spaced 4 feet apart plus 640 lbs/foot uniformly distributed load) or an HL-93 32 kip axle load loading spaced a minimum of 14 feet apart.

e. For structures constructed adjacent to a light rail or railroad line, the structure shall be designed to meet the requirements of AREMA or the Guidelines of the track owner.

f. Structures, members or connections supporting elevators shall have an impact load as prescribed by ASME A17.1.

g. Structures, members or connections supporting machinery shall have an impact load as prescribed by ASCE 7 Section 4.6.3.

h. Structural members or connections supporting hoists for façade access and building maintenance equipment shall have an impact load as prescribed by ASCE 7 Section 4.6.4

i. Structural members or connections supporting cranes or monorails shall be designed for Vertical Impact Forces as provided in ASCE 7 Section 4.9.3 unless larger Vertical Inertia forces are required by CMAA 70, CMA 74 or ASME B30.11.

j. Structural members or connections supporting cranes or monorails shall be designed for Longitudinal Forces as provided in ASCE 7 Section 4.9.5 unless larger longitudinal forces are required by CMAA 70, CMA 74 or ASME B30.11.

k. Structural members or connections supporting cranes or monorails shall be designed for Lateral Forces as provided in ASCE 7 Section 4.9.4 unless larger lateral forces are required by CMAA 70, CMA 74 or ASME B30.11.

l. For fall arrest, lifeline and rope descent systems anchorages and the structural elements that support these anchorages shall be designed for a live load as prescribed by ASCE 7 Section 4.6.5.

m. 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

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

o. See local jurisdiction for fire truck loading requirements.

3) Roof Live Loads

a. Design roof structures for applicable IBC or IEBC roof live load or for snow and drift load, whichever is greater.

b. Minimum design roof live load, for roofs not used for assembly purposes, is 20psf.

c. Roof areas used for occupancies other than assembly shall be designed for the same live load as the occupancy served.

d. For concrete buildings, roof live load shall be per ASCE 7 unless future expansion is anticipated.

e. Primary roof beams and all open web trusses shall be designed for an additional point load of 2,000 pounds located at any location along the top of the beam or truss to accommodate potential future equipment.

f. Secondary roof beams shall be designed for an additional point load of 300 lbs at any location along the beam.

4) Snow Loads

a. The minimum design roof snow load is 25 psf or as calculated from the Minimum Ground Snow Load, whichever is greater.

b. Minimum Ground Snow Load shall be site specific as provided by the ASCE Online Hazard Tool at https://asce7hazardtool.online/.

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

d. Design roofs for drifting snow, including snow drifting against rooftop projects and roof-mounted equipment as required by the IBC, IEBC or ASCE 7. Drifting snow shall be evaluated as an additional snow design case from the minimum design roof snow load of 25 psf or as calculated from the Minimum Ground Snow Load, whichever is greater.

5) Rain Loads

a. Rain loads shall be in accordance with ASCE 7 Chapter 8.

   i. Bays with Low Slope shall meet the strength and stiffness requirement or ASCE 7 Section 8.3 to prevent ponding loads described in ASCE 7 Section 8.2.

6) Soil Loads

a. Maximum settlement

   i. Differential settlement of ½" over 30ft

   ii. Total settlement of 1"

b. Below-grade structures shall be designed for the lateral soil pressure, hydrostatic pressures and/or buoyancy pressures per the recommendations of the geotechnical report. Loads for soils prone to liquefaction shall be designed for the hydrostatic and buoyant forces associated with the liquefied soils.

c. Allowable vertical and/or lateral soil bearing pressures shall not exceed the value in IBC Table 1806.2 Presumptive Load-Bearing Values unless a geotechnical report provides different values. If the type of soil is not determined the maximum vertical soil bearing pressure shall not exceed 1,500 psf.

7) Wind Loads

a. Wind loads shall be site specific in accordance with the requirements of ASCE 7 for the Main Wind Force Resisting System, for Building Appurtenances and Other Structures, and Components and Cladding using the following parameters:

   i. Wind speed as provided in the ASCE Online Hazard Tool at https://asce7hazardtool.online/ using:

      a) Risk Category II

      b) MRI = 700 years

   ii. Exposure as described in ASCE. (Exposure in the City of Seattle may be determined from the City of Seattle, SDCI Wind Load Factors map at https://www.seattle.gov/sdci/resources/wind-load-factors. Exposure in the City of Bellevue may be determined from the Bellevue Wind Load Factor maps when they become available.

   iii. Wind Speed up Effect K_{zt} as described in ASCE 7. (K_{zt} in the City of Seattle may be determined from the City of Seattle, SDCI Wind Load Factors map at https://www.seattle.gov/sdci/resources/wind-l

oad-factors. K_{zt} in the City of Bellevue may be determined from the Bellevue Wind Load Factor maps when they become available.

iv. Wind Directionality Factor K_d as provided in ASCE 7, Table 26.6-1

v. Surface Roughness as provided in ASCE 7, Table 26.7.2.

vi. Ground Elevation Factor K_e as provided in ASCE 7, Table 26.9-1

vii. Velocity Pressure Coefficients, K_h and K_z as provided in ASCE 7 Table 26.10

viii. Internal pressure coefficient, GC_{pi} as provided in ASCE 7 Table 26.13-4

b. Wind loads acting on rooftop or ground-mounted solar panel systems shall be in accordance with ASCE 7 Chater 29.

8) Earthquake Loads

a. Seismic loads shall be site specific in accordance with the requirements of ASCE 7 for the Main Lateral Force Resisting System, for Nonstructural Components, Nonstructural Component Anchorage, Mechanical and Electrical Compents using the following parameters:

i. Unless site-specific ground motion analysis is required by ASCE 7 or the Authority Having Jurisdiction, the Design Spectral Acceleration Parameters as provided in the ASCE Online Hazard Tool at https://asce7hazardtool.online/ using:

a) Importance Factor, I_e as provided in ASCE 7 Table 1.5-2

b) Risk Category as provided in ASCE 7 Table 1.5-1

c) Seismic Design Category as provided in ASCE 7 Table 11.6-1 and Table 11.6-2

ii. Seismic Analysis Procedure may be completed using the Equivalent Lateral Force, Modal Response Spectrum Analysis, Linear Response History Analysis, or Nonlinear Response History Analysis methods as provided in ASCE 7 Section 12.6.

b. For seismic mass calculations, 10 psf for framed partitions, 10psf for areas with moveable partitions, and 5 psf for all other areas, including roof. This is in addition to the added reserve dead load in the table in Section 03.B.1.d.

9) Deflection Limit

a. Vertical serviceability and deflections

i.	Elevator/Escalator Support Beams	L/1000
ii.	Supports of Vibrating equipment	L/800

iii. Monorail or Bridge Cranes deflection limits shall be in accordance with the requirements of ASCE 7, CMAA 70, CMAA 74 or ASME B30.11 for the type of crane or monorail system being used.

iv. 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.

c. Ponding

10) Floor Vibration Requirements

a. Coordinate floor vibration limits with King County.

b. Parking Structures shall be evaluated for vibration in accordance with "Vibration Evaluation of a Parking Structure"[1].

c. Office or Other occupied structures shall be evaluated for vibration in accordance with "Steel Design Guide 11".[2]

d. Designer shall submit proposed vibration design and acceptance criteria for King County review and approval at the start of the design phase.

e. Office buildings shall have a maximum Acceleration Limit of 0.5% G as determined by AISC Design Gude 11.

i. Damping Factor[3]

a) Bare concrete floor, β = 0.02

b) Furnished Spaces that include low partitions, β = 0.03

c) Furnished Spaces that include full height partitions, β = 0.05

d) Parking Garages, β = 0.05

[1] Technical Note TN409-PS-Vibration-053011, Aalami, Bijan, ADAPT Software
[2] Floor Vibrations Due to Human Activity, Steel Design Guide 11, AISC, 1997
[3] Technical Note TN290R-Vibrations_Floor_011214, Aalami, Bijan, PT-Structures, January 2014

f. Parking Garages shall have a maximum Acceleration Limit of 0.5% G and an RMS velocity: 0.05 to 0.1 inches per second.

i. Damping Factor[4]

a) Parking Garages, β = 0.05

ii. Exciting Force of Vibration[5]

a) Cars: 4000 lbs + 5% Impact Factor

b) SUVs and Pick-up Truck: 5000 + 5% Impact Factor

11) Cranes and Monorails

Cranes and Monorails shall be designed in accordance with the requirements of the CMAA or ASME B30.11 for the type of Crane or Monorail being used.

a. Top Running, Multiple Girder Cranes shall meet the requirements of CMAA #70 Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes

b. Single Girder cranes shall meet the requirements of CMAA #74 Single Girder Cranes.

c. Monorails shall meet the requirements of ASME B30.11 Monorails and Underhung Cranes.

12) 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. Lifts

e. HVAC and mechanical or electrical equipment

f. High density filing or library systems

g. Window washing equipment

h. Cladding

[4] Technical Note TN409-PS-Vibration_053011, Aalami, Bigan, ADAPT Software, May 2011

[5] ibid

13) Load Combinations

Load combinations shall be in accordance with ASCE 7 Chapter 2.

i. Design of structures, their components and connections shall be designed using Strength Design Combinations taken from ASCE 7 Section 2.3 Load Combinations for Strength Design.

ii. Foundation bearing pressures, settlement and deflections shall be designed using Allowable Stress Design Combinations taken from ASCE 7 Section 2.4 Load Combinations for Allowable Stress Design.

iii. Design of structures, their components and connections subject to Extraordinary Events (low-probability events such as fire, explosions, and vehicular impact) shall be designed using the additional Strength Design Combinations taken from ASCE 7 Section 2.5 Load Combinations for Strength Design when directed by the King County Project Manager.

C. Structural Criteria: Elements & Materials Guidelines

1) Concrete

a. Mix design

Use a hydrophobic, hydrophilic waterproofing admixture, complying with ACI 212.3R as a permeability-reducing admixture for hydrostatic conditions (PRAH) for building slabs and walls below the water table or exposed to the elements, and parking garage decks exposed to the weather.

b. Reinforcing steel

Generally, use ASMT A615 grade 60 ksi steel. Higher strength steel such as 75 ksi or 80 ksi may be used to reduce congestion in heavily reinforced members subject to the limitations of ACI 318.

c. Materials, Mix Design and Minimum Thickness

i. Minimum concrete slab on grade thickness shall be 6” reinforced concrete with minimum concrete strength of f’c=4,000 psi.

ii. Concrete mix design shall be in accordance with the requirements of ACI 301 Section 4 for:

a) Minimum cementitious content

b) Maximum cementitious content of Fly Ash, Slab Cement, Silica Fume or other pozzolans.

c) Maximum Water/cementitious material content and minimum concrete f’c for concrete in Exposure S (sulfate) classes.

d) Maximum Water/cementitious material content, minimum

concrete f'c and air entrainment for concrete in Exposure F (freezing) classes.

e) Maximum Water/cementitious material content, minimum concrete f'c and air entrainment for concrete in Exposure W (in contact with water where low permeability is required) classes.

f) Maximum Water/cementitious material content, minimum concrete f'c and air entrainment for concrete in Exposure C (corrosion protection) classes.

iii. 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.

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

v. Epoxy bonding agent complying with the requirements of ASTM C881, Type II or V, Grade 3 and Class as required by project conditions, shall be used at all joints of fresh concrete to hardened concrete unless otherwise approved.

d. Concrete cover to reinforcing

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

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

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

iv. Polyethylene Foam preformed joint filler meeting the requirements of ASTM D7174 at joints exposed to vehicle traffic or where concrete slabs abut existing concrete.

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 Sika 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 does not require a surface hardener.

e. Non-Structural Slab

i. Provide reinforcing bars or welded wire fabric at mid-depth providing a minimum temperature reinforcing of .0018 in both directions. 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.

f. Spread Footings

i. Self-weight of footing may be neglected for the structural design of footings unless noted or advised otherwise by a Professional Geotechnical Engineer.

ii. Unless other top and/ or bottom reinforcement is required by analysis, provide a minimum temperature reinforcing of .0018 in both directions at all spread footings.

iii. For Site Class E or F, individual spread footings shall be interconnected by ties as required by ASCE 7 Section 12.13.8.2.

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

g. Pile Foundations

i. Piling shall be designed to withstand the deformations from earthquake ground motions and structure response as required in ASCE 7 Section 12.13.

ii. Provide grade beams or reinforced concrete slabs as required by ASCE 7 Section 12.13.8.2.

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.

h. 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.

i. Anchorage to Concrete:

i. Post-installed anchors shall have a current ICC-ES Evaluation Report which indicates that the anchors are for use to resist static, wind, and seismic (Design Categories A through F) tension and shear loads in cracked and uncracked normal and lightweight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi.

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

j. Rebar Doweling into Concrete

i. Post-installed rebar dowels shall have a current ICC-ES Evaluation Report which indicates that the anchors are for use to resist static, wind, and seismic (Design Categories A through F) tension and shear loads in cracked and uncracked normal and lightweight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi.

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 members, if possible.

b. Non-participating elements (those not part of the seismic-force-resisting system) shall be isolated in their own plane from the seismic-force-resisting system except as required for gravity support. Isolation joints and connectors shall be designed to accommodate the design story drift.

c. Minimum and maximum reinforcement shall be in accordance with the "Building Code Requirements and Specification for Masonry Structures" as published by the MSJC. Unreinforced masonry construction will not be permitted.

d. All cells shall be fully grouted.

e. The design strength shall be not less than f'_m = 2000 psi.

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

g. Anchorage to Fully Grouted Masonry:

   i. Post-installed anchors installed in fully grouted masonry shall have a current ICC-ES Evaluation Report which indicates that the anchors are for use to resist static, wind, and seismic (Design Categories A through F) tension and shear loads in cracked and uncracked fully grouted masonry.

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

h. Anchorage to Hollow Brick Masonry:

i. Post-installed anchors installed in masonry shall have a current ICC-ES Evaluation Report which indicates that the anchors are for use to resist static, wind, and seismic (Design Categories A through F) tension and shear loads in cracked and uncracked ungrouted masonry.

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

j. Anchorage to Multi-wythe Hollow Brick Masonry:

k. Post-installed anchors installed in multi-wythe hollow brick masonry (conforming to ASTM C652, Grade SW) shall have a current ICC-ES Evaluation Report which indicates that the anchors are for use to resist static, wind, and seismic (Design Categories A through F) tension and shear loads in cracked and uncracked ungrouted masonry.

   i. 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.

Structural Steel Member Specification Table		
Type of Member	**Fy (ksi)**	**ASTM Reference**
Rolled wide-flange shapes	50	A992
Square and rectangular HSS sections	50	A1085 Grade A
Round HSS sections	50	A1085 Grade A
Steel pipes	35	A53, Grade B
Column Base Plates	50	A572 Grade 50
Plates, channels, angles	36	A36
Threaded rods	36 or 55	F1554
Anchor rods (hooked, headed, threaded, nutted)	36 or 55	F1554
Structural framing bolts	---	F3125 Grade A325 or A490
Hex nuts	---	A563 Grade A
Flat circular washers	---	F436
Compressible-washer type direct-tension indicators	---	F959

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

c. KCMT Engineering prefers Steel Braced Frame (SCBF using a buckling restrained brace (BRB) system) systems with light gage 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 damage after an earthquake. In areas of vehicle or equipment traffic, reinforced concrete 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 for all braced frame systems shall meet the redundancy requirements of ASCE 7, 12.3.4.2, 1. In no event shall there be less than 2 bays of seismic force resisting framing on each side of the center of mass.

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

h. All steel Quality Control and Quality Assurance shall be in accordance with the requirements of AISC "Specification for Structural Steel Buildings" Chapter N. At a minimum, welding inspection tasks shall be in accordance with AISC "Specification for Structural Steel Buildings" Chapter N Section N5, 4.

i. All bolting inspection tasks shall be in accordance with AISC "Specification for Structural Steel Buildings" Chapter N Section N5, 6.

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

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

h. Exterior roof edges, and edges of raised roof sections shall be provided with a Washington Administrative Code, WISHA approved fall protection railing system.

i. 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.

j. At building or fascia joints where substantial lateral movements are expected, apply proper seismic joints detailing to accommodate the calculated seismic movements.

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 liquid spills.

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

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

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

2) Additional Requirements by Structure Type

a. Parking Structures

i. Post-Tensioning Requirements

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

b) Slab Tensile Stresses:

Top and Bottom Stresses to be Less than $6\sqrt{f'c}$

c) Beam Tensile Stresses:

Top Stresses to be Less than $6\sqrt{f'c}$

Bottom Stresses to be Less than $7.5\sqrt{f'c}$

Bottom Stresses with Snow Loading to be Less than $7.5\sqrt{f'c}$

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 one-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.)

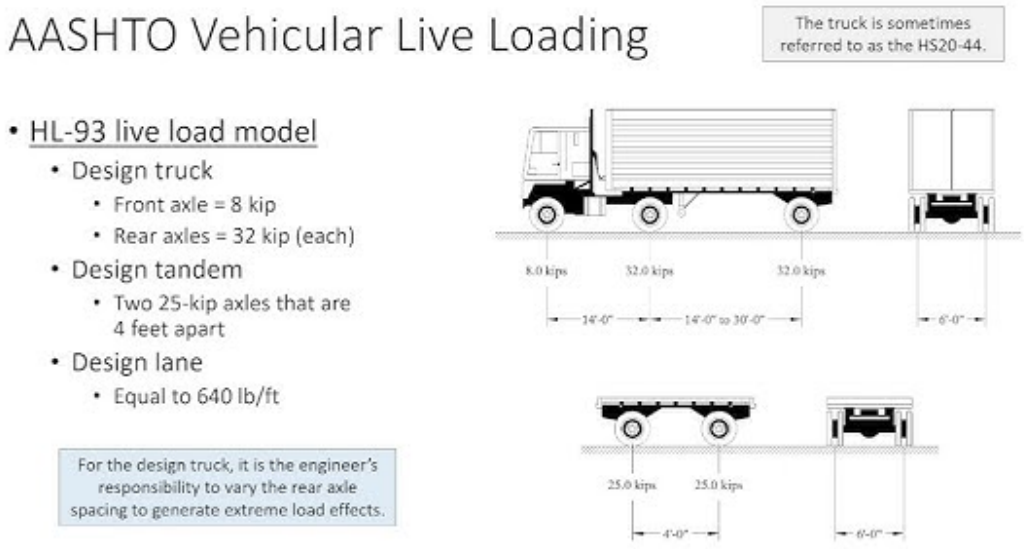
iii. The slope of ramps with parking stalls is preferred to be 5%. The maximum allowable slope is 6%. The parking floor shall meet ADA requirements, where applicable.

iv. Truck Loading Consideration on Interlocking Concrete Pavers

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 support these anticipated loads. When a crane stabilizer outriggers are in place, a point load of as much as 45,000 lbs can result. It is expected that sufficient timbe crane pads will be used to reduce the resulting pressure on the slab to the design live load capacity.



v. Top Level Considerations

The following options shall be considered to account for slabs 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
g) Waterproofing
h) Hydrophobic or hydrophilic waterproofing admixture,

vi. Special Considerations

a) Long span slabs and beam to be designed by EOR. But maintain 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 conform to the requirement of ACI 318 Section 25.7.2.1 and 25.7.2.2.

c) Adjust concrete design for 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) Crack sensitive floor coverings and topping slabs

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

m) Consider the use of bonded strands to allow for future penetrations.

n) Future penetration problems can be minimized by bundling post-tensioning tendons and spacing the bundles as widely as permitted by ACI 318.

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 to be full of 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 on the shop floors.

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

E. Structural Plan Standard Requirements

The following structural design criteria shall be listed in the structural drawings:

1) Building Category

a. Structural Risk Category from IBC Table 1604.5

b. Importance Factors

i. I_e

ii. I_p

iii. I_s

2) Roof Loads

a. Roof live load

b. Roof superimposed dead load

c. Roof reserve dead load

d. Solar Panel System Dead Loads

e. Solar Panel wind loads.

3) Roof snow load

a. Ground Snow Load, p_g

b. Exposure Factor, C_e

c. Slope Factor, C_s

d. Thermal Factor, C_t

e. Flat Roof Snow Load, p_f

f. Minium Snow Load

g. Drift Loads, p_d

h. Drift Width, w

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
b. Exposure category
c. Internal pressure coefficient, Cp_i
d. Topographic factor, K_{zt}
e. Directionality factor, K_d
f. Enclosure classification
g. Gust effect factor, G
h. Minimum Wind Load (ASCE 7, 27.1.5)
i. Wind Pressure on Each Surface, p

6) Seismic loads

a. Site Class
b. Mapped spectral response accelerations, S_s and S_1
c. Design spectral accelerations, S_{ds} and S_{d1}
d. Seismic design category
e. Seismic force resisting system
f. Response modification coefficient, R
g. Seismic response coefficient, C_s
h. Seismic analysis procedure with ASCE 7 reference
i. Design Base shears

7) Other loads

a. Operating weight of mechanical equipment and its location

8) Soil Properties

a. Allowable bearing pressure
b. Lateral pressure acting on walls

9) List the following concrete design criteria in the structural drawings:

a. Specified compressive strength, f'_c
b. Minimum compressive strength at time of posttensioning
c. Specified grade of reinforcement

d. Anchorage length of reinforcement
e. Lap Length of Reinforcement
f. Magnitude and location of prestressing forces

10) List the following masonry design criteria in the structural drawings:

a. Specified compressive strength, f'_m
b. Mortar Type
c. Grout strength
d. Maximum grout lift height
e. Specified grade of reinforcement
f. Lap Length of Reinforcement
g. Magnitude and location of prestressing forces

11) List the following timber design criteria in the structural drawings:

a. Timber species and grade
b. Preservative treatment
c. Fire retardant treatment
d. Nailing Schedules

12) Concrete properties in the Structural Specifications or General Notes

Cast-in-Place Concrete Materials	
Mixed Material Type	**Specification Reference**
Portland-Limestone Cement	ASTM C595 Type IL
Fly ash (as applicable)	ASTM C618 Class F or C
Slag cement (as applicable)	ASTM C989
Light weight aggregate	Light weight aggregates shall not be used without prior approval of King County
Normal weight aggregate	ASTM C33
Sand	ASTM C33
Water	Potable per ASCM C94
Air entraining admixture	ASTM C260
Chemical admixture	ASTM C494
Flowable concrete admixtures	ASTM C1017
Hydrophobic or Hydrophilic Water Proofing Admixture	ACI 212.3R permeability-reducing admixture for hydrostatic conditions (PRAH)

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 levelness, F(L) 35; with minimum local values of flatness, F(F) 30; and levelness, F(L) 24.

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.

The list in this section includes design manuals, 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. These may include, but are not limited to the Codes, Manuals, Standards, Guides, Specifications and Reports published by:

Americans with Disabilities Act (ADA)

Architectural Woodwork Institute (AWI)

Consumer Protection Safety Agency (CPSA)

Master Painters Institute (MPI)

National Association of Architectural Metals Manufacturers (NAAMM)

National Fire Protection Association (NFPA)

National Paint & Coatings Association (NPCA)

Paint & Coatings Industry (PCI)

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 January 2024 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 Metro Transit CPD Engineering Services 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 KCGBO. 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 number 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. Use grommeted fasteners at curb flashings. Provide metal separation where dissimilar metals are used.

k. Fall protection shall be in compliance with OSHA, WISHA, WAC Chapter 296-24, local jurisdictional authorities, and the Structural Design Standards in this publication.

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

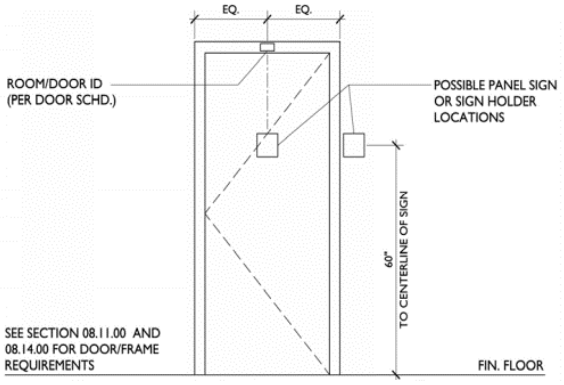
Coordinate Architectural requirements with Electrical design for secured entry card-reader systems and security camera installations.

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

a. Customer signage mounting locations



b. 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

The list in this section includes design manuals, 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.

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

ASHRAE Standard 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings

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 through manner to aid orderly review. Alternatives Analysis (AA) Requirements for Mechanical Design

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

   i. 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.

b. Ventilation calculations:

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

c. Mechanical equipment noise criteria:

   i. 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.

d. Drawings per the King County Metro CAD standards for CAD and graphic requirements for all KCMT Engineering drawings.

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

f. Specifications in Construction Specifications Institute (CSI) format

g. 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

- The alternatives shall include at least one electric-only option. Natural gas-powered equipment to be used only when no other alternative available.
- Compare refrigerant vs non-refrigerant options as applicable.
- For each alternative, perform a building energy analysis to predict energy cost impact and to form basis of the LCCA as described in the next section.
- 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. LCCA in accordance with Section 01 GENERAL.

b. FM Global Review and Implementation

i. As Specified in Section 01 GENERAL.

c. Commissioning

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

a) All mechanical projects over $250,000

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

c) Generator, automatic transfer switch and fire control panel projects

d) Mechanical projects of any size that involve environmental risk and/or life safety systems, including but not limited to:

1) Underground and aboveground fuel and fluid tanks

2) Fueling and other combustible fluid distribution systems

ii. Commissioning agent shall also commission special systems, such as but not limited to:

a) Compressors

b) Vehicle Maintenance Fluid Systems

c) Cranes

d) Hydraulic 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 KCMT CPD 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.

b. Natural Gas System (for repair of existing only; new installations provide only if there are special equipment needs, with documented justification).

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

d. Drinking Fountains

i. All drinking fountains shall meet ADA requirements. In addition, all drinking fountains should have bottle filling capabilities with touch-free activation sensors.

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 electrical type unless it is determined that electrically powered models cannot match gas power in terms of safety and reliability.

ii. If required, gas-fired boilers shall be condensing type. Flue material should be per manufacturer's recommendation. Provide engineering justification for gas fired equipment. Gas fired equipment is expected to be prohibited in all cases by King County in the near future.

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. 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.

D. Design Criteria for Occupied Zones

1) General Office and Conference Rooms

a. General office HVAC system shall consist of either a variable refrigerant flow (VRF) system or heat pump Variable Air Volume (VAV) system, dependent on an energy-based alternatives analysis for the facility as well as any applicable "buy American" contract provisions. The system shall be coordinated with a full control system that is BMS compatible. Provide VAV system with rooftop air handler with electric or hydronic reheat. If VRF, basis of design is 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 VAV units in areas that require Demand Control Ventilation (DCV). DCV shall be controlled using Carbon Monoxide (CO2) sensor.

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, electric coils or heat pump and intake/exhaust air heat recovery. Include door switches to set back heating temperature setpoint when roll up doors are open.

b. Radiant heating systems were historically used to provide comfort and for high bay areas where stratification can cause performance issues with forced air heating systems- especially when bay doors are open. Gas-fired radiant heater is prohibited unless it is determined that electrical powered radiant heaters cannot match gas powered models in terms of safety and reliability.

c. Vehicle Exhaust System (VES) standard: dedicated vehicle exhaust fan with hose reels and custom 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 buses served at the facility. Historical gas-powered basis of design: Whitco for steam cleaning equipment and Alkota for part cleaning equipment. To be updated with electric-powered options when available.

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 (0.2 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.

e. Ensure TAB is performed on existing system prior to demolition.

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 spaced 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).

7) Compressor Room

a. The compressor room shall be provided with a means of cooling via transfer air and exhaust/transfer of house air (preferably from the maintenance bay area). A dedicated exhaust fan shall be controlled via VFD to maintain the compressor room temperature. During the summer cooling season, the compressor room shall be exhaust directly to the building exterior. During the heating season the air shall be redirected back into the building maintenance bay area if it is deemed feasible such as the bay area being sufficiently close to the compressor room.

F. Design Criteria for Special Equipment

1) Compressed Air System

a. General Requirements

Compressed air systems shall include a liquid separator between the compressor and wet air receiver. Shop Air systems shall include a particulate filter after the dryer. Paint Booth Spraying systems shall include an oil coalescing filter after the dryer. An additional filter before the wet receiver is recommended, for both systems, if the receiver is not galvanized or internally coated.

b. System Type

Compressed air systems shall be direct drive variable speed with air receiver. Belt driven single spend type will be allowed only if no alternatives exist. Provide separate compressed air systems for the Vehicle Maintenance Areas (125 PSIG) and the Tire Shop (150 PSIG).

c. Tire Shop and Vehicle Maintenance System

i. Compressed air system shall include an aftercooler and cycling refrigerated dryer between the compressor and the 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.

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

   i. Three air-cooled direct drive VFD rotary screw compressors, two duty compressors, and a third to provide backup. Manufacturer shall be Quincy or Approved Equal.

   ii. Two air dryers.

   iii. One receiver tank.

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

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

   vi. To minimize dissipated heat and noise inside the building compressors shall be installed in a dedicated compressor room with high mass acoustical insulated walls.

e. Compressed air working pressures shall be confirmed with KCMT Engineering. Typical compressed air pressures:

   i. Minimum Vehicle Maintenance shop working pressure is 125 psig.

   ii. Tire Shop working pressure requires 150 psig (minimum startup pressure shall be greater than 132 psig). Minimum compressor HP shall be 10 unless a 5HP or 7.5HP unit has startup capability to be greater 132 psig or greater.

f. A separate dedicated air compressor system for tire shop is required. The system shall be designed to handle the pressure demands using variable speed units if available and air receiver system.

g. Systems shall be designed to meet more than one working pressure, with the following equipment:

   i. Equipment: Air-cooled rotary screw compressors, with aftercoolers built into the units.

   ii. Compressor type, such as variable or fixed speed, shall be selected as appropriate for the system and project. Manufacturer shall be Quincy or Approved Equal.

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. Provide up to 1000 gallons per 200 buses at maintenance base. Actual size of the receiver shall be determined in conjunction with the VFD compressor performance characteristics.

ii. Secondary standard: Provide up to 2000 gallons per 200 buses at maintenance base. Actual size of the receiver shall be determined in conjunction with the VFD compressor performance characteristics.

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 components: 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. Transit-wide standardization study Alternative Analysis in progress as part of project 1134326 “Atlantic Base Vacuum System Replacement”. Consult with final version and unique base requirements prior to adoptions of the following criteria.

i. Central Vacuum System- Inside the Wash and Clean Building on the side of the lanes that passengers normally embark and disembark, locate self-contain vacuum systems with coiled hose reels capable pulling dirt and debris into a cyclonic separator. The dirt and debris are collected in a dirt cannister attached to the bottom of the cyclonic separator. The cyclonic separator captures most of the dirt and debris, then the cyclonic filtered air passes through a final filter at the top of the unit before it is discharged. This filter is cleaned by a pulse jet filter cleaner that periodically

blows air over the filter to dislodge any dust attached to the filter. Manufacturer shall be EuroVac or Approved Equal.

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; customization features to be confirmed based on active coaches at base)

4) Fuel System

a. New base construction standard for fuel storage is Aboveground Storage Tanks (ASTs) with the following criteria:

   i. 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 (if any) based on planned conversion to fully electric fleet.

   ii. Conform to NFPA 30 and 30A and FM Global recommendations, and requirements from the AHJ Fire Marshall. If it is determined that spill containment and/or vehicle impact protection such as bollards are required, conform to the KCMT Engineering Services Civil and Structural Standards and Guidelines contained herein.

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 impacting fueling operations. Fuel and other fluid management and leak detection detailed in Fluid Monitoring Section below.

   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.

c. Tank basis: ACE Tank US 1316 fiberglass

d. Pump Types:

   i. Diesel fueling: Submersible Turbine Pump. Basis: Veeder Red Jacket

   ii. Gasoline Fueling: Submersible turbine suction 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 KCMT Engineering Services 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 as well as leak detection. 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 wastewater will be directed to the first vault until it reaches maximum capacity. The industrial wastewater 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 wastewater 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 wastewater 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 Wastewater limits. Include dosing/sample collection port for KCMT Environmental Compliance access.

f. Preferred sump pump type is pneumatic submersible sump pump.

g. KCMT Environmental Compliance Manager applies for permits. Permitting process will require an estimated of daily volume discharge to KC wastewater 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 wastewater 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. Historical standard is Metro Transit proprietary custom design hydraulic post lifts: refer to *Ryerson Base Lift Replacement Project* - drawings, specifications, O&M manual, lessons learned (KPFF EOR). Customer request as of August 26, 2021 for sole-source standardization based on Rotary post lift. Alternatives analysis with renewed stakeholder engagement to be performed as part of

project 1134246 "Atlantic Base Vehicle Maintenance Phase 2 Bus Lift Replacement", active August 2021.

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 is based on the existing fleet, however requirements must be re-evaluated as new coaches are purchased.

iv. All lifts shall be structurally designed according to the KCMT Engineering Services Structural Standards and Guidelines contained herein.

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.

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.

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

Under development

I. Mechanical Engineering Guideline Specs

Under development

06 ELECTRICAL

A. Electrical Engineering Requirements Introduction

This Section defines minimum requirements to be adhered to by the Electrical Engineer of Record.

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

Codes, Standards and Authority Having Jurisdiction

The list in this section includes design manuals, 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.

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)

NFPA 101 Life Safety Code (NFPA-101-HB85)

ANSI C2 National Electrical Safety Code (ANSI C2-1987)

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 project and State Electrical Code Supplement

The King County Strategic Climate Action Plan (SCAP)

Leadership in Energy and Environmental Design (LEED)

OSHA Standard Number 1910.146

Requirements of local utility companies

Inspection Authorities

The local Authority Having Jurisdiction shall have responsibility for interpreting 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 Engineer

B. Electrical Engineering Criteria - General

1) Submittals

All submittals listed below shall be labelled and tagged.

a. Alternatives Analysis (AA) Requirements for Electrical Design

b. Life Cycle Cost Analysis (LCCA) Requirements for Electrical Design

c. 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.

d. Electrical equipment noise criteria

e. 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.

f. Drawings per the King County Metro CAD standards for CAD and graphic requirements for all KCMT Engineering drawings.

g. Specifications in (Construction Specifications Institute) CSI format

h. Equipment cut sheets

2) Sustainable Design Practices

a. 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.

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

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

ii. 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.

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

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

3) Resiliency

a) Electrical Services rated above 480 volts shall have a reliability analysis in accordance with IEEE 3006 series, with downtime and recovery scenarios matched against the operational expectations of the supported load.

4) 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.

5) Commissioning

The following projects require a third-party commissioning agent:

a. All Electrical projects over $500,000.

b. As required for compliance with energy codes.

c. Generator, automatic transfer switch and fire control panel projects.

d. 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

1) General Electrical Engineering Criteria

a. Design Criteria

i. Delineate existing systems differently from new modifications.

ii. Identify point of Connection interface with the servicing utility on Point of Connection.

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

iv. Generally, there shall be only one Main Service Disconnect at the site of a facility, and the NEC option for six disconnects shall not be utilized. (26 13 00 & 26 23 00)

v. Perform Power Studies throughout the design process to determine voltage drop, short circuit current ratings, and equipment sizing, Calculations shall be submitted at each milestone deliverable. When design reaches 100%, the Power Study calculation shall represent the full One-Line Diagram. Overcurrent protective devices supporting systems rated over 1000 volts shall be selectively coordinated.

vi. All over current protective equipment and motor controllers shall be by one manufacturer. This includes modifications to existing facilities; equipment shall be of the same manufacturer as installed in the existing facility.

vii. Coordination with other disciplines:

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

b) Provide adequate space in electrical rooms and closets for equipment, clearances, additional (Future) equipment, potential future growth and maintenance space allowance for conduit entry routes, conduit exit routes, top hats. shelving, tables, and workspace.

c) Coordinate with mechanical engineer to ensure switchboard rooms are ventilated and dehumidified.

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

e) Maintain required workspace clearances and required clearances for equipment access doors and panels, include spaces above, below, between, in front and back of equipment.

f) Consider project conditions. Such as:

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

2) Coordinate door height and widths for equipment entry.

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

a. Ambient Temperature: Not exceeding 104 deg F.

b. Altitude: Not exceeding 1000 feet.

viii. Designer Inspection requirements for delivery and storage per-installation.

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

x. Busing: Busing in all panelboards, Switchgear and Switchboards shall be Hard drawn copper, 98% conductivity. Buses rated 400 amps and above to be silver plated per industry standards.

xi. Transformer windings: windings (coils) in all transformers shall be copper.

2) General Electrical Drawing Requirements

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: 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 and/or the Lead Designer assigned to the project. Remove symbols not used.

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. Remove abbreviations not used.

c. Electrical Site and Major Area Plans:

   i. Show raceways at the designed location, coordinated with other site elements. Do not use the "home run" symbol. Show handholes larger than 3' x 3' to scale.

   ii. Electrical Site plan shall include (minimum requirements):

      a) Electric Point of Service

      b) Underground Electric Service Duct Bank

      c) Grounding electrode system (ground ring, ground rods, etc.),

      d) Generator placement, generator feeders/control duct bank

      e) Underground duct banks for Electric Power and Telecommunications feeding buildings and equipment on the site.

      f) Site lighting & associated underground conduit

d. Exploded view site and area drawing format for:

   i. Electrical site and area plans will use architectural or civil backgrounds

   ii. Plans shall be divided into specific electrical systems based on the nature of the work and the density of the information.

   iii. All normal, emergency, and special egress lighting shall be shown and identified on the "Lighting Plan."

   iv. Show receptacles, vendor rough-in, HVAC, wiring to all equipment and power feeders on the "Power Plan."

   v. The drawings are to show the actual conduit routing for all major power loads.

   vi. Home run designation may be used for lighting and general-purpose receptacle circuits, but not on site plans

e. Single Line Diagrams (One Line Diagram)

   i. Single line diagrams shall show information supporting the delivery of electrical power and information such as ampacities, voltages,

impedances, and insulation ratings. Requirements related to physical performance such as clearances, enclosure environmental ratings, duct encasement, etc shall be shown on plans and details.

ii. Power Single line diagram shall include:

a) The entire electrical distribution system from the incoming utility point of connection to each panelboard and any single load greater than 100 amps.

b) Systems protection elements:

1) Identify trip settings and interrupting capacity for circuit breakers, fuses, and relays. Reference to Power Systems Study with author, date and version defined.

2) Bus bars: distinguish bracing requirements from the ampere interrupting capacity identified for overcurrent protective devices.

3) Short circuit information: Show utility available short circuit current. At each distribution node show the greater of the three phase symmetrical fault current or the single phase line to ground fault current from either the utility or generator source. Include X/R ratio to allow vendors to determine derating requirements and, if necessary, conduct harmonic analysis.

4) Surge protection: Identify arrestor protection kV for MV systems and current profile for less than 600V.

5) Symbols: Indicate all one line diagram symbols on the Legend or symbol list. Utilize separate symbology for fixed vs drawout, air vs vacuum, power vs control, and other elements of performance. The flow of power should be emphasized with a bold line weight. Lighter line weights and dashing shall identify monitoring and controls; and extent of equipment enclosures, room limits, floors, and building limits.

iii. Grounding Riser Diagram: Include ground sizes, grounding electrodes, and ground bus locations

iv. Block Diagrams: Use symbols and line weights similar to One Line Diagram. Where any of the following elements are included as part of the project provide a block diagram showing the control wiring connections between the elements:

a) Power meters and network

b) SCADA points and data inputs (typicals are acceptable)

c) Engine Generator, Annunciator, Automatic Transfer Switch

d) Solar system control elements

v. Wiring Diagrams to include

a) Power, signal, and control wiring

b) Termination block diagram, wire labeling

c) Controls explanation

d) Provide CT and system connection wiring diagram for the EMON system.

vi. Elevation Views

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

b) 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.

c) Show housekeeping pads with dimensions and embeds for equipment anchorage.

vii. Section Views

a) 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.

viii. Details

a) Special details will be developed as needed for the project for clarity. Details to be to scale.

b) Frame mounting assembly for equipment independently mounted.

c) Cross section of duct banks

d) Cross sections of cable arrays/trays on support hangers with seismic bracing.

3) General Specification Requirements

a. Refer to Section 01 GENERAL for specifications requirements.

b. For smaller projects (Under $250,000 in electrical content of work), refer to KC Electrical Mini Specification. 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.

4) General Calculation Requirements

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. All final stamped and signed calculations shall be included in the Operations and Maintenance manual.

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

   i. Lighting Calculations: AGI32 Lighting Design software by Lighting Analysts.

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

e. Perform all calculations required by the National Electric Code to meet specific elements of construction. Include the following calculations unless engineering judgement by KCMT determines their result would not add value to the project:

   i. Cable pulling tension and bending radius jamming ratio

   ii. Raceway fill and derating

   iii. Voltage drop

   iv. Ground resistance

   v. Surge arrestor size

   vi. Duct Bank thermal performance

5) 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. Obtain utility standards and point of connection requirements and show this information on the drawings.

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

6) 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.

b. Fix major loads 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 locations and size. Include both NEC connected and demand load values, for each building or process area.

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

f. Base final computations on actual loads shown on the drawings.

g. New systems shall include a minimum allowance for 30%+ growth for additional branch circuits and spare physical space for additional panel boards.

h. 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.

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

7) 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.

a) Certify compliance with test parameters.

b) Arc-flash label installed for all electrical equipment

8) Wiring and Cable

a. Copper rated 600 volts, types THHN/THWN for indoor applications and type XHHW for exterior and below grade or slab applications.

b. All wiring shall be contained in raceways.

c. Splices and Connections

i. Run new wire point to point without splicing.

ii. Wire nuts up to 8AWG, with silicon fill in exterior above grade locations. Insulated barrel compression above 8AWG.

iii. Below grade: Resin type kit to electrically insulate and seal against water around barrel compression.

iv. Compress compression connectors with tool approved by connector manufacturer.

v. Connect to terminals with lugs. Utilize ring, spade, or locking fork type crimp terminals.

9) Medium-Voltage Cables

a. Load Analysis

i. Perform Load Analysis on MV cable system. Limit load on new construction to NEC requirements. Limit new added load on existing systems to maximum of 70% of cable rating. Verify remaining spare capacity requirements with KCM, subject to each application.

b. Testing

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

ii. 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.

iii. Specify that following minimum tests and inspections are performed:

a) All measuring equipment has calibrations within 90 days.

b) Visual and mechanical inspections.

c) Cable dielectric strength: Very Low Frequency (VLF) compliant with IEEE 400 and 400.2

d) Shield Continuity Test

e) Thermographic surveys of bolted connections on energized and loaded cables

10) Grounding and Bonding for Electrical Systems

a. General Design Criteria

i. A grounding system shall be designed such that the ohmic value of the "grounding electrode" does not exceed the identified test values.

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

iii. New facilities: Request soil resistivity data for the site.

iv. Ground bonding common with lightning protection system.

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

b. Drawing Requirements

i. Details to include:

a) Grounding buses in electrical and IT/ communication rooms

b) Ground connections

c) Ground rod and ground measurement test well

d) Manhole ground ring and bus

e) Equipment grounding typical

f) Isolated ground details including cabinetry where needed

ii. Grounding Bus: Provide 20” or longer bus bar in electrical and telecom rooms.

c. Calculations

i. A grounding system shall be designed such that the ohmic value of the Electric Service Entrance "grounding electrode" does not exceed the expected testing value for the systems.

d. Testing

i. Fall-of-potential testing to be per IEEE 81.

ii. Measured ground resistances shall not exceed the following values:

a) Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

b) Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.

c) Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

d) Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.

e) Substations and Pad-Mounted Equipment: 5 ohms.

f) Manhole Grounds: 10 ohms.

For interconnected grounding electrodes the lowest resistance may be used to satisfy each of the above.

11) Hangers and Supports for Electrical Systems

a. General Design Criteria

i. Consultant to coordinate routing of conduit/cable tray and method of attachments with other disciplines.

ii. Locate and dimension penetrations in walls and floors. Determine and design reinforcing.

iii. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents. Hangers and support systems shall not be designed to support maintenance staff using as work platforms.

iv. Seismic-Restraint Loading:

a) All equipment shall be seismically rated for the applicable conditions.

b) Include in project specifications requirement for static capacity testing if King County requires.

c) Boxes and Enclosures, aboveground, in wet/damp areas: NEMA 250, Type 4x.

b. Specification

i. Include in project specifications requirement for static capacity testing if required by KCMT Project Engineer.

c. Calculations

i. Consultant to design seismic-restraint devices.

ii. Provide plan runs and mounting details for conduit runs and/or cable tray of greater than 30 pounds per linear foot and 60 pounds per square foot.

iii. 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. Future determination shall be weight of supported components plus 20 pounds per linear feet or 50 pounds per square feet.

d. Documentation

i. 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.

ii. Signage: Include DO NOT USE FOR MAINTENANCE USE signage if a concern.

12) Raceway and Boxes for Electrical Systems

a. General Design Criteria

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

ii. Locate and dimension penetrations in walls and floors. Determine and design reinforcing.

iii. Provide in-line pull boxes to limit the number of directional changes (bends) of the conduit to a total not more than 270 degrees in any run between pull boxes.

iv. 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.

b. Calculations

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

c. Documentation

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

d. Usage

i. Fittings

a) Compression type for EMT

b) Threaded for metal conduit

c) Liquid Tite shall have compatible fitting with insulated throat

ii. Supports

a) Hot dipped galvanized for interior locations.

b) Clamp backs and spacers shall be cast or malleable iron.

c) Stainless steel concrete anchors

e. Application

i. Unless otherwise noted in the following table, raceway shall be hot-dip galvanized rigid steel conduits, type GRS. Minimum trade

size for all conduit shall be ¾-inch when exposed and 1-inch when embedded (underground or within walls).

LOCATION	APPLICATION / CONDITION	RACEWAY
Above ground, up to 10 ft. AFF	All raceway applications not specified below.	GRS
Over 10 ft above finished floor, in walls or ceiling spaces	Where not subject to physical abuse or moisture.	EMT, IMC
	Subject to occasional moisture.	IMC
All wet areas	Subject to constant moisture (i.e. wash bays, steam shop, paint shop, floor to roof)	GRS
Underground (3)	Direct buried. Salmon safe finish.	PVC 80 with GRS elbows
Under road/bus lane	Encased in red concrete.	PVC 40/GRS
	Directionally Bored	HDPE Sch. 80
Outdoors	Within structural envelope of the gantry that supports pantographs	Aluminum
Outdoor	Exposed to weather.	GRS (2)
Hazardous, classified areas	Exposed	GRS

ii. GRS installed outside of a building envelope shall be coated to achieve salmon safe utilization. Below grade shall have a 20 mil PVC coat or a field applied bitumastic 300M coal tar epoxy. Above grade shall have the same, unless attached to a building wall whereas it shall be painted to match the building.

iii. Minimum burial depth of conduit is 24". Provide warning tape 18" below grade.

iv. Rigid conduit entering sheet metal boxes or cabinets shall be secured by locknuts on both the interior and exterior of the enclosure or with a Myers Hub.

v. Run raceway parallel to lines of building construction. Support raceways at 8 foot intervals.

vi. Avoid running raceway on exposed walls. Raceway on exterior walls shall be painted to match the adjacent surface.

vii. Exterior boxes and enclosures shall be stainless steel type 316, unless otherwise accepted by KCMT.

13) Cable Trays for Electrical Systems

a. General Design Criteria

i. Examine drawings and existing conditions below ceiling spaces and include bends and offsets to avoid ducts, pipes, conduits, etc.

ii. Locate and dimension penetrations in walls and floors. Determine and design reinforcing.

a) Locate any fire seals in the plans.

b) Indicate tray dividers where tray used for power and specialty systems.

c) Tray to be labeled that "NOT DESIGNED FOR MAINTENANCE ACCESS OR SUPPORT".

iii. On-site fabricated transition shall not be accepted.

b. Calculations

i. Consultant to calculate fill for cable tray and limit to 20% less than the maximum calculated capacity fill as identified in Article 392 of the National Electrical Code.

ii. Structure of trays shall be suitable to support a continuous loading of cables, when supported on 12' centers, without any deflection exceeding 1/100 of the span, with a safety factor of 1.50. Consult KCM to determine spare capacity allowance based on the specific application.

14) Underground Ducts and Raceways for Electrical Systems

a. General Design Criteria

i. Conduits to be filled from the bottom up or center to the outer edges

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

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

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

v. County preference for pre-cast handholes and manholes. Refer to civil section for structural weight bearing requirements.

b. Drawing Requirements

i. Drawings to include:

a) Duct bank route, to scale dimensions if greater than 2 conduits.

b) Provide profile for duct banks demonstrating coordination with utilities.

c) Provide details for foundations and foundation wall pass throughs.

d) Slope raceway away from buildings and electrical equipment, and toward manholes and handholes. Avoid undrainable low points wherever possible.

e) 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

ii. Schedules to include:

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

b) Handhole/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

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

c. Calculations

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

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

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

15) Identification for Electrical Systems

a. General Design Criteria

i. Each electrical circuit, cable, and equipment item to have separate, unique identification number.

ii. Identification tags and locations per King County Specifications, Section 26 05 53 Identification for Electrical Systems for detailed requirements.

iii. Contract drawings shall include schedule showing complete text for all phenolic label required on project for all switchboards, distribution boards, disconnect switches (fused/non-fused/circuit breaker/etc.), circuit breaker panelboards, transformers, ATSs, lighting cabinets, MCCs, meter cabinets and meters on project.

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

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

b. Drawing Requirements

i. Details to include:

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

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

ii. Schedules to include:

a) Identification naming for all MV cabling and electrical equipment Identification type, color, material

16) Medium Voltage Transformers

a. General Design Criteria

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

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

iii. Ensure connections from incoming line/supply side and outgoing load side are compatible.

iv. Provide flexible MV cabling in line side-transformer throat connection.

v. Provide accessible grounding connection point.

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

b. Electrical Efficiency

i. Losses to be less than published standards.

ii. Winding Material: Copper with Class H insulation.

iii. 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.

iv. Outdoor transformers to be bio-oil filled.

17) Medium-Voltage Switchgear and Switchboards

a. General Design Criteria

i. All medium voltage switchgear and switchboards shall be labeled with Arc Flash Hazard level, NEC 110-16.

ii. Interrupting Rating: AIC rating shall comply with the larger of the line to ground or three phase fault current at supply side of switchgear adjusted for the asymmetric offset determined by the X/R ratio.

iii. Working Space: Comply with code requirements but no less than 6 feet, front and 4 feet on non accessible sides. for 4kV and higher switchgear.

iv. Bus: Copper with silver joints. Horizontal bus shall be fully rated with end opposite the incoming lugs configured for extension to future vertical section. Show space for future vertical section on plan. Ampacity to exceed load by 30%.

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

vi. Recommend to King County on Cost-Benefits for overcurrent protective device types.

b. Testing

i. Specify that the Contractor's/Manufacturer's Start up Plan contains the following:

a) Inspection of the switchgear, wiring, components, connections, and equipment installation. Perform inspections and tests stated in NETA ATS Section 7.1. Test and adjust components and equipment.

b) Megger test power and control wiring and hi-pot medium voltage cables prior to energization. Submit test reports.

c) Interrupter switches: Perform inspections and tests stated in NETA ATS, Section 7.5.

d) Circuit Breakers: Perform inspections and tests stated in NETA ATS, Section 7.6.

e) Protective Relays: Perform inspections and tests stated in NETA ATS, Section 7.9.

f) Instrument Transformers: Perform inspections and tests stated in NETA ATS, Section 7.10.

g) Metering and Instrumentation: Perform inspections and tests stated in NETA ATS, Section 7.11.

h) Ground Fault Systems: Perform inspections and tests stated in NETA ATS, Section 7.14.

i) Battery Systems: Perform inspections and tests stated in NETA ATS, Section 7.18.

j) Surge Arrestors and Capacitors: Perform inspections and tests stated in NETA ATS, Section 7.19 and 7.20.

k) Arc-flash label installed for all electrical equipment

18) Low Voltage Transformers

a. General Design Criteria

i. Determine installation method: floor mount, wall mount, ceiling hung. Limit wall mount to 30kVA and below. Floor mount preferred for sizes greater than 15kVA.

ii. Define path of ingress and egress. Specifically, flooring loading on transformers above 225kVA.

iii. Provide accessible grounding connection point.

iv. Minimum clearances around LV transformer in accordance with code and manufacturer ventilation requirements.

v. 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.

vi. Taps: (2)-2-1/2% FCAN, (4)-2-1/2% FCBN

vii. Evaluate usage requirements and provide K-factor transformers where needed.

viii. 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.

b. Specification

i. Enclosure: Ventilated, NEMA 250, Type 2.

ii. Comply with NEMA ST 20 and list and label as complying with UL 1561.

iii. Comply with NEMA Standard TP-1 (or its successor) for transformers rated 15kVA to 1000kVA. (DOE 2016)

iv. Indoor: Ventilated.

v. Outdoor, other unconditioned locations: Consider encapsulation, raintight NEMA 3R.

vi. Finish: ANSI 61 gray.

19) Switchboards and Switchgear

a. General Design Criteria

i. Label Switchgear/Switchboards with Arc Flash Hazard level, NEC 110-16.

ii. Interrupting Rating: AIC rating shall comply with fault current availability at supply side of switchgear/Switchboard/Panelboard, including motor contribution.

iii. Provide bus connection provisions and dedicated space and housekeeping pad for one future Switchgear/Switchboard vertical section of the same width as the largest vertical section.

iv. Size switchgear/switchboards to allow for future growth

a) Above 1000V review spare capacity against standard component ratings with KCMT engineering.

b) Below 1000 volts: Minimum 30% spare bus ampacity and minimum 30% spare breaker spares/spaces. Amperage of space shall be indicated and at least one space shall be rated the highest allowable ampacity based on the enclosure size.

v. For existing switchgear/switchboards, perform 30-day metering of equipment loads prior to start of design. Follow up with 7-day metering 60 days prior to issuance of Bid Document issuance.

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

20) Panelboards

a. General Design Criteria

i. Label with Arc Flash Hazard level.

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

iii. Bus: Copper, neutral: 100% phase bus capacity

iv. 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 or panelboards that meet the requirements for spare capacity and space.

v. Panel board shall have a minimum of 30% spare breaker capacity for 480Y/277V panels and 30% for 208Y/120V panels.

vi. For any load addition in excess of 5% of the panel's ampacity, provide a new panel if the demand of the load addition plus the existing load causes the revised load on the panel to exceed 75% of the panel's ampacity.

vii. New panelboards at existing facilities shall be of the same manufacture and type as the existing panelboards.

viii. Panel fronts shall be of the door-in-door type such that breaker handles can be accessed by opening the inner door and panel wiring can be accessed by opening the outer door (Both doors shall swing on constructed hinges). Panels shall be lockable with two identical keys provided for each panel. All panels shall be keyed alike.

ix. For existing panels, perform 30-day metering of panelboard loads at the start of design. Adjust metering values at required by Washington State.

x. Designer shall submit Excel based electronic version of panel schedules to King County at 100% Design.

xi. Main Circuit Breaker (a non-auto switch is acceptable) 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.

xii. Panelboards shall have individual feeds. Multiple section panels with feed-through lugs are allowed only with King County approval.

xiii. Series rated panelboards are not permitted.

xiv. Circuit breakers are the standard protective device for mains and branch circuits. Consult with electrical engineering supervisor prior to using fuses.

xv. A Surge Protective Device is required for panels serving predominantly computer loads, sensitive electronic loads, and LED lighting loads.

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

xvii. Branch Overcurrent Protective Devices: Bolt-on circuit breakers

xviii. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one main service disconnecting and overcurrent protective devices.

xix. Flush mounted panelboards: Provide three 1-inch empty conduits from top of panelboard into accessible ceiling space for future branch circuit conductors.

xx. Panels located in high bay maintenance areas and other nonconditioned spaces to be considered as Outdoor locations (NEMA 3R).

xxi. Panels in Fuel and Wash facilities and Steam and Brake Bay/ shops shall be located in spaces isolated from the process or rated for hose direct spray, NEMA 4X.

21) Motor-Control Centers

a. General Design Criteria

i. All low voltage Motor Control Centers shall be labeled with Arc Flash Hazard level.

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

iii. Main-Bus Rating: Copper, 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.

iv. Size Motor Control Center to allow for minimum 30% spare capacity. In addition, provide buss connection and added room space and housekeeping pad for one added vertical section.

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

b. Drawing Requirements

i. 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.

ii. Motor control schematic wiring diagram for each type, size, and variant of motor, to include:

a) Power, signal, and control wiring

b) Termination block diagram

c) Control explanation

d) Bus transfer controls

e) Safety shutdown feature

c. Testing

i. Specify test MCC with 1000-Volt Megger for 480-Volt systems and 500-Volt Megger for 208-Volt systems after installation is complete.

ii. Specify 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.

22) Low-Voltage Enclosed Bus Assemblies

a. Testing

i. Specify that the following are performed:

a) Field-torquing of all bus to bus connections

b) 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

23) Power System Studies

a. General Design Criteria

i. Power System Studies must be performed by the Electrical Engineer of record. Engineer to use for determination of equipment sizing and selection. The Engineer performing these studies will choose equipment that will satisfy the potential Arc Flash Energy and Selective Coordination requirements, while maintaining the reliability of the electric service.

ii. In compliance with NFPA 70 (NEC) emphasis on Arc Flash and NFPA 70E emphasis on safety, performing the Power Systems Studies is one of the most important design roles 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.

iii. Coordinate with KCMT Project Electrical 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.

iv. As a minimum, provide Arc Flash, Short Circuit Current and Overcurrent Protective Device Coordination study for the entire electrical distribution. Studies to be Basis for Design and incorporated as Addendum to the Bid Document set. Provide arc flash labels and label field equipment.

v. Use SKM Power Tools for Windows for Power Studies, project related files generated as a result of these studies shall be backed up and delivered to the KCM Project Engineer.

vi. The Contractor's bid shall include the costs to recalculate the study, with SKM software, with the specific equipment installed on the project. In- field relay settings, equivalent to those determined in design, to be determined by the contractor's studies.

b. Utility Services

i. Determine utility requirements for connection and incorporate the requirements into the design.

ii. 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.

iii. 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.

c. Calculations

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

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

24) Electricity Metering

a. General Design Criteria

i. The energy code and King County require sub-metering on select panels (i.e., lighting, HVAC, process). Typically, the panel is metered at the upstream breaker that feeds it. The following represents the minimum points that shall be metered:

a) Main Distribution Panel (At Main Circuit Breaker). New electrical services rated over 999 amps shall have an owner meter on the incoming service with the following features:

1) Front Display, with user interface

2) Volts line to line, line to neutral, peak and rms

3) Amps per phase, max demand amps, averaged over a rolling 15 minute interval, resettable.

4) KW, KVA,KVAR, Power Factor. Max kW, averaged over a rolling 15 minute interval, resettable.

5) Event tracking
6) Web interface
7) BACnet data access

b) Emergency Main Distribution Panel (secondary side of Emergency Transfer Switch).
c) Panels dedicated to HVAC Equipment.
d) Panels Dedicated to Lighting Loads.
e) Panels Dedicated to Process loads.
f) Air Compressors.
g) If allowed on project, gas mains shall be metered.
h) Non-revenue fleet electric vehicle charging
i) Battery Electric Bus Charging

ii. Consult with King County Project Engineer on extent of below service entrance sub- metering, Currently King County Maintenance Electrical staff have employed the use of the EMON equipment for monitoring of the electrical system, with some use of the Siemens Apogee HVAC Building Control System.

b. Documentation

i. 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.

c. Testing

i. Specify 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.

25) Wiring Devices

a. General Design Criteria

i. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

ii. Use only industrial/commercial grade receptacles and light switches as appropriate for the installation.

b. Drawing Requirements

i. Layout receptacle to follow guidelines:

a) Provide double duplex on wall where likely placement of computer equipment to be located.

b) 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.

c) Mounting height for maintenance and service areas: +48" AFF.

d) Use isolated ground receptacles for IT/ Communication equipment.

e) Provide dedicated circuits for copy machines, water coolers, vending machines, and similar loads.

c. Testing

i. Specify 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) Fuses

a. General Design Criteria

i. As a general rule, low voltage fusible panels and switchboards are not allowed, when fuses are required and approved for use, 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.

ii. 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.

iii. Verify that the let-through current of the selected fuse does not exceed the rating of downstream devices or conductors.

b. Specification

i. Fuses for circuits under 600V shall be UL listed, Class J, Class L, Class R or RK.

ii. Fuses for safety switches shall be Class R, intended for use with rejection clips.

iii. Use Class L and Class T fuses to protect loads over 600A such as transformer secondaries, switchboard mains, or large feeders.

iv. Use Class J, Class K and Class R fuses to protect most feeder and branch circuit applications.

27) Enclosed Switches and Circuit Breakers

a. General Design Criteria

i. The following functions may be required based on specific project parameters. Coordinate use with King County:

a) Undervoltage Trip.

b) Auxiliary Contacts.

c) Keyed Interlocks.

d) Electrical Operator.

ii. Provide disconnect within sight of any equipment item.

b. Documentation

i. All switches and enclosed circuit breakers to be from one manufacturer.

ii. Provide Lock Out-Tag Out requirements and placards

28) Enclosed Controllers

a. General Design Criteria

i. Provide reduced voltage starters, and variable frequency drives for integral horsepower motors where required by code and for voltages and sizes noted below:

a) 5 HP and larger – 208V, 3 phases.

b) 25 HP and larger – 480V, 3 phases.

ii. Preference is to provide enclosed controller within sight of any equipment item.

b. Documentation

i. All controllers to be from one manufacturer.

ii. Specify Lock Out-Tag Out requirements and placards

29) Engine Generators

a. General Design Criteria

i. This Section includes packaged engine-generator sets for emergency and/ or optional stand- by power with the following features:

a) Diesel engine.

b) Unit-mounted OR Remote-mounting control and monitoring.

c) Outdoor, sound attenuated enclosure where installed outdoors.

d) Indoor, provide sound and vibration dampening.

ii. Generator power is divided into different groups, per the National Electrical Code (NEC), (Emergency, Legally required Standby and Optional Standby). Where the Authority having Jurisdiction (AHJ) has a common definition or usage for defined Emergency and Legally Required Standby loads, they may be addressed with a single Automatic Transfer Switch (ATS). The King County - Metro Transit Required basic service loads are defined by the NEC as Optional Standby Power and is controlled by one or more subsequent ATSs.

iii. 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.

iv. King County to provide listing of Optional Standby loads. Engineer to coordinate refinement of listing.

v. 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.

vi. Designer shall select appropriate input/output voltages based on project parameters.

vii. Fuel Supply:

a) Comply with code run time requirements for emergency and legally required standby loads.

b) Establish run time requirements for optional standby loads with assistance from KCMT.

c) Allow for monthly testing of generator.

d) Determine refueling intervals based on tank size. Evaluate fuel polishing.

e) Engine generator to be sized for Continuous Standby applications.

f) Prioritize Loading as:

- Fire Pumps
- Emergency circuits including:
  - Egress Lighting
  - Elevator cab lighting
  - Fire Alarm Monitoring system.
  - All other Fire/Life Safety Systems
  - IT systems related to life safety
- Legally Required Standby Loads:
  - Code required loads
  - Mechanical loads for emergency systems
- Optional Standby
  - Owner designated loads. Certain loads such as offices, HVAC, air compressors, garage doors, vehicle lifts, etc. may be selected to provide limited functionality at various facilities.,
  - IT systems other than life safety (Provide separate ATS if >50kVA
  - IT/ communication room HVAC cooling equipment.

b. Drawing Requirements

i. 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, re- fueling agent, and King County Maintenance.

ii. Coordinate with mechanical engineer to provide adequate ventilation during operating periods and permitting maintenance staff to enter and exit the enclosure or room.

iii. Coordinate with structural engineer to address weight and vibration.

c. Calculations

i. Perform Power Studies with commercial power interruption and generator assuming emergency loads. Perform generator sizing calculations to determine the requirements for block loading.

ii. Determine harmonic loading impact.

iii. Minimum sound attenuation of 12 dB at 500 Hz or as required by the local AHJ.

d. Documentation

i. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces to be defined in Section 26 05 40 "Seismic Controls for Electrical Systems."

e. Testing

i. Pre-delivery factory testing at ¼, ½ ¾ for 1 hours, followed by 2 hours at full load, and 1 hour cool down.

ii. Specify that:

a) Pre-setting the frame, the housekeeping pad is inspected for compliance.

b) Specify a rough-in inspection 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.

c) Load shed block loading protocol and programming has been provided.

d) Perform on-site testing at ¼, ½, and ¾ simulated load bank for 1 hours, followed by 8 hours at full load. After which a 1 hour cool down. Conduct separate noise related testing at night.

iii. Performance tests:

a) 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.

b) Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load.

c) 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.

d) Coordinate tests with tests for transfer switches and run them concurrently.

30) Static Uninterruptible Power Supply (UPS)

a. General Design Criteria

i. Evaluate the need for a redundant incoming power source (normal or emergency) on a per project basis.

ii. Computing equipment including BOSS, MIRS, FMS, Fare Box, shall be connected via the UPS. The unit shall have adequate capacity to provide continuous power for 30 minutes.

iii. Consider UPS as a low carbon alternative to diesel generators for the emergency power supply.

b. Specification

i. Consider the following specification requirements where UPS capacity exceeds 30kVA:

ii. Provide Maintenance Bypass Switch.

iii. Provide connection for testing load bank post output section.

iv. The UPS shall supply 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:

a) Inverter is switched to battery source.

b) Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.

c) Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.

d) 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.

e) Load is 50 percent unbalanced continuously.

v. Minimum Duration of Supply: Determine duration of performance based on application with KCMT concurrence.

vi. 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.

vii. Maximum Energizing Inrush Current: 1.5 times the full-load current.

viii. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus, or minus 2 percent over the full range of battery voltage.

ix. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

x. Limitation of harmonic distortion of input current of THD to 2% for 100% linear load and 6% for 100% non-linear load

xi. Minimum Overload Capacity: 125 percent of rated full load for 10 minutes, and 150 percent for 60 seconds in all operating modes.

c. Testing

i. Pre-delivery factory testing at ¼, ½ ¾ rated load for 30 minutes each without battery, followed by 2 hours at full load

ii. Pre-setting the frame, the housekeeping pad is inspected for compliance.

iii. On-site testing at ½ and ¾ rated load using inductive, resistive load bank for 1 hours, followed by 4 hours at full load.

iv. Equalization charging of battery cells

v. Confirm test instrumentation has certification within 90 days of test.

vi. Load the system using an inductive/ resistive variable load bank to simulate kVA, kW, and PF of load for the unit's rating.

vii. Simulate malfunctions to verify protective device operation.

viii. Test duration of supply on emergency, low-battery voltage shutdown and transfers and restoration due to normal source failure.

ix. Test output voltage under specified transient load conditions.

x. Test efficiency at 50%, 75% and 100% rated loads.

xi. Test remote status and alarm functions.

xii. Test battery-monitoring system functions.

xiii. Witness these performance tests:

a) 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.

b) Harmonic-Content Tests: Measure harmonic content of input current and output voltage under 25 percent and at 100 percent of rated linear load.

c) Noise Level Tests: Measure A-weighted level of noise emanating from UPS

31) Power Factor Correction Equipment

a. General Design Criteria

i. New projects shall be designed to meet 95% power factor or better.

b. Calculations

i. At Service Entrance: Determine total power factor without correction summing loads and power factors.

ii. Coordinate with King County if fixed or adjustable correction. Determine if automatic or manual correction.

iii. At individual items of equipment: Determine power factor correction.

32) Surge Protective Devices for Low-Voltage Electrical Power

a. General Design Criteria

i. This equipment shall be installed between all probable voltage transient sources and voltage sensitive equipment such as computers, microprocessor based and other electronic equipment.

ii. Applies to service equipment and branch circuit distribution equipment including panelboards.

iii. Provide SPD protection on all panelboards feeding LED lighting devices.

iv. Provide SPD protection when motor control centers contain voltage sensitive equipment such as Programmable Logic Controllers and Variable Frequency Drives.

v. Two stage coordinated SPD protection is acceptable.

vi. Determine surge rating.

vii. 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:

a) Line to Neutral: 1000 V for 480Y/277 V, 700 V for 208Y/120 V.

b) Line to Ground: 1000 V for 480Y/277 V, 700 V for 208Y/120 V.

c) Neutral to Ground: 1000 V for 480Y/277 V, 700 V for 208Y/120 V.

d) Line to Line: 1800 V for 480Y/277 V, 1200 V for 208Y/120 V

viii. Peak Surge Current Rating: The single-pulse surge current withstand rating per phase shall not be less than 160 kA.

ix. SCCR: Match protected equipment.

33) Lighting

a. General Design Criteria

i. Lighting systems throughout every Transit Facility shall meet the prevailing 'Seattle 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.

ii. Lighting systems shall provide for the safety and security of King County - Metro Transit personnel and property.

iii. Current requirements of King County and King County Metro Transit, state that all installed lighting shall be LED and that existing lighting systems shall be transitioned to LED.

iv. Replacement of existing non-LED fixtures shall not negatively impact illumination levels and safety is not diminished.

v. Luminaire Photometric Data: Accreditation per OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

vi. The color temperature of the LED light source shall be limited to the 3500K to 4500K temperature range.

vii. All materials used for lighting equipment must be capable of being recycled.

viii. All material taken from the site for disposal shall be through certified recyclers (county or state).

b. Lighting Calculations

i. Comply with IES recommended illumination levels. Maintenance bases exterior bus yards shall comply with WAC 296-800-210.

ii. 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.

iii. 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.

iv. Uniformity ratio for bus zone flyer stops on or near freeways and ramps shall be no greater than 3:1.

v. 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.

vi. Interior foot-candle levels shall be calculated by modeling the space and utilizing a point by point grid appropriate to the application.

34) Interior Lighting

a. General Design Criteria

i. 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.

ii. Emergency lighting is to be provided in electrical rooms and where any other equipment needs to be monitored continuously.

iii. 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 an Orange Dot, in a manner that will not interfere with the illumination of the space the fixtures are serving. (WAC 296-46B-700)

iv. Fixture installation shall allow for maintenance/replacement of equipment with the use of equipment that Metro has available in its maintenance facilities.

v. 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.

b. Drawing Requirements

Layout lighting to follow guidelines:

i. 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.

ii. Provide staged light levels per energy code for outside light influence.

iii. Provide fixture on roof top areas and adjacent to serviceable equipment.

iv. Lighting within the transit facility shall be designed and installed to provide sufficient illumination for the tasks outlined for that portion of the facility.

v. 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.

vi. ALL lighting shall be LED.

vii. High bay Lighting Luminaires located in a high bay location (shop, storage room, fueling lanes, etc.) shall be cord and twist lock plug/receptacle connected with readily removable mounting.

c. Warranty

i. Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion

d. Testing

i. Specify that:

a) Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

b) Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.

35) Exterior Lighting

a. General Design Criteria

i. Specify vandal resistant fixtures where warranted by specific application.

ii. Work areas in bus yards around maintenance and operations buildings shall be designed to meet Washington Administrative Code (WAC 296-800) requirements for task and non-task lighting.

b. Drawing Requirements

Layout lighting to follow guidelines:

i. Coordinate lighting fixture locations with architectural and civil plans and programmed use layout. Avoid placement so inaccessible due to, equipment, or other interferences.

ii. Provide fixture on roof top areas and adjacent to serviceable equipment.

iii. Lighting within the transit facility shall be designed and installed to provide sufficient illumination for the tasks outlined for that portion of the facility.

iv. Exterior Pole Lighting: Provide a handhole adjacent to each light pole.

v. Grounding: Bond pole, foundation, and equipment grounding conductor.

vi. Poles in transit yard to be elevated above grade 6-feet. Pole foundation to be protected with 4-foot bollards in 4-corner locations.

vii. Coordinate mounting height of fixtures in service yards. Use latch in place lowering ring above 60-feet.

viii. 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.

c. Testing

i. Specify that:

a) Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery or generator and retransfer to normal

b) 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
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. TPSS Design Criteria and Performance Requirements

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
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 is 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.

f. Include the ESS charge load necessary to replenish the State of Charge consumed during all regular service off-wire trolley operations. Refer to Metro Fleet Engineering for ESS charge load requirements.

   Additional Contingency Operations for consideration: One OCS trolley circuit is out of service at a time. Out of service is defined as de-energized wire. Assume that all trolleys which normally use the out of service trolley circuit are operating in ESS mode and will replenish the ESS State of Charge when they return to an energized OCS circuit. Consider the bus zone locations nearest to the OCS circuit sectionalizers for transitioning on and off of ESS mode

7) 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 duct banks and underground vaults shall be utilized for all incoming utility AC and outgoing DC feeder cables.

8) 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. Siting order of preference shall be as follows: a) Public property, b) City and County R.O.W, c) light commercial areas.

9) Utility Interface

a. Shall be close to utility lines to minimize transmission costs

10) 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 service and rectifier-transformer units 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 MDC. However, other suppliers meeting the functional design requirements of the Siemens Sitras MDC 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.

11) Protection

a. Based on the magnitude of load, overload, and short circuit currents, a comprehensive protective scheme shall be provided to protect the substation equipment, the feeders, and the OCS.

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.

12) 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.

13) 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 LRFDLTS	LRFD Specifications for Structural Supports for Highway Signs
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:	470 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

Refer to the National Electrical Safety Code (NESC), Section 23 for all electrical clearance requirements.

6) Normal Trolley Wire Heights and Position (600 F, no wind and no ice condition).

Normal height at support be at a range	18’-9” to 19’-3”
Normal minimum height at mid-span	18’ – 0”
Normal minimum height at support mid-span with ¼ ” ice	As per NESC
Normal minimum height at support mid-span with ½ ” ice	As per NESC
Normal maximum height at support	20’

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 head-spans 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

ASTM: B47

Size and type: No. 4/0 AWG, grooved

Material: H.D. Copper

Allowable wear: 30% (for maximum permissible mechanical stress)

15% (for electrical average fusing ampacity)

Tension at 60°F: 4/O - 2000 lb.

Size:	8M Guy Wire	16M Guy Wire
Material:	Copperweld	Copperweld
Make-up Stranding:	7 x 0.092”	7 x 0.128”
ASTM:	A460	A460
Overall Diameter (in.):	0.276	0.386

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:

Group	Applicable Loads	Percent of Allowable Stress
I	Dead Load at 0°F	100%
II	Dead Load at 60°F + Wind Load	133%
II	Dead Load at 0°F + Ice Load + ½ Wind Load	165%

6) OCS Configurations

Description	METRO Standard	Change in Trolley Wire Bearing Angle at support
Tangent Span	Standard cross spans	0˚ to 10˚
1 Double Curve Hanger/Rail	SA-307.2 (two way) SA-317.2 (one-way)	1˚ to 2.5˚
2 Double Curve Hanger/Rail	SA-308.2 (two way) SA-318.2 (one-way)	2.5˚to 4˚
Curve Segment Span	SA-310.2 (two way) SA-320.2 (one-way)	4˚to 7˚

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 1o direction and up or downward profile deviation of the trolley wires, resulting in 70 lb. of radial loads per support.

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°
      - Double curve hanger span: 5°

   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 Authorities Having Jurisdiction (AHJ)

See Section 02 CIVIL.

2020 Edition City of Seattle Standard Plans for Municipal Construction

B. Traffic Engineering Design Criteria

1) Lane Width for Bus Operations

It is desirable for lanes with transit use to be at least 11' wide. 12' may be needed in some situations, such as curved segments or where there are fixed objects near the travel lane.

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
- Lane Width Criteria
- 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:

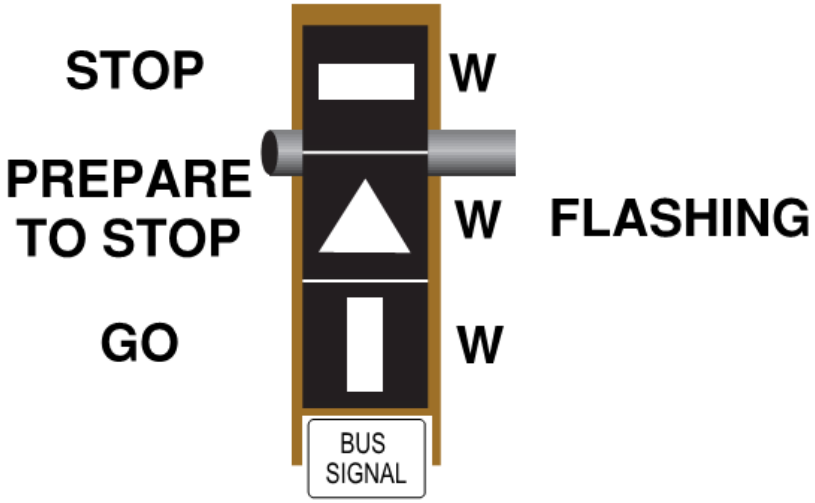
It is often desirable to install a pair of loop detectors or video detection zones combined with AND logic to activate the queue jump phase. The two detectors should be spaced 30 feet apart so that both detectors are activated simultaneously by a long vehicle (i.e., a bus) but will not be triggered by 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

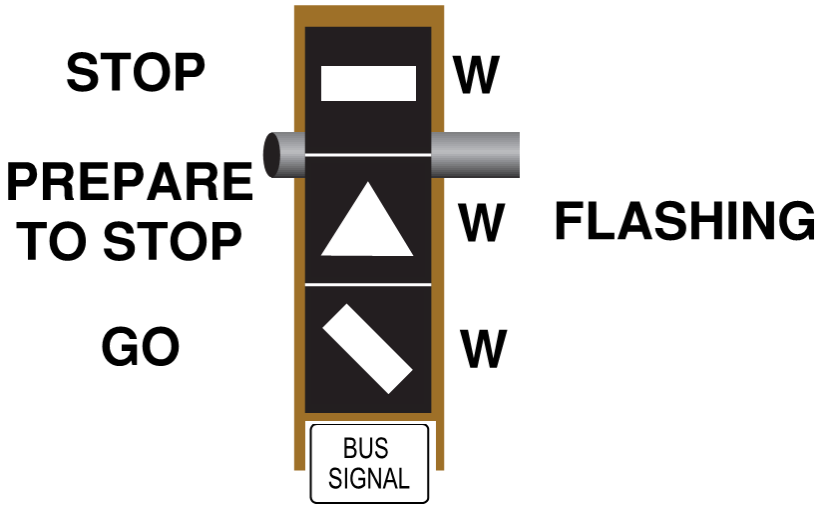
Metro's preferred Transit-Only Movement signal display style is noted below.

Note 1 **The stop indication (horizontal bar) may be red.**



M

etro'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. Metro's preference for red BUS ONLY markings is to follow SDOT standard Plans 750 and 717a.

9) *AutoTURN Guidelines*

See Section 02 CIVIL.

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.

C. Traffic Standard Plans, Standard Specifications and Guideline Specifications

See Section 02 CIVIL.

10 ELECTRIC VEHICLE CHARGING FACILITIES

A. Battery Electric Bus (BEB) Charging Facilities

1) General

a. Project Criteria will supersede requirements identified herein.

b. Comply with SAE J3105 and J3105/1.

c. Load Calculations:

i. Minimum load shall be determined by modeling of anticipated vehicle assignment and vehicle usage, or as directed by King County.

ii. System capacity shall exceed minimum load to allow any vehicle to become fully charged when parked in any stall. See charger criteria below.

iii. Allow for load growth due to battery capacity improvements and other technological advances.

d. There is no expectation that facility design support Vehicle to Grid transfer of energy.

e. There is no expectation that bases will have on site energy storage for standby power or peak shaving of utility demand level, unless specifically identified in the project scope of work.

f. The SEPA process will require an EMF analysis. The analysis shall evaluate AC and DC voltages and currents. Include code references, defacto standards, and background information that will facilitate understanding of the hazards by reviewers not familiar with electrical engineering. If the analysis determines hazardous conditions the design shall include mitigating measures and establish appropriate safety procedures.

g. Metering

i. Metering points shall enable the determination of the net energy delivered to buses. Provide metering on incoming main power to duplicate utility metering. Provide additional metering on non charging loads to enable subtraction of the non-charging loads from the incoming power load, thereby leaving the energy delivered to the buses.

ii. Meters monitoring circuits rated above 2000 amps or above 2000 volts shall have event tracking and waveform capture. Tie meter to

King County Information Technology(KCIT) network with Ethernet per KCIT standards.

iii. Refer to CPD-E for appropriate protocol communication with KCM's existing energy tracking software.

iv. Verify that the aspects of the energy code's metering requirements do not apply to the facility per Washington State or Seattle Energy Code C409.1 Exception 2.

2) Electrical Distribution System

a. Arrange charger to pantograph wiring to minimize the effect on operations in the event of a charger failure, consider charger circuiting against lane and row stacking of buses, and how deenergized circuits will affect charging and traffic patterns.

b. Primary Power Systems

i. KCMT bases with depot charging of more than 20 buses will likely necessitate an electrical service in excess of 1000 volts (primary power).

ii. Primary power system shall have:

a) Owner meter with event tracking

b) SCADA system with status points and alarms, tied to KCM's existing system

iii. Primary power systems shall be designed with manual switching and redundancy to:

a) Prevent a single point of failure resulting in an outage in excess of 4 hours

b) Allow for deenergized maintenance of primary metering compartment and switchgear (requires two of each).

c. Resiliency: Transformer and switchboard configuration shall be coordinated with KCMT to develop operational responses to a failure. Responses may include use of redundant distribution designed for the facility or bus service adjustments. Conduct an analysis per IEEE 3000 series.

d. Transformers

i. Padmount transformers with non flammable, biodegradable insulating fluid. Preferred size is 2500kVA with 55/65/75 temperature rise.

ii. Provide fluid leakage containment.

e. Switchboards

i. Main circuit breaker with electronic trip and 100% continuous load rating.

ii. Charger branch circuit overcurrent protection

a) Selectively coordinate with ground fault protection on switchboard main circuit breaker.

b) Lockout provisions

iii. Power meter:

a) When NEC connected load exceeds rating of main circuit breaker power meter shall connect to selected circuit breakers with shunt trip to keep load within rating of switchboard.

f. Raceway, boxes and associated connected equipment:

i. Construction shall prevent rodent (<1/8 square inch) entry.

ii. LFMC may be used within four feet of the pantograph to allow for field flexibility in positioning the pantograph.

3) Electric Vehicle Supply Equipment (Chargers)

a. Comply with Buy America requirements.

b. Listed in accordance with Washington State requirements.

c. Warranty: 2 years transferrable to King County

d. Suitable for use in an outdoor environment, fully exposed to any condition of weather in King County

e. Utilize SAE J3105 and supporting documentation for WIFI and RFID communication with Bus for charging parameters

f. Compliant with the most recent version of the Open Charge Point Protocol and connected to KCMT's network via Ethernet.

g. Include pushbutton lowering of the pantograph without DC power to check for proper pantograph movement. Button to be located in vicinity of charger.

h. Minimum power delivery ratings as follows:

i. Depot or base charging:

a) Utilize chargers with multiple power delivery levels per port, one port per coupler. Wiring between the port and the coupler shall, at a minimum, be rated for twice the average power per port to take advantage first come first serve (dynamic) charging.

b) The average power delivery per port shall comply with the greater of the following:

- The minimal level of power determined by block/route modeling plus 30%.
- The power rating needed to bring the battery of Metro's next planned bus purchase from 10% state of charge to 90% state of charge in 5 hours.
- As directed by CPD-E after review of above sizing criteria.

ii. Opportunity Charging:

a) Meet or exceed the maximum power delivery level the BEBs are capable of accepting, with a growth allowance for technology advances.

i. Harmonics injected to the power system shall be compliant with IEEE 519, using the branch circuit overcurrent protective device as the point of common coupling. The rms value of harmonic currents reflected to the supply system shall not exceed 5% of the fundamental.

j. Enclosure: Weatherproof with keyed latching door. All chargers furnished to KCM by a single manufacturer shall be keyed alike. Provide filtered cooling air and heaters to prevent condensation.

k. Commissioning: Manufacturer shall provide onsite personnel to support programming of charger, alignment of antennas, safety checks, and installation guidance.

4) Couplers

a. BEB couplers are standardized on SAE J3105/1 pantograph down as the means of connecting the bus to the EVSE during depot, layover, or opportunity charging. Pantographs exposed to the weather shall be rated 600 amps. Pantograph mounting and travel distance shall allow for charging of standard and double deck buses in a kneeling position. Pantographs and chargers shall utilize WIFI to recognize buses and RFID technology to sense bus proper presence and automatically lower the pantograph. KCMT will provide information on the RFIDs purchased with the bus fleet.

b. Provide charging status indication beacon at pantograph

c. Informational: Battery Electric Buses are also equipped with SAE J1772 couplers for special emergency and maintenance applications.

5) Physical Accommodation Guidelines

a. Electrical Distribution equipment, EVSE, and supporting structures shall have bollards or other means to provide a visual deterrent to vehicular traffic.

b. Chargers, data cabinets and switchboards shall be located in areas protected from windblown rain to facilitate maintenance and extend the life of equipment. Roofing and siding shall prevent rain from being driven into the open door of a charger or switchboard.

c. Opportunity and layover facilities in community areas:

   i. Equipment and supporting structures will have a visual impact on the community and should have aesthetic considerations.

   ii. Columns supporting pantographs should have a smooth exterior skin to inhibit climbing up the column. Raceways should be brought up inside the column.

   iii. Wiring should be well protected to prevent cable theft and vandalism.

d. Bus Base Quarantine Area: At bus bases provide a location for a distressed, (battery fire, contamination, etc.) 60 foot, BEB to be isolated for resolution. Quarantine area shall have ten feet clear from distressed bus to other buses, buildings, charging structural elements, fire hydrants, and property line. Provide for distressed bus to access quarantine area via tow truck or via push.

e. Striping and Signage:

   i. Lane striping

   ii. Steering wheel centerline and door centerline to align bus with overhead pantograph. Begin steering wheel alignment 20 feet prior to stop line.

   iii. Overhead sign identifying each lane number on first gantry after lane entry.

   iv. Allowance on Transit Center gantries for future King County Metro branding.

f. Access to manholes shall not require closure of more than one travel lane.

g. Do not locate catch basins under wheel point loading locations in the charging area.

h. Structural elements supporting chargers and pantographs, and related electrical systems shall be augmented to deter aviary roosting and nesting. For example. flat surfaces should have sloping, spike or wire deterrents: and vertical conduit racks are preferred over horizontal ones.

6) Documentation

Present system drawing information at appropriate points in time that will allow CPD-E to understand the design intent and determine if performance enhancements are appropriate and in line with project budgeting. Drawing information shall include:

a. Show all power, control, and data raceways on plans. Single line representations may be used for multiple conduits if sections are included showing allocation of space.

b. Detail the following elements of design:

   i. Conduit entry to underside of charger cabinets.

   ii. Raceway entry from below grade up beside or through gantry columns, coordinated with foundation design.

   iii. Provide section at attachment of pantograph gantry to supporting column, showing all raceways that travel from column to gantry.

c. The design engineer of record shall define a control point for the pantograph, delegating this to a contractor is not acceptable. List horizontal and vertical control point data for each pantograph to coordinate with lane striping and SAE J3105/1. Pantograph movement range shall allow for:

   i. Single or double decker buses.

   ii. Bus kneeling position.

   iii. Connection dead band of pantograph movement range.

   iv. Pavement height at point of connection and stall slope.

   v. Field flexibility related to construction work tolerances.

d. Provide a block diagram shown interconnection of metering, SCADA, data, and controls. Provide SCADA point list.

7) Charge Management Systems

a. Provide CAT 6A wiring in raceway from each bus charger to a KCIT network switch. Charge management system software will be procured by KCIT.

b. The power system design shall provide a default mode of charging in the event the charge management system is non-communicative or otherwise non-functional.

B. Non Revenue Vehicle Charging Infrastructure

1) General

a. Project Criteria will supersede requirements identified herein

b. SAE J1772 Compliant (KCMT considering conversion to J3400)

c. Protect chargers from errant traffic with bollards and/or wheel stops.

d. Provide power system meters to determine the net energy delivered to the electric vehicles. Connect the metering system to KCMT's existing metering network with protocols as directed by CPD-E.

2) Raceway:

a. Size raceway to chargers at 1/2" diameter or more above the code required minimum, up to the maximum allowed by charger enclosure entry provisions.

b. Flexible raceway not permitted.

3) Metering:

Provide metering to isolate vehicle power(fuel) from facility energy usage. Tie metering system to the existing NRV energy tracking data base.

4) Charger:

a. Three year warranty

b. Access control pursuant to location and use assessment

c. Positive indication of operation visible on the exterior of the enclosure

d. Deploy and retract minimum usable cable length

5) Couplers:

Utilize SAE J1772 couplers, however, check vehicle purchase expectations against evolving standards (NACS) utilized in North America.

6) Striping and signage:

Green paint for stall lines and other EV-related stall markings are not required for non-public charging stalls. Inclusion or exclusion of such provisions should consider their necessity, usefulness, and the cost of implementation, and maintenance and upkeep of such provisions under an anticipated large deployment of charging infrastructure.

11 REFERENCES

A. Referenced within this Document

The following Documents are available either online or by request via the Engineering Manager.

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
- 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

- Pdf's 0 – 19 – Standards, Guide Specs & Design Criteria, NEMA / ANSI / IEEE Standards, CSI 5 digit sections 16150 – 16690

- 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

Architectural

- Transit Facility Square Footage (4.7MB PDF) Amount of areas for Transit facility structures and properties.

CAD

- KCMTD Capital Division title and border.
- Metro Transit Capital Division .DWG and .DWT title and border files.
- King County Metro CAD Standards
- Civil pavement details
- CTB.zip Contains Metro standard plot style tables for AutoCAD
- Electrical blocks and details
- Passenger Facility Guidelines Metro Transit passenger facility design guidelines
- 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 added & index updated 1/2/2005
- Construction Plans updated 12/5/2017 (site updated April 2018)
- Structural Plans added & index updated 1/2/2005