APPENDIX 9A

Standard Specifications for Electrical Design

SUMMARY SHEET

PART I Introduction

This appendix of the Design Standards and Guidelines (DSG) presents Seattle Public Utilities (SPU) Standard Specifications for electrical design. These specifications are presented in Construction Specification Institute (CSI) MasterFormat 2004. Table 1 lists the template SPU standards developed during DSG publication. It will be necessary to review its list and add or subtract sections with the current MasterFormat as specific project requirements.

Table 1
CSI Specifications List Revision 2020

	CSI #	Title
1	26 05 00	Common Work Results for Electrical
2	26 05 19	Low Voltage Electrical Power Conductors and Cables
3	26 05 26	Grounding and Bonding for Electrical Systems
4	26 05 29	Hanger Supports for Electrical Systems
5	26 05 33	Raceway and Boxes for Electrical Systems
6	26 05 36	Cable Tray for Electrical Systems
7	26 05 48	Vibration and Seismic Controls for Electrical Systems
8	26 05 53	Identification for Electrical Systems
9	26 08 13	**Acceptance Testing**
9	26 09 13	Electrical Power Monitoring
10	26 09 23	Lighting Control Devices
11	26 12 19	Pad-Mounted Transformers
12	26 13 13	Medium-Voltage Circuit Breaker Switchgear
13	26 13 19	Medium-Voltage Vacuum Interrupter Switchgear
14	26 22 00	Low-Voltage Transformers
15	26 24 13	Switchboards
16	26 24 16	Panelboards
17	26 24 19	Motor Control Center (MCC)
18	26 25 00	Enclosed Bus Assemblies
19	26 27 26	Wiring Devices
20	26 28 13	Fuses
21	26 28 16	Enclosed Switches and Circuit Breakers
22	26 29 13	Enclosed Controllers
23	26 29 23	Variable-Frequency Motor Controllers
24	26 32 13	Engine Generators
25	26 33 53	Static Uninterruptable Power Supply
26	26 36 00	Transfer Switches
27	26 41 13	Lightning Protection for Structures

28	26 43 13	Surge Protection Device (SPD)
29	26 51 00	Interior Lighting
30	26 56 00	Exterior Lighting
31	40 95 33.23	Fiber Optic Process Control Networks

Construction Specifications Institute Format (CSI)

The Construction Specifications Institute (CSI) has developed a standard format for specifications. DSG electrical specifications have been arranged and formatted to conform to CSI standard, MasterFormat 2004. Division 26 is the CSI section for electrical specifications.

Other CSI Technical Specifications

Project technical specifications contain equipment and material specifications in which designers are most interested. While electrical specifications are in Division 26, designers also need to be concerned with other CSI sections that have electrical content. The electrical design engineer should review the following other sections:

Division	Content	Equipment
22	Plumbing	Water heaters
23	HVAC	Review HVAC sections
33	Utilities	Review all sections for motors, motor control, control systems, etc.
40	Process Integration	I&C
44	Pollution Control	Water Treatment Equipment

Relationship to Drawings

Electrical specifications generally are qualitative, with exact quantities, ratings, and dimensions covered in the drawings and schedules or on data sheets. If the specifications conflict with the drawings, the written specifications take precedence over the drawings.

Front-end Specifications

In addition to technical specifications, a typical set of construction specifications includes numerous general and legal sections (referred to as *front-end* sections). While the front-end sections are nontechnical, it is important for the electrical design engineer to know what is in them and how they relate to Division 26 technical specifications.

Data Sheets

Data sheets are brief descriptions of specific ratings and requirements for equipment or material. They are generally used in conjunction with a written specification to convey detailed information about a particular piece of equipment when a general section species multiple similar items. Data sheets reduce the need to edit a master specification and can be generated automatically from a database.

Document Production

The CSI specifications are produced in a document processing template preferred by SPU Contracting.

SUMMARY SHEET

Section Name: COMMON WORK RESULTS FOR ELECTRICAL

Section Number: 26 05 00

Prepared By: Tim Kim

Reviewed By: Carter Le

Date Issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) Revised
1	10/30/09	Entire document reformatted to SPU contracts style.

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Site information.
2. Electrical equipment coordination and installation.
3. Sleeves for raceways and cables.
4. Sleeve seals.
5. Grout.
6. Common electrical installation requirements.

1.03 DEFINITIONS

A. The following standard acronyms are used throughout the Bid Documents:

EPDM: Ethylene-propylene-diene terpolymer rubber.

NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

A. Product Data: For sleeve seals.

1.05 SITE INFORMATION

A. Location: [Greenfield site at 1234 North Avenue Street, Seattle, WA 98101]

B. Serving Utility: [Seattle City Light, 700 5th Avenue, #3200, Seattle, WA 98104, John CommercialRep, 206-684-3000, John.CommercialRep.scl@seattle.gov]

C. Service Source: [Underground to utility-owned pad-mount transformer, 480/3/60, 400A nominal, 12,000A available fault current before motor contribution]

1.06 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right-of-way for piping and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 PRODUCTS

2.01 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches thickness shall be 0.052 inch.

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.02 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Link Seal, Inc (SPU preferred).

d. Metraflex Co.

e. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Stainless steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time. Product: Jet Set.

PART 3 EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1, NEC, NFPA 70E, OSHA and SPU DSG.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right-of-Way: Give to piping systems installed at a required slope.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.03 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

End of Section 26 05 00

SUMMARY SHEET

Section Name: LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

Section Number: 26 05 19

Prepared By: Tim Kim

Reviewed By: Carter Le

Date Issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) Revised
1	10/30/09	Entire document reformatted to SPU Contracts style

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PART 4 GENERAL

4.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

4.02 SUMMARY

A. This Section includes the following:

1. Wires and cables rated 600 V and less.

2. Connectors, splices, and terminations rated 600 V and less.

4.03 SUBMITTALS

A. Product Data: For each type of product indicated. Under Part II, line-out products not offered for this job.

4.04 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 5 PRODUCTS

5.01 CONDUCTORS AND CABLES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Alcan Products Corporation; Alcan Cable Division.

2. American Insulated Wire Corp.; a Leviton Company.

3. Belden.

4. General Cable Corporation.

5. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.

5.02 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.

2. Hubbell Power Systems, Inc.

3. O-Z/Gedney; EGS Electrical Group LLC.

4. 3M; Electrical Products Division.

5. Tyco Electronics Corp.

B. Description: UL listed and labeled factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 6 EXECUTION

6.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Stranded for all feeder conductors.

B. Branch Circuits: Copper. Stranded for all branch circuits.

6.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW, single conductors in raceway.

B. Exposed Feeders: Type XHHW, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type XHHW single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type XHHW, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW, single conductors in raceway.

H. Class 1 Control Circuits: Type THHN-THWN, in raceway.

I. Class 2 Control Circuits: Type THHN-THWN, in raceway.

6.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated. Surface-mount on unfinished cement walls.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

6.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors. No aluminum conductors are allowed.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6-inches of slack.

6.05 FIELD QUALITY CONTROL

A. Testing Agency: Contractor to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test Reports: Prepare a written report in conformance with NETA specifications to record the following:

1. Model, serial number and latest calibration of each instrument used.

2. Test procedures used.

3. Test results that comply with requirements.

4. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

5. Legibly sign, print name, and date each sheet.

E. Remove and replace malfunctioning units and retest as specified above.

End of Section 26 05 19

SUMMARY SHEET

Section name: GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

Section number: 26 05 26

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

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PART 7 GENERAL

7.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

7.02 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

7.03 SUBMITTALS

A. Product Data: For each type of product indicated. In Part 2 line-out items not offered for this project.

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:

1. Test wells.

2. Ground rods.

3. Ground rings.

4. Grounding arrangements and connections for separately derived systems.

C. Grounding for sensitive electronic equipment.

D. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:

1. Instructions for periodic testing and inspection of grounding features at test wells based on NETA MTS.

   a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.

   b. Include recommended testing intervals and maximum values.

7.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 8 PRODUCTS

8.01 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.

3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4-in in diameter.

4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8-in wide and 1/16-in thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:

1. No. 4 AWG minimum, soft-drawn copper.

2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

D. Grounding Bus: Rectangular bars of annealed copper, 1/4-in x 2-in in cross section, unless otherwise indicated; with insulators.

8.02 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

8.03 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, 3/4-in x 10-ft.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48-in long or UL approved mechanical ground rod connector.

2. Backfill Material: Electrode manufacturer's recommended material.

PART 9 EXECUTION

9.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24-in below grade.

2. Duct-Bank Grounding Conductor: Bury 12-in above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 1-in, minimum, from wall 6-in above finished floor, unless otherwise indicated.

2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.

3. Connections to Ground Rods at Test Wells: Bolted connectors.

F. Connections to Structural Steel: Welded connectors.

9.02 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.

2. Lighting circuits.

3. Receptacle circuits.

4. Single-phase motor and appliance branch circuits.

5. Three-phase motor and appliance branch circuits.

6. Flexible raceway runs.

7. Armored and metal-clad cable runs.

C. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

D. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-in x 2-in x 12-in grounding bus.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

E. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

9.03 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2-in below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in **Division 26 Section "Underground Ducts and Raceways for Electrical Systems,"** and shall be at least 12-in deep, with cover.

1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end. Comply with Seattle Electrical Code Supplement: see 250.104(E).

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60-ft apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.

2. Bury ground ring not less than 24-in from building foundation.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20-ft of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20-ft long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

9.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

b. Perform tests by fall-of-potential method according to IEEE 81.

3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.

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

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

4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify project manager promptly and include recommendations to reduce ground resistance.

End of Section 26 05 26

SUMMARY SHEET

Section name: HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

Section number: 26 05 29

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
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PART 10 GENERAL

10.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

10.02 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

B. Related Sections include the following:

1. Division 6 Section 26 05 48, "Vibration And Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

10.03 DEFINITIONS

A. RMC: Rigid metal conduit.

10.04 PERFORMANCE REQUIREMENTS

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

10.05 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems (Electric strut).

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.

2. Steel slotted channel systems. Include Product Data for components.

3. Equipment supports.

10.06 QUALITY ASSURANCE

A. Comply with NFPA 70.

PART 11 PRODUCTS

11.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Allied Tube & Conduit.

b. Cooper B-Line, Inc.; a division of Cooper Industries.

c. ERICO International Corporation.

d. GS Metals Corp.

e. Thomas & Betts Corporation.

f. Unistrut; Tyco International, Ltd.

g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

a. Channel Dimensions: Selected for applicable load criteria but in no case less than 1-5/8-in.

3. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.

4. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Mallablei-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Epoxy and powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Hilti Inc.

2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

3) MKT Fastening, LLC.

4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.

6. Hanger Rods: Threaded steel, minimum 3/8-in dia - must be double-nutted.

PART 12 EXECUTION

12.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 3/8-in in diameter - must be double-nutted.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

D. Secure raceways and cables to these supports with single-bolt conduit clamps.

12.02 SUPPORT INSTALLATION

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

B. Raceway Support Methods: In addition to methods described in NECA 1, RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Epoxy anchors.

4. To Existing Concrete: Epoxy anchors.

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4-in thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4-in thick.

6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for epoxy anchors in concrete at locations and to depths that avoid reinforcing bars.

End of Section 26 05 29

SUMMARY SHEET

Section name: RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

Section number: 26 05 33

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 13 GENERAL

13.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

13.02 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

NOTE: A paragraph on underground distribution was deleted.

13.03 DEFINITIONS

A. RMC: Rigid metal conduit.

1. Al: Aluminum.

2. GRS: Galvanized rigid steel

B. PVC-GRS: PVC coated galvanized rigid steel

C. IMC: Intermediate metal conduit.

D. EMT: electrical metallic tubing

E. LFMC: Liquidtight flexible metal conduit.

13.04 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.

2. For handholes and boxes for underground wiring, including the following:

a. Duct entry provisions, including locations and duct sizes.

1) Frame and cover design.

2) Grounding details.

3) Dimensioned locations of cable rack inserts, pulling and lifting irons, and eye-bolts.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.

2. Process piping, HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section 26 05 48,"Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For professional engineer and testing agency.

F. Source quality-control test reports.

13.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 14 PRODUCTS

14.01 METAL CONDUIT AND TUBING

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AFC Cable Systems, Inc.

2. Alflex Inc.

3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. Manhattan/CDT/Cole-Flex.
7. Maverick Tube Corporation.
8. Ocal.
9. O-Z Gedney; a unit of General Signal.
10. Robroy.
11. Wheatland Tube Company.

B. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch minimum.

C. Rigid Steel Conduit: ANSI C80.1.

D. IMC: ANSI C80.6.

E. FMC: Zinc-coated steel.

F. LFMC: Flexible steel conduit with PVC jacket.

G. Fittings for Conduit (Including all Types and Liquidtight): NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

H. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

14.02 METAL WIREWAYS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 12, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

1. Finish: Manufacturer's standard enamel finish.

14.03 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.

2. EGS/Appleton Electric.

3. Erickson Electrical Equipment Company.

4. Hoffman.

5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.

6. O-Z/Gedney; a unit of General Signal.

7. RACO; a Hubbell Company.

8. Robroy Industries, Inc.; Enclosure Division.

9. Thomas & Betts Corporation.

10. Walker Systems, Inc.; Wiremold Company (The).

11. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

C. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast iron with gasketed cover.

D. Hinged-Cover Enclosures: NEMA 250, Type 12, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

E. Cabinets:

1. NEMA 250, Type 12, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.

2. Hinged door in front cover with flush latch and concealed hinge.

3. Key latch to match panelboards.

4. Metal barriers to separate wiring of different systems and voltage.

5. Accessory feet where required for freestanding equipment.

14.04 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.

1. Color of Frame and Cover: Gray.

2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.

3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

5. Cover Legend: Molded lettering, "ELECTRIC."

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Armorcast Products Company.

b. Carson Industries LLC.

c. CDR Systems Corporation.

d. NewBasis.

e. Utility Vault

C. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Armorcast Products Company.

b. Carson Industries LLC.

c. Christy Concrete Products.

d. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.

D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Carson Industries LLC.

b. Christy Concrete Products.

c. Nordic Fiberglass, Inc.

14.05 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

14.06 SLEEVE SEALS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.

2. Calpico, Inc.

3. Link Seal

4. Metraflex Co.

5. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

2. Pressure Plates: Stainless steel. Include two for each sealing element.

3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 15 EXECUTION

15.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit.

2. Concealed Conduit, Aboveground: Rigid steel conduit.

3. Underground Conduit: RNC, Type EPC-80-PVC, direct buried.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

5. Boxes and Enclosures, Aboveground: NEMA 250, Type 12.

6. Application of Handholes and Boxes for Underground Wiring:

a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Fiberglass enclosures with polymer-concrete frame and cover, SCTE 77, Tier 15 structural load rating.

b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.

c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3,000-lbf vertical loading.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: RMC.

2. Exposed, Not Subject to Severe Physical Damage: RMC.

3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

a. Process areas.

b. Loading dock.

c. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.

d. Mechanical rooms.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

5. Damp or Wet Locations: Rigid steel conduit.

6. Boxes and Enclosures: NEMA 250, Type 12.

C. Minimum Raceway Size: 3/4-in trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

15.02 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6-in away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping. Do not interfere with operating and maintenance access to process piping devices, as valves, strainers, gages, etc.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section 26 05 29, "Hangers and Supports for Electrical Systems."

E. Group conduit in parallel runs where practical, and use conduit rack constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit. Bends in parallel conduit runs must be concentric. All conduits must be run straight and true.

F. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

G. Install no more than the equivalent of three 90-degree bends in any conduit run without a pullbox.

H. Raceways Embedded in Slabs:

1. Minimum size conduit larger than 1-in trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.

2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

3. Change from PVC to rigid steel conduit before rising above the floor.

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions. Provide MSDS for any compound used.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits entering or leaving Class I, Div 1 or Class I, Div 2 areas.

2. Where otherwise required by NFPA 70.

L. Flexible Conduit Connections: Use maximum of 72-in of liquid tight flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

15.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6-in in nominal diameter.

2. Install backfill as specified in Division 31 Section "Earth Moving."

3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12-in of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3-in of concrete.

b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60-in from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

6. Warning tape: Bury detectable warning tape 12-in above direct-buried conduits.

15.04 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-in sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

D. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

15.05 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

End of Section 26 05 33

SUMMARY SHEET

Section name: CABLE TRAYS FOR ELECTRICAL SYSTEMS

Section number: 26 05 36

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 16 GENERAL

16.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

16.02 SUMMARY

A. This Section includes steel cable trays and accessories.

16.03 SUBMITTALS

A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

Note: Retain subparagraph and associated subparagraphs below if products are required to withstand seismic loads and Architect either has delegated design responsibility to Contractor or wants to review structural data as another way to verify product's compliance with performance requirements. Professional engineer qualifications are specified in Division 01 Section "Quality Requirements."

2. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.

a. Design Calculations: Calculate requirements for selecting seismic restraints.

b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

Note: Retain first paragraph and subparagraphs below if Drawings do not include detailed floor plans or if Project involves unusual coordination requirements.

C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:

1. Vertical and horizontal offsets and transitions.

2. Clearances for access above and to side of cable trays.

3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.

D. Field quality-control reports.

E. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

16.04 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

16.05 DELIVERY, STORAGE, AND HANDLING

A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

PART 17 PRODUCTS

17.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Chalfant Manufacturing Company.

2. Cooper B-Line, Inc.

3. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.

4. GS Metals Corp.; GLOBETRAY Products.

5. MONO-SYSTEMS, Inc.

6. MPHusky.

7. PW Industries.

17.02 MATERIALS AND FINISHES

Note: Select one of first four paragraphs and associated subparagraphs below. See Evaluations for discussion of cable tray materials and finishes.

A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.

Note: Retain one of seven subparagraphs below.

1. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.

B. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

1. Center-hanger supports may be used only when specifically indicated.

17.03 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray. No covers.

B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

17.04 WARNING SIGNS

Note: Revise size of lettering in first paragraph below to suit 25-foot (7.6-m) viewing distance.

A. Lettering: 1-1/2-in high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and fastening are specified in Division 26 Section 26 05 53, "Identification for Electrical Systems."

PART 18 EXECUTION

18.01 CABLE TRAY INSTALLATION

A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.

B. Remove burrs and sharp edges from cable trays.

C. Fasten cable tray supports to building structure and install seismic restraints.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section 26 05 48, "Vibration and Seismic Controls for Electrical Systems."

2. Place supports so that spans do not exceed maximum spans on schedules.

3. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

4. Support bus assembly to prevent twisting from eccentric loading.

5. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.

6. Locate and install supports according to NEMA VE 1.

D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.

E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.

F. Make changes in direction and elevation using standard fittings.

G. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

H. Workspace: Install cable trays with enough space to permit access for installing cables.

I. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

J. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

18.02 CABLE INSTALLATION

A. Install cables only when cable tray installation has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. On vertical runs, fasten cables to tray every 18-in. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

D. In existing construction, remove inactive or dead cables from cable tray.

18.03 CONNECTIONS

A. Ground cable trays according to manufacturer's written instructions.

B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

18.04 FIELD QUALITY CONTROL

A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:

1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.

2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.

3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.

4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.

5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.

B. Report results in writing.

18.05 PROTECTION

A. Protect installed cable trays.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

End of Section 26 05 26

SUMMARY SHEET

Section name: VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

Section number: 26 05 48

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
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PART 19 GENERAL

19.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

19.02 SUMMARY

A. This Section includes the following:

1. Channel support systems.

2. Anchorage bushings and washers.

B. Related Sections include the following:

1. Division 26 Section 26 05 29, "Hangers And Supports For Electrical Systems" for commonly used electrical supports and installation requirements.

19.03 DEFINITIONS

A. The IBC: International Building Code.

19.04 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Comply with NFPA 70.

PART 20 PRODUCTS

20.01 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Amber/Booth Company, Inc.

2. California Dynamics Corporation.

3. Cooper B-Line, Inc.; a division of Cooper Industries.

4. Hilti Inc.

5. Loos & Co.; Seismic Earthquake Division.

6. Mason Industries.

7. TOLCO Incorporated; a brand of NIBCO INC.

8. Unistrut; Tyco International, Ltd.

B. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

C. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

D. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

20.02 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel or powder coat for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 21 EXECUTION

21.01 EXAMINATION

A. Examine areas and equipment to receive seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

21.02 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

21.03 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.

2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-in.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

4. Set anchors to manufacturer's recommended torque, using a torque wrench.

5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

21.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

End of Section 26 05 48

SUMMARY SHEET

Section name: IDENTIFICATION FOR ELECTRICAL SYSTEMS

Section number: 26 05 53

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
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PART 22 GENERAL

22.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

22.02 SUMMARY

A. This Section includes the following:

1. Identification for raceway and metal-clad cable.
2. Identification for conductors and communication and control cable.
3. Underground-line warning tape.
4. Warning labels and signs, especially arc-flash hazard labels.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

22.03 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

C. 8-1/2 x 11-in full-scale copies for each type of label and sign to illustrate sizes, lettering style, mounting provisions, and graphic features of identification products.

22.04 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with NFPA 70E.

D. Comply with 29 CFR 1910.145.

22.05 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by

codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 23 PRODUCTS

23.01 RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Color for Printed Legend:

1. Power Circuits: Black letters on an orange field.

2. Legend: Indicate voltage.

3. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

23.02 CONDUCTOR AND COMMUNICATION - AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch-thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.

E. Write-On Tags: Polyester tag, [**0.010 inch (0.25 mm)**] [**0.015 inch (0.38 mm)**] <**Insert thickness**> thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

23.03 DETECTIBLE UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape with metallic foil laminate.

1. Not less than 6-in wide by 4-mils thick.

2. Compounded for permanent direct-burial service.

3. Embedded continuous metallic strip or core.

4. Printed legend shall indicate type of underground line.

23.04 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Engraved laminated plastic signs: White, surface layer with red (warning), yellow (caution) or black layer exposed by engraving. 3/32-in nominal thickness, minimum 1 x 3-in, minimum text 1/8-in, adhesive mounting, but drilled holes for use if adhesive doesn't stick.

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36-INCHES."

3. Only if Hazardous Areas are shown on classification drawing, "HAZARDOUS AREA – EXPLOSIVE VAPORS MAY BE PRESENT."

4. Arc-Flash Warning similar to the sample appended to this specification.

23.05 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8-in.

23.06 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength: 50 lb (22.6 kg), minimum.

3. Temperature Range: Minus 40 to plus 185 F (Minus 40 to plus 85 C).

4. Color: Black, except where used for color-coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 24 EXECUTION

24.01 APPLICATION

A. Accessible Raceways and Metal-Clad Cables, 600V or Less, for Service, Feeder, and Branch Circuits.

B. Power-Circuit Conductor Identification: For [**primary**] [**and**] [**secondary**] conductors No. [**1/0**] <**Insert size**> AWG and larger in vaults, pull and junction boxes, manholes, and handholes use [**color-coding conductor tape**] [**marker tape**] [**aluminum wraparound marker labels**] [**metal tags**] [**write-on tags**]. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

C. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use [**color-coding conductor tape**] [**marker tape**] [**aluminum wraparound marker labels**] [**metal tags**] [**write-on tags**]. Identify each ungrounded conductor according to source and circuit number.

D. Conductors to Be Extended in the Future: Attach [**write-on tags**] [**marker tape**] to conductors and list source and circuit number.

E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:

a. Power transfer switches.

b. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

G. Instruction Signs:

1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-in high letters for emergency instructions at equipment used for power transfer.

H. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Adhesive film label or Engraved, laminated acrylic. Unless otherwise indicated, provide a single line of text with 1/2-in high letters on 1-1/2-in high label; where 2 lines of text are required, use labels 2-in high.

b. Outdoor Equipment: Engraved, laminated acrylic 4-in high.

2. Equipment to Be Labeled:

a. Panelboards, electrical cabinets, starters, starter doors in motor control centers, motors, equipment wired by electrical contractor and enclosures.

b. Access doors and panels for concealed electrical items.

c. Electrical switchgear and switchboards.

d. Transformers.

e. Electrical substations.

f. Emergency system boxes and enclosures.

g. Motor-control centers.

h. Disconnect switches.

i. Enclosed circuit breakers.

j. Motor starters.

k. Push-button stations.

l. Power transfer equipment.

m. Contactors.

n. Remote-controlled switches, dimmer modules, and control devices.

o. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.

24.02 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for all ungrounded power conductors.

1. Color shall be factory applied.

2. Colors for 208/120-V Circuits:

a. Phase A: Black.

b. Phase B: Red.

c. Phase C: Blue.

d. Neutral: White.

e. Ground: Green.

3. Colors for 480/277-V Circuits:

a. Phase A: Brown.

b. Phase B: Orange.

c. Phase C: Yellow.

d. Neutral: Gray

e. Ground: Green.

F. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6-in from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

End of Section 26 05 53

SUMMARY SHEET

Section name: ELECTRICAL POWER MONITORING

Section number: 26 09 13

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
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PART 25 GENERAL

25.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

25.02 SUMMARY

A. This Section includes the following for monitoring of electrical power system:

1. Communication network and interface modules **for IEEE 802.3** data transmission protocols.

25.03 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

C. KB: Short for kilobyte. When used to describe data storage, "KB" represents 1024 bytes.

D. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

E. LAN: Local area network; sometimes plural as "LANs."

F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

G. Modbus TCP/IP: An open protocol for exchange of process data.

H. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

I. PC: Personal computer; sometimes plural as "PCs."

J. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

K. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

L. RS-485: A TIA standard for multipoint communications using two twisted-pairs.

M. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

N. THD: Total harmonic distortion.

O. WAN: Wide area network.

25.04 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring features to illustrate coordination among related equipment and power monitoring and control.

B. Shop Drawings: For power monitoring equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.

2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components

3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

4. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

C. Software and Firmware Operational Documentation:

1. Procedures to ensure data access from laptop,

2. Software operating and upgrade manuals.

3. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.

D. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.

E. Software licenses and upgrades required by and installed for operating and programming power meter.

F. Qualification Data: For manufacturer.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For power monitoring units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Operating and applications software documentation.

2. Software licenses.

3. 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.

25.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring equipment similar to that indicated for this Project and with a record of successful in-service performance.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

25.06 COORDINATION

A. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored by power monitoring equipment.

PART 26 PRODUCTS

26.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allen-Bradley; Rockwell Automation.

2. Cutler-Hammer Group; Eaton Electrical Inc.

3. Schneider Electric.

4. <Insert manufacturer's name.>

26.02 POWER MONITORS

A. Separately mounted, permanently installed instrument for power monitoring and control.

1. Enclosure: NEMA 250, Type [12].

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 32 to 107 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.

C. rms Real-Time Measurements:

1. Current: Each phase, neutral, average of three phases, percent unbalance.

2. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.

3. Power: Per phase and three-phase total.

4. Reactive Power: Per phase and three-phase total.

5. Apparent Power: Per phase and three-phase total.

6. Power Factor: Per phase and three-phase total.

7. Displacement Power Factor: Per phase and three-phase total.

8. Frequency.

9. THD: Current and voltage.

10. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

11. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

12. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).

D. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:

1. Present.

2. Running average.

3. Last completed interval.

4. Peak.

E. Demand Real Power Calculations, Three-Phase Total:

1. Present.

2. Running average.
3. Last completed interval.
4. Predicted.
5. Peak.
6. Coincident with peak kVA demand.
7. Coincident with kVAR demand.

F. Demand Reactive Power Calculations, Three-Phase Total:

1. Present.
2. Running average.
3. Last completed interval.
4. Predicted.
5. Peak.
6. Coincident with peak kVA demand.
7. Coincident with kVAR demand.

G. Demand Apparent Power Calculations, Three-Phase Total:

1. Present.
2. Running average.
3. Last completed interval.
4. Predicted.
5. Peak.
6. Coincident with peak kVA demand.
7. Coincident with kVAR demand.

H. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:

1. Last completed interval.
2. Coincident with kW peak.
3. Coincident with kVAR peak.

4. Coincident with kVA peak.

I. Power Analysis Values:

1. THD, Voltage and Current: Per phase, three phase, and neutral.

2. Displacement Power Factor: Per phase, three phase.

3. Fundamental Voltage, Magnitude and Angle: Per phase.

4. Fundamental Currents, Magnitude and Angle: Per phase.

5. Fundamental Real Power: Per phase, three phase.

6. Fundamental Reactive Power: Per phase.

7. Harmonic Power: Per phase, three phase.

8. Phase rotation.

9. Unbalance: Current and voltage.

10. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to [31st] harmonic.

J. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.

2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.

b. Fixed block that calculates demand at end of the interval.

c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

a. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.

b. Demand can be synchronized with clock in the power meter.

K. Sampling:

1. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.

2. Power monitor shall provide continuous sampling at a rate of [128] samples per cycle on all voltage and current channels in the meter.

L. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:

1. Line-to-line voltage.

2. Line-to-neutral voltage.

3. Current per phase.

4. Line-to-line voltage unbalance.

5. Line-to-neutral voltage unbalance.

6. Power factor.

7. Displacement power factor.

8. Total power.

9. Total reactive power.

10. Total apparent power.

11. THD voltage L-L.

12. THD voltage L-N.

13. THD current.

14. Frequency.

M. Harmonic Calculation: Display and record the following:

1. Harmonic magnitudes and angles for each phase voltage and current through [31st] [63rd] <Insert number> harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.

2. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.

N. Current and Voltage Ratings:

1. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.

2. Withstand ratings shall be not less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.

3. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.

O. Accuracy:

1. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters.

2. Accuracy from Light to Full Rating:

3. Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.

a. Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.

b. Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.

c. Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.

P. Waveform Capture:

1. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.

2. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.

Q. Input: One digital input signal.

1. Normal mode for on/off signal.

R. Outputs:

1. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.

2. Closed in either a momentary or latched mode as defined by user.

3. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.

4. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V rms isolation.

5. [One] relay output module(s), providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.

6. Output Relay Control:

7. Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.

8. Normally open and normally closed contacts, field configured to operate as follows:

   a. Normal contact closure where contacts change state for as long as signal exists.

   b. Latched mode when contacts change state on receipts of a pickup signal; changed state is held until a dropout signal is received.

   c. Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.

   d. End of power demand interval when relay operates as synchronization pulse for other devices.

   e. Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.

   f. Output controlled by multiple alarms using Boolean-type logic.

S. Onboard Data Logging:

1. Store logged data, alarms, events, and waveforms in [800] KB of onboard nonvolatile memory.

2. Stored Data:

   a. Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 to 52 days of 15-minute interval data, depending on number of quantities selected.

   b. Custom Data Logs: [Three] user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:

      1) Schedule interval.

      2) Event definition.

      3) Configured as "fill-and-hold" or "circular, first-in first-out."

   c. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.

   d. Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."

3. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

T. Alarms.

1. User Options:

a. Define pickup, dropout, and delay.

b. Assign one of [four] severity levels to make it easier for user to respond to the most important events first.

c. Allow for combining up to [four] alarms using Boolean-type logic statements for outputting a single alarm.

2. Alarm Events:

3. Over/undercurrent.

a. Over/undervoltage.

b. Current imbalance.

c. Phase loss, current.

d. Phase loss, voltage.

e. Voltage imbalance.

f. Over kW demand.

g. Phase reversal.

h. Digital input off/on.

i. End of incremental energy interval.

j. End of demand interval.

U. Control Power: 90- to 457-V ac or 100- to 300-V dc.

V. Communications:

1. Power monitor shall be permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet.

2. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.

26.03 LAN CABLES

A. Unshielded Twisted Pair Cables: Category 6.

PART 27 EXECUTION

27.01 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section 26 05 53 "Identification for Electrical Systems."

B. Label each power monitoring module with a unique designation.

27.02 GROUNDING

A. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

27.03 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Electrical Tests: Use caution when testing devices containing solid-state components.

2. Continuity tests of circuits.

3. Operational Tests:

a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored.

b. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at power monitor. Resolve discrepancies greater than 5 percent and record resolution method and results.

c. Record metered values, control settings, operations, cues, time intervals, and functional observations.

C. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

D. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

E. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

F. Remove and replace malfunctioning devices and circuits and retest as specified above.

End of Section 26 09 13
SUMMARY SHEET

Section name: LIGHTING CONTROL DEVICES

Section number: 26 09 23

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description:

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts standards

WARNING: The standards and guidelines being provided do not relieve the licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 28 GENERAL

28.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

28.02 SUMMARY

A. This Section includes the following lighting control devices:

1. Time switches.

2. Outdoor photoelectric switches.

3. Lighting contactors.

B. Related Sections include the following:

1. Division 26 Section 26 27 26, "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

28.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

28.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 29 PRODUCTS

29.01 TIME SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; Schneider Electric.
2. Intermatic, Inc.
3. Leviton Mfg. Company Inc.
4. Lightolier Controls; a Genlyte Company.
5. Lithonia Lighting; Acuity Lighting Group, Inc.
6. Paragon Electric Co.; Invensys Climate Controls.
7. Watt Stopper (The).

B. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Configuration: SPST.
2. Contact Rating: 30-A inductive or resistive, 240-V ac.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
4. Astronomic time dial.
5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
6. Skip-a-day mode.
7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

29.02 OUTDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Intermatic, Inc.
2. Lithonia Lighting; Acuity Lighting Group, Inc.
3. Novitas, Inc.
4. Paragon Electric Co.; Invensys Climate Controls.
5. Square D; Schneider Electric.
6. Watt Stopper (The).

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, o operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.

2. Time Delay: 15-second minimum, to prevent false operation.

3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.

4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

29.03 LIGHTING CONTACTORS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Allen-Bradley/Rockwell Automation.

2. ASCO Power Technologies, LP; a division of Emerson Electric Co.

3. Eaton Electrical Inc.; Cutler-Hammer Products.

4. GE Industrial Systems; Total Lighting Control.

5. Hubbell Lighting.

6. Lithonia Lighting; Acuity Lighting Group, Inc.

7. MicroLite Lighting Control Systems.

8. Square D; Schneider Electric.

9. Watt Stopper (The).

B. Description: Electrically operated and electrically held, combination type with fusible switch complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation but not less than 22,000AIC.

3. Enclosure: Comply with NEMA 250.

4. Provide with Hand-Off-Auto selector switch matching the NEMA type specified for the enclosure.

29.04 CONDUCTORS AND CABLES

A. Power and Control Wiring: Not smaller than No. 12 AWG.

PART 30 EXECUTION

30.01 SENSOR INSTALLATION

A. Install and aim photocell North.

B. Mount in an accessible location.

C. Install an override switch or intermatic wind-up timer to control the lights for testing and maintenance purposes.

30.02 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

30.03 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section 26 05 53, "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors, timers, replay enclosure, override switch and photocels.

B. Label time switches and contactors with a unique designation.

30.04 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements

2. Operational Test: Verify operation of each lighting control device, adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work

30.05 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance for adjusting controls to meet actual use

conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

End of Section 26 09 23

SUMMARY SHEET

Section name: PAD-MOUNTED TRANSFORMERS

Section number: 26 12 19

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: May 2009

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

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This specification was originally issued for the Morse Lake Power Supply Project.

PART 31 GENERAL

31.01 SCOPE OF WORK

A. Furnish and install the outdoor, liquid filled, pad mounted transformer as shown on the Drawings and as specified herein.

31.02 RELATED WORK

A. Concrete equipment pads are included in **City of Seattle Standard Specifications Division 6 (omitting all references to Division 1**).

31.03 SUBMITTALS

A. Submit, in accordance with **Section 01 33 10**, shop drawings and product data, for the following:

1. Equipment sectional and plan views, bottom plan showing conduit openings and anchor bolt pattern, bushing arrangement, dimensions, weight and construction details.

2. Winding and core arrangement, materials, ratings and insulation details.

3. Transformer diagrammatic nameplate information.

4. Itemized bill of materials for accessories.

5. Certified shop test reports.

6. Field test reports.

7. Installation and maintenance manuals.

31.04 REFERENCE STANDARDS

A. Transformer shall be designed, built and tested in accordance with the following standards:

1. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

2. Western Underground Committee Guide 2.13 for vandal resistance.

3. NEMA Standard TRI - Transformers, Regulators and Reactors.

4. IEEE Sta. 462A, B-1978 "Short Circuit Requirements Supplement to ANSI C57.12.00-1973".

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

31.05 QUALITY ASSURANCE

A. The equipment furnished under this Section shall be the product of a manufacturer who has produced this same type of equipment for a period of at least 10 consecutive years.

B. Transformer shall be designed, assembled and tested by the manufacturer of the core and coil assemblies used in the transformer.

31.06 MAINTENANCE

A. Provide the following spare parts specified:

1. Three replacement power fuses or refills.

2. One refinishing kit for field touch-up of paint.

B. Spare parts shall be boxed or packaged for long term storage and clearly marked on the exterior of the package. Identify each item with manufacturers name, description and part number.

31.07 MANUFACTURERS

A. Acceptable Manufacturers:

1. Square D Company

2. Eaton/Cutler-Hammer

3. General Electric

4. ABB

PART 32 PRODUCTS

32.01 RATINGS

A. Transformer self cooled kVA rating shall be as shown on the drawings. Winding temperature rise shall not exceed 55/65 degrees C above a 30 degree C average ambient temperature, with a maximum ambient not to exceed 40 degrees C, operating at full rated kVA load.

B. Primary windings shall have the following ratings:

1. Voltage: 26,400 Volts, 3 Phase, 60 Hz

2. Connection: Delta

3. Basic Impulse Level (BIL): 95 kV

C. Secondary windings shall have the following ratings:

1. Voltage: 4,160/2,400 Volts.

2. Connection: Grounded wye

3. Basic Impulse Level (BIL): 60 kV

D. Transformer impedance shall range between 2.6 and 5.4 percent for 500 kVA units and smaller. Impedance of 750 kVA units and above shall be 7.0 percent, subject to ANSI tolerance of plus/minus 7.5 percent.

E. Transformer shall be designed to supply the specified kVA rating without exceeding its nameplate temperature rise, with 100 percent connected non-linear type loads. The transformer "K" factor shall be K4 or better.

32.02 CONSTRUCTION

A. Transformer shall be compartmental type, liquid filled, self-cooled, tamper resistant, weatherproof and suitable for mounting on a concrete pad.

B. Transformer tank shall utilize welded steel construction, sealed to withstand an internal pressure of up to 7 psi without distortion, and top oil temperatures ranging from 50 to 105 degrees C. Tank cover shall be designed to permit access to internal components for inspection or repair. Heavy duty, non-removable lifting lugs and jacking pads shall be provided. When required, welded cooling panels or radiators shall be provided on the back and sides of the tank.

C. The high and low voltage compartments shall be located side-by-side separated by a steel barrier. When facing the transformer, the low voltage compartment shall be on the right. Terminal compartments shall be full height, air filled with individual doors. The high voltage door fastenings shall not be accessible until the low voltage door has been opened. The low voltage door shall have a 3-point latching mechanism with vault type handle having provisions for a single padlock. The doors shall be equipped with lift-off type stainless steel hinges and door stops to hold the doors open when working in the compartments. The front sill of the compartment shall be removable to allow the transformer to be rolled or skidded into position over conduit stubs. ANSI tank grounding provisions shall be furnished in each compartment.

D. The core shall be five-legged. Windings and internal leads shall be copper, insulated and braced to prevent phase flashovers during fault conditions. Transformers with wye connected primary and secondary windings shall have the primary neutral insulated from the secondary neutral and brought out into the primary compartment through a separate bushing. Both neutral bushings shall be externally connected to the tank with removable copper straps.

E. Transformer insulating oil shall be Envirotemp FR3 oil, or equal. Insulating oil shall be free of P.C.B. contamination or any E.P.A. listed toxic chemical. The transformer manufacturer shall test the insulating oil for P.C.B. after filling the tank.

F. Terminations:

1. High voltage primary terminations shall be arranged for dead front radial feed and conform to ANSI C57.12.26 requirements. Provide universal type bushing wells and parking stands for disengaged elbows. Bushings or wells shall be externally clamped to allow external replacement. The transformer manufacturer shall furnish 200 Amp load-break elbows (15 kV line-to-ground maximum) elbow terminators for each bushing in accordance with ANSI C119.2.

2. Low voltage secondary bushings shall be externally clamped, molded epoxy, spade type with NEMA standard four or six hole arrangement. Neutral shall be brought out through an insulated bushing and grounded to the tank wall with a removable grounding strap.

32.03 HIGH VOLTAGE PRIMARY SWITCHING AND PROTECTIVE EQUIPMENT

A. Furnish an oil immersed, three phase, gang operated, two position radial feed, load break primary switch, mounted inside the transformer tank. An external, hook stick type switch operator and index plate shall be mounted in the high voltage primary terminal compartment. Switch positions shall be clearly marked. Minimum switch ratings shall be as follows:

1. 28 kV, 200 Amps continuous.

2. Momentary and fault close: 10,000 Amps symmetrical.

3. One minute 60 Hz withstand: 50 kV

B. Where shown on the Drawings, furnish three, 1 Pole, 200 Amp, fused air break switches. Fuses shall be current limiting with an interrupting capacity of 50,000 Amps RMS symmetrical. Phase to phase and phase to ground insulating barriers shall be furnished.

C. Primary Fuse Arrangement:

1. Provide oil immersed partial range current limiting fuses in series with externally removable Bay-O-Net type expulsion fuses. Fuse mounts shall be dead front, externally removable, hot stick operated, load-break individual fused disconnect devices, located in the high voltage compartment above the primary bushings to permit fuse replacement without opening the tank. Current limiting fuses shall be accessible through a handhole in the tank cover.

2. The CLF and expulsion fuses shall be properly coordinated such that the CLF protects for fault values above the expulsion fuse interrupting rating, the expulsion fuse protects the CLF for current values below the CLF interrupting capability and the CLF will not operate for low side faults beyond secondary terminals.

D. Lightning Arresters:

1. Furnish three 25 kV distribution class lightning arresters mounted in the high voltage primary compartment for surge protection.

32.04 ACCESSORIES

A. Each transformer shall be furnished with the following accessories:

1. Nameplate in the low voltage compartment.

2. 1-in drain plug (75 to 500 kVA) or 1-in drain valve with sampling device (750 to 5000 kVA).

3. 1-in upper filter press and filling plug.

4. Dial type thermometer with maximum temperature indicator, mounted in a sealed drywell in the low voltage compartment.

5. Auxiliary, sealed, dry contact in thermometer for remote indication of high temperature alarm.

6. Pressure-vacuum gauge mounted in the low voltage compartment.

7. Pressure relief valve.

8. Pressure relief diaphragm.

9. Sudden pressure relay.

10. Magnetic liquid level gauge located in the low voltage compartment at the 25 degree C level mark.

11. Auxiliary, sealed, dry contact in the level gauge for remote indication of low oil level alarm.

12. Mounting provision for voltage and current metering transformers.

32.05 SURFACE PREPARATION AND SHOP COATINGS

A. All welds shall be ground smooth and all metal surfaces cleaned of oil, grease and weld spatter using a hot phosphate chemical treatment. A zinc-rich, heat cured epoxy primer shall be applied to inhibit rust.

B. The equipment shall receive an intermediate coat of heat cured epoxy finish color, followed by an air dried finish coat of Outdoor green, Munsell No. 7GY3.29/1.5. After finish painting, all bottom surfaces, and sides up to a minimum of 1-in above the ground shall be protected against corrosion by an epoxy tar coating.

32.06 SHOP TESTING

A. Perform manufacturers standard production testing and inspection in accordance with ANSI Test Code C57.12.90 and/or NEMA TR1. Testing shall include the following as a minimum:

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.

2. Ratio tests on the rated voltage connection and on all tap connections.

3. Polarity and phase-relation tests on the rated voltage connections.

4. No-load loss at rated voltage on the rated voltage connection.

5. Exciting current at rated voltage on the rated voltage connection.

6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project.

7. Temperature Test or tests shall be made on one unit only of a project covering one or more units of given rating. Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit.

8. Applied potential test.

9. Induced potential tests.

10. Toxic chemical (e.g. P.C.B.) test.

11. Short circuit capability of transformer design.

B. Manufacturer shall certify compliance with transformer coating performance per ANSI C57.12.28.

C. Results of the above tests including no load loss data shall be submitted with final drawings in the form of certified test reports.

PART 33 EXECUTION

33.01 INSTALLATION

A. The equipment shall be leveled and anchored directly to a concrete equipment pad sized as required per transformer manufacturer’s dimension, weights, cable openings, etc. Provide hardware and metal shims for installation. Anchor bolts shall be 1/2-in galvanized steel.

B. Install the equipment in accordance with the manufacturer's instructions.

C. Remove temporary packing and shipping braces. Touch-up damaged paint finishes.

33.02 FIELD TESTING

A. Engage the services of an independent testing firm to inspect and test the installed equipment prior to energization. The testing firm shall provide all material, labor, equipment and technical supervision to perform the tests and inspection. Notify the Owner and Engineer at least 2 weeks prior to scheduling any testing.

B. Equipment testing and inspection shall be performed in accordance with NETA Standard ATS and shall include the following:

1. Visual and mechanical inspection.

2. Ground resistance test.

3. Insulation resistance tests, winding-to-winding and winding-to-ground, using a megohmmeter, at nominal tap position with all cables disconnected.

4. Perform insulation power factor tests or dissipation factor tests on all windings and bushings. Test voltage shall be limited to the line-to-ground voltage rating of the winding.

5. Sample and test insulating liquid for dielectric breakdown voltage, acid neutralization number, specific gravity, interfacial tension, color and visual condition. Perform PPM water and P.C.B. tests on 25 kV units and higher and on silicone filled transformers.

6. Perform individual excitation current tests on each phase.

C. In the event of an equipment fault, notify the Engineer and Owner immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, the Engineer and Owner and the equipment manufacturer's factory service technician. Repair or replace the equipment as directed by the Engineer and Owner prior to placing the equipment back into service.

33.03 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

End of Section 26 12 19
SUMMARY SHEET

Section name: MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR

Section number: 26 13 13

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: May 2009

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document was formatted to SPU Contracts style

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This specification was specifically developed for the Morse Lake Power Supply project.

PART 34 general

34.01 SCOPE OF WORK

A. The Contractor shall furnish, witness test, functional test, deliver, install, complete, field test, make ready for operation, energize, operate and maintain 4160 Volt factory assembled generator paralleling switchgear equipment with digital electronic controls, as specified herein and as shown on the Drawings.

B. The Contractor shall furnish and terminate new medium voltage cable and conduit, control wiring, communications and instrumentation wiring required to complete the interfacing of the new paralleling switchgear with the new standby generators. For details refer to the respective sections of Division 26.

C. The generator set manufacturer will supply the paralleling equipment to provide a single source of responsibility for all the products provided. Technicians specifically trained to support the product and employed by the generator set supplier will commission and start-up the paralleling switchgear equipment.

D. The engine generators will be leased by Seattle Public Utilities. It shall be the responsibility of Contractor to coordinate all related work with the switchgear and the engine generator supplier. The generator information is provided in Table 1:

Table 1: Stand-by Generator Sizes

Location	Quantity	Enclosure Type	Stand-by Rating	Manufacturer	Model	Voltage
Morse Lake Pump Plant	4	Outdoor – Walk in type	2,000 kW	Cummins	2000 DQAB	277/480V (Four 2500kVA transformers to step up the voltage to 4160V)

E. The Contractor shall be responsible for assisting the switchgear equipment manufacturer with the protective relay settings during commissioning and start-up.

F. Contractor shall provide both a preliminary and a final short circuit, selective coordination and arc flash study of the complete electrical distribution system as specified herein and as shown on the Drawings. The study shall include motor starting/running calculations.

G. Obtain and pay for the services of the Medium Voltage Switchgear manufacturer, subject to the approval of the Engineer, to provide a complete fault current, distribution protective devices selective coordination and Arc Flash study. The selective coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and including the largest feeder circuit breaker and motor starter in the all low voltage motor control centers and power distribution panelboards. The study shall also include transformers and protective devices associated with emergency and standby generators, and the associated paralleling equipment and distribution switchgear. The arc flash study shall begin with the utility company's feeder protective device and include all of the electrical distribution equipment down to and including low voltage motor control centers and

power distribution panelboards and lighting panels. All information required to perform the study shall be obtained by the entity performing the study.

H. Submit the preliminary short circuit, selective coordination and motor starting/running study prior to submittal of medium voltage switchgear shop drawings. The aforementioned shop drawings will not be reviewed until the preliminary power system study is approved by the Engineer. No exceptions will be allowed. The preliminary study shall include but not limited to:

1. Short circuit, and protective device coordination and motor starting studies shall be performed on nationally recognized computer software such as SKM System Analysis, EDSA, ETAP, or approved equal.

2. Obtain and verify with the utility company all information needed to conduct the study.

3. Current transformers' ratio and burden calculations shall be based on a 10 percent maximum ratio error per ANSI C57.13. Identify current transformers that will not allow the protective devices to operate within acceptable ANSI error margins and recommend corrective action.

4. The preliminary study shall verify equipment is being applied within their design ratings and electrical protective devices will coordinate.

5. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments, and minor modifications to equipment that are required to accomplish conformance with the approved short circuit and protective device selective coordination studies shall be carried out by the Contractor at no additional cost to the Owner.

I. After release of electrical equipment by the manufacturer, but prior to energizing the electrical equipment, submit the final short circuit and selective coordination study including all calculations, tabulations, protective devices coordination graphs, etc. as specified herein.

1. Provide a complete short circuit study and protective device selective coordination study for both the utility power distribution system and the emergency/standby power distribution system under the scope of this study. The study shall include but shall not be limited to:

   a. Full compliance with applicable ANSI and IEEE Standards.

   b. Preformed on nationally recognized computer software such as EDSA, SKM System Analysis, ETAP, or equal.

2. Provide a report summarizing the selective coordination and motor starting/running study including: one-line diagram of the system, relay and breaker setting tabulation, coordination curves, relay curves, circuit breaker curves, motor

starting/running curves, protective device coordination and short circuit calculation, all prepared by the specialty firm.

3. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments and minor modifications to equipment that are required to accomplish conformance with the approved short circuit and protective device selective coordination studies shall be carried out by the Contractor at no additional cost to the Owner.

34.02 RELATED WORK

A. Standby Engine Generators are included in the attached **Section 26 32 12** for information purposes only.

B. Equipment mounting hardware and seismic calculations shall meet the requirements of **Section 26 05 48**.

C. Common Work Results for Electrical **Section 26 05 00**.

D. Identification for Electrical Systems **Section 26 05 53**.

E. Pad Mounted Transformer **Section 26 12 00**.

F. Low Voltage Transformer **Section 26 22 00**.

34.03 SUBMITTALS

A. Submit, in accordance with **Section 01 33 10**, shop drawings and product data, for the following:

1. Updated point-to-point compartment wiring diagrams for metering, relay, and control circuits. Show wire and terminal numbers.

2. Field test and inspection reports.

34.04 REFERENCE STANDARDS

A. Switchgear and components shall be designed, built and tested in accordance with the latest revision of the following standards:

1. NEMA SG.4 - Alternating-Current High-Voltage Circuit Breakers.

2. NEMA SG.5 - Power Switchgear Assemblies.

3. ANSI C37.20.2 - Standard for Metal-Clad and Station-Type Cubicle Switchgear.

4. Underwriters Laboratories (UL) Standards for Medium Voltage Switchgear.

B. Solid-state circuitry shall meet or exceed the Transient Overvoltage Withstand Test per NEMA ISCI-109 and the Surge Withstand Capability Tests (SWC) per IEEE Standard 472 (ANSI C37.90A). In addition, where UL Standards exist for components, devices and/or assemblies, such standards shall apply.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

34.05 SWITCHGEAR MANUFACTURERS

A. Equipment specifications for this project are based on microprocessor-based paralleling equipment manufactured by Cummins Power Generation.

34.06 QUALITY ASSURANCE

A. The contractor shall install the switchgear in accordance with the switchgear manufacturer's recommendations.

B. Equipment components and devices shall be UL listed and labeled where UL standards exist for such equipment.

34.07 SYSTEM DESCRIPTIONS

A. General:

1. The switchgear shall be arranged for fully automatic or manual operation at the discretion of the operator. Loading of the generator shall be initiated automatically. Load shedding shall be automatic with provisions for operator selectable manual load shedding controls and operation. Sequence of operations are included in 1.08 below. Each section shall be complete and include the necessary AC instrumentation, relaying, voltage regulator equipment, generator control equipment, engine governor controls, pilot lights, selector switches, etc., and accessories, as shown on the Drawings and as specified herein.

2. All control voltage for auxiliary relays, circuit breakers, synchronizing and other automatic equipment shall be obtained from the switchgear DC batteries.

3. Each engine generator shall be connected to the bus within 10 seconds after start circuit is energized, and the second generator shall then be synchronized, and paralleled within 5 seconds, and shall divide the load as required between units. In the event only one unit is available, the system shall have manual/automatic controls to allow the operation as a single unit.

4. All time delay registers used shall include the maximum time delay ranges on the display. Time delay alarm limits shall be displayed in table format and display logically in one or two HMI screens as necessary. Any time delays shall be operator selectable with the required password protection.

5. All system status and alarms shall be displayed on the Human Machine Interface (HMI) of the master controller.

6. The switchgear controls shall provide the operator manual controls of the generator paralleling operation. In addition the system shall allow the manual override of the automatic synchronization or testing of the generator tie breaker. The system shall provide all the necessary manual controls to close and trip the Utility Main Breaker in the event the automatic switchgear paralleling controls are not operational.

7. Generator start-up sequencing information is provided in **Section 26 32 12.**

34.08 SEQUENCE OF OPERATIONS

A. Loss of Normal Power:

1. In the absence of utility power, the operator will manually reconfigure the electrical distribution system by opening SW-1 and closing Switchgear-01's Main breaker (52-F1) to allow the generator station to supply power to the pump stations. The generator starting function will be manually operated via the master controller. The synchronization of the generators and load management will be controlled automatically through the master controller.

2. On receipt of operator's start signal from the HMI , all generator sets automatically and independently start, accelerate to rated frequency and build up to rated voltage. The first start system monitors this process, and on finding a generator set at 90% of rated voltage and frequency, automatically disables all other units from closing to the bus, and closes the ready unit to the bus. At this time the utility switch is opened.

3. The priority (load add) controls prevent overloading of the system bus by providing control signals to delay operation of designated system loads until sufficient generating capacity is available on the bus, or until the priority override switch on the HMI is actuated.

4. After the first unit is closed to the bus, the control of the remaining units is switched to the synchronizer in each generator paralleling control, which causes the generator set to synchronize with the system bus, and then close to it at the proper operator selectable time.

5. Once the first unit is on the bus and ready to take load, the Switchgear-01's Main breaker (52-F1) will close.

6. As each unit closes to the bus, the unit assumes its proportional share of the total load on the bus, and the control system will automatically add loads to the generator bus by sending a signal to the pump station network system to start the pre-selected plant loads. Pump Station network system to be provided by others.

7. Manual override controls shall be provided to allow the operation of the system in the event the automatic controls are out of service.

B. Failure Of A Unit To Start Or Synchronize:

1. If a unit fails to start, after the overcrank time delay (in the generator set control) has expired, the unit will be shut down, and an alarm will sound. The priority control will prevent the lowest priority loads from being added to the system without manual intervention. The priority override controls on the HMI may be used by an operator to manually add low priority loads to the bus, if he determines that generator capacity is available to serve the loads. Bus overload monitoring shall protect the first priority loads in the event that the bus is inadvertently overloaded due to operator error.

2. If a unit fails to synchronize, after a preset time delay, an alarm will sound, but the unit will continue to attempt to synchronize until signaled to stop by manual operation of the control switches on the generator set.

C. Bus Overload:

1. If a bus overload occurs for any reason, a load shed signal will be generated to initiate load shedding in the system. These load shed points are a pre-determined set of Pump Plant loads controlled by the Pump Plant network system.

2. If the bus does not return to proper frequency within a predetermined period of time (adjustable via the HMI), additional load shed signals will be generated until the generator set bus returns to normal frequency.

3. Loads that are shed due to overload shall require manual reset via the HMI via specific registers. Each register shall be password protected to prevent any inadvertent operation.

D. Load Demand Mode:

1. When the system running is in the emergency mode with the “load demand” switch on the HMI in the “on” position, controls shall continuously monitor the total load on the bus. If the total load on the bus falls below preset limits for a period of 15 minutes, the controller will automatically shut down generator sets in an operator predetermined order, until the minimum number of generators required to operate the load remain on the bus. The purpose of this function is to allow the generator sets to operate closer to their rated capacity, thereby decreasing fuel consumption, and reducing wear on the system.

2. On sensing that the available bus capacity is being approached, the standby units will automatically be restarted (in the reverse order of which they were shut down) and paralleled with the bus to assume their proportional share of system load.

E. Return of Normal Power:

1. When normal power returns, the system shall be sequentially transferred back to the utility by manually opening the Switchgear-01’s Main breaker (52-F1), then closing SW-1.

2. When all loads have been transferred back to the utility, the generator set paralleling breakers shall all open, and the generator sets shall operate at no load

for a cool down period. When the cool down period has been completed, the generator sets shall shut down.

3. If a system start signal is received during the cool down period, one generator set shall immediately close to the system bus and all other units shall synchronize to it, as described in “Loss of Normal Power” above.

F. Automatic/Manual Operation:

1. Controls at the switchgear shall be provided to allow the operator to select automatic or manual transfer mode, and initiate load transfer manually or automatically from the System Human Machine Interface (HMI). In the event communications is lost with the Pump Plant network system, the switchgear controls shall be able to independently operate the stand-by units manually without Pump Station Network system intervention. There shall be an override mode switch in the HMI that allows the manual operation of the paralleling system in the event of a pump station network system communications loss.

G. Manual Synchronizing Provisions:

1. The generator set control system shall be configurable for automatic and manual paralleling at the generator set control. Manual control provisions shall include manual breaker open/close switches, synchronized indication, bus and generator frequency and voltage, and indication of degrees out of phase with bus.

H. Fail to Synchronize:

1. The automatic control system shall include a fail to synchronize function, which includes an adjustable time delay to indicate failure to reach synchronous condition and connect to the genset bus within an acceptable time period.

2. The operator shall be provided with manual synchronizing provisions that allow manual adjustment of the generator frequency or voltage to facilitate manual paralleling but do not affect load sharing adjustments.

I. Lockout and Alarm System:

1. Each control section shall be provided with HMI alarm indications, to shut down the engine generator, disconnect it from the main bus, and provide an alarm description with the appropriate tag in the HMI system.

2. A failure at the engine shall cause the respective alarm to be displayed and the engine will be shut down and locked out of the automatic mode of operation.

3. To reset an engine generator after a failure, the engine selector switch shall be placed in the "lockout/reset" position.

4. After the failure has been corrected, the engine generator shall then be returnable to a standby condition.

34.09 SELECTOR SWITCH COORDINATION

A. Coordinate the functions and circuitry of the various selector switches, to insure that the various settings available do not cause malfunction in the intended system operation. The required electrical interlocks shall be provided for the safe operation of the system.

34.10 PROTECTIVE DEVICE COORDINATION

A. Contractor shall assist the equipment manufacturer with the settings and adjustments for all the protective devices included in the switchgear equipment.

B. Overload settings shall follow NEC and ANSI requirements.

C. Settings shall be provided for all overcurrent relays, voltage relays, current relays, and generator relays, etc. included herein.

1. The recommended protective device or settings shall be in easy to read tabular form in the report.

2. Phase and ground time current and instantaneous overcurrent relays should be shown on time-current coordination curves

3. Time-current curves shall be drawn for limiting conditions. For each bus a time-current curve will include the largest downstream protective device, the feeder, bus Tie, and incoming breakers.

4. Any time-current currents furnished will be neatly drawn or computer generated.

5. Cable protection will consider overload and short circuit damage points as outlined in the NEC, ANSI, and applicable technical manuals.

6. Protective device settings will be tabulated and cross-referenced to the appropriate time-current curve.

7. Calculation sheets will be provided for relays that cannot be shown in the time-current curves.

8. If additional relays are recommended from those shown on the drawings, where appropriate, provide either the model number with the suggested settings or settings in primary amperes and time.

9. The manufacturer shall calibrate and test the relays provided in the switchgear. A certified report with all the settings shall be provided.

PART 35 PRODUCTS

35.01 RATINGS

A. Switchgear system configuration: 4.16 kV, 3 Phase, 3 Wire, solidly grounded, 60 Hz systems.

B. Power circuit breakers shall have the following symmetrical ratings in accordance with ANSI Standard C37.06.

1. Nominal 3 phase interrupting rating: 350 MVA

2. Nominal voltage class: 4.16 kV, RMS

3. Maximum rated voltage: 4.76 kV, RMS

4. Crest impulse voltage (BIL): 60 kV

5. Maximum interrupting capability: 49 kA, RMS

6. Rated interrupting time: 5 cycles

7. Closing and latching current: 78 kA, RMS.

C. The continuous current rating of each circuit breaker shall be as shown on the Drawings.

D. The continuous current rating of the bus shall be 2000 Amps as shown on the Drawings. The bus shall be designed to carry its rated continuous current in the specified ambient temperature without exceeding the temperature rise limits specified in ANSI Standard C37.20.2. The bus supports, bus and connections shall be designed to withstand the specified circuit breaker close and latch short circuit current. Line and load bus connections to circuit breakers shall be rated to carry the full continuous current of the device frame.

E. The switchgear and protective devices shall be designed for continuous operation at its rated current in a 40 degree C ambient temperature.

35.02 CONSTRUCTION

A. General:

1. The general arrangement of the Switchgear is shown on the Drawings. Switchgear shall be Cummins Power Command Medium Voltage Paralleling Metal Clad Switchgear with Power/Vac vacuum breakers as manufactured by the Square D Co.

B. Structure:

1. Switchgear shall be located outdoors in a weatherproof thermal acoustic insulated walk in type enclosure. The switchgear shall be metal enclosed and sectionalized to isolate and minimize the effects of internal short circuit currents. The structure shall consist of a framework of preformed steel channels or angles covered with bolted steel sheets. Each individual breaker/metering cell shall be completely segregated from adjacent compartments and sections by steel barriers at top, bottom, rear and sides.

2. A spare compartment shall be provided to allow the installation of the Orange and Rockland Remote Terminal Unit (RTU). The RTU will monitor the protective relays on the switchgear for the utility controls. This compartment shall be a minimum of 36 inches wide.

3. Breaker compartments shall be equipped with grounded metal shutters to protect against contact with the energized primary disconnects when the breaker is removed from its compartment. Each individual breaker cell, metering and auxiliary compartment shall be provided with a hinged front panel door.

4. Provide side barriers between adjacent vertical structures in cable and bus compartments.

5. Rear cable compartments shall be isolated from the main and riser bus by insulated or grounded steel barriers. Cable compartments shall have adequate space for terminations and accessories. Provide hinged and bolted covers on the rear of each vertical section.

6. The switchgear shall be housed in a factory assembled, prewired, weatherproof, NEMA 3R, walk-in, modular steel enclosure. The enclosure shall provide a full length service aisle with access doors opposite the switchgear face. Access doors shall be gasketed, with interior panic hardware and external padlockable door latch. Full height, hinged and a gasketed, padlockable rear section door shall be provided. Shielded ventilation louvers shall provide air circulation within the structure while excluding insects, vermin, moisture and dust. Provide removable filter elements on all louvered exterior openings. A structural steel base will be included with lifting lugs and jacking plates to support the switchgear and floor plates with removable steel cover plates over conduit entrance areas. A bituminous undercoating shall be applied to the base and to the underside of the floor. The following accessories shall be provided:

    a. Enclosure Design Criteria:

        1) Design Loads

            a) Roof Live Load = 25 psf minimum.

            b) Ground Snow Load = 25 psf, Is = 1.10.

            c) Wind Loads: Basic Wind Speed = 85 miles per hour, Exposure C, Iw = 1.15.

            d) Earthquake Loads: Site Class D, SDs = 0.773g, SD1 = 0.403g, Seismic Design Category D, Ie = 1.25.

            e) Collateral Loads: A uniform roof load of 10 psf shall be included, to account for miscellaneous suspended accessories.

        2) Load combinations shall be as required by the IBC.

        3) Deflection limitations:

a) Deflection of primary structural framing members shall not exceed 1/240 of their span.

b) Deflection of secondary structural members and of wall and roof panels shall not exceed 1/180 of their span.

b. Enclosure Construction: The enclosure shall be Galvanized steel Skin Walls and roof with stiffeners. Walls and roof to be 4 inches thick. 22 Gauge perforated galvanized steel liner. 4 lbs. per cu/ft density mineral and wool with 2 mil poly liner.

c. Enclosure Painting

1) All exterior galvanized surfaces will be solvent cleaned per SSPC – SP1 and painted as follows:

a) Primer - Macropoxy (2 - 5 mils DFT)

b) Finish – Acrolon Acrylic Polyurethane

2) All carbon steel surfaces power tool cleaned per SSPC - SP3 and Painted as follows:

a) Primer - Macropoxy (2 - 5 mils DFT)

b) Finish - Acrolon Acrylic Polyurethane

3) Color to be determined by the owner.

d. Accessories: The following shall be provided:

1) Aisle Lighting for a minimum of 30 foot-candles. Lights shall be operated by switches located inside of each of the switchgear enclosure doors as shown on the lighting fixture schedule on the drawings

2) Light switch at each inside of each door of the switchgear enclosure.

3) Two photo cell controlled light fixtures with lamps for switchgear enclosure outside lighting as shown on the lighting fixture schedule on the drawings

4) Emergency lighting and exist signs as shown on the lighting fixture schedule on the drawings

5) Space heaters in each breaker and auxiliary compartment.

6) Two GFCI protected convenience outlet outside of the switchgear enclosure as shown on the drawings.

7) Six convince outlets inside of the switchgear enclosure.

8) Panelboards and transformers as described in section 2.03.

9) Manual Transfer Switch:

   a) Manual transfer switch shall be heavy duty, double throw, quick-break, quick-make, 3 or 4 Pole, 600 Volt, with Ampere rating as shown on the Drawings.

   b) Switches shall be UL-1008 listed, electrically and mechanically interlocked, with electrical initiation of transfer with pushbuttons mounted on the front of the enclosure. Safe external manual operator for switching under load shall also be provided.

   c) Switch enclosures shall be NEMA 1.

   d) Manual transfer switches shall be Russelectric Inc. Model RMTD-MAN, ASCO Model 7NTS; GE Zenith Controls ZTSM Series, or equal.

10) Space heaters for the switch gear aisle with thermostats for temperature control.

11) One auxiliary storage section.

12) Insulated rubber floor mat(s).

13) HVAC: The enclosure shall be climate controlled with Air Conditioning:

   a) The HVAC system shall have forced air ventilators that are bird proof and equipped with a back draft damper. Intake vents are aluminum with interior dampers, and removable filters. The heating system shall be wall mounted units controlled by a thermostat located on the enclosure wall.

   b) HVAC system shall be comprised of Industrial wall mounted units with an internal heat strip and auto-change over thermostat. The thermostat shall be located on the enclosure wall.

14) Air intake – fixed weather louvers, filters and bird screens (galvanized construction). Air Discharge – 2 5000 CFM exhaust fans with gravity dampers. (Galvanized construction)

15) Doors - (2) Single man doors 36" W x 80" H & (5) Single service doors 32" W x 95" H. Door hardware includes:

   a) Hinges – Heavy duty leaf

   b) Refrigerator type latches with inside panic release – chrome plated

   c) Service doors with flush mounted, lockable latches

   d) Neoprene gasket single sealed around door perimeters

   e) Bolting hardware – S.S.

C. Auxiliary Sections:

1. Provide bus extensions and compression lugs for number and size of incoming cables as shown on the Drawings.

D. Buses and Connections:

1. Main and riser bus shall be copper with a flame retardant, track resistant fluidized bed epoxy insulation system rated for 105 degree C operation. Bus joints shall be silver plated, bolted and insulated with removable PVC boots.

2. The main and vertical riser buses shall be enclosed in a segregated metal compartment with removable covers for accessibility. Horizontal bus supports between adjacent cubicles shall be flame retardant, track resistant molded glass-reinforced polyester through-bushings.

3. Circuit breaker load side runbacks shall be copper bus with epoxy insulation and porcelain support bushings. Provide two hole NEMA drilling for two cables per phase at each cable connection point.

4. Circuit breaker primary connections shall be mounted in molded glass-reinforced polyester insulated contact tube assemblies, bolted to the rear of each breaker cell compartment.

E. Grounding:

1. Make provisions for connection of incoming and outgoing cable sheaths and for the copper grounding conductors shown on the Drawings.

2. Provide a continuous horizontal ground bus extending through the entire length of the switchgear. Bus material and short circuit rating shall be equal to the main bus. The ground bus shall have at least one bolted connection to the structure in each bay.

3. Provide a ground bus riser assembly in each cable compartment connected to the ground bar in each circuit breaker or potential transformer drawout assembly compartment. Connect metering, relaying and instrument transformer grounds to this riser assembly.

4. Provide a grounding disconnecting device between each circuit breaker removable element and the equipment ground bus which shall maintain contact at all times, except when the primary disconnecting devices are separated at a safe distance.

5. Provide a static grounding device on each voltage transformer drawout carriage to contact the primary fuses in the disconnected position. Each drawout carriage shall be bonded to the ground riser bus assembly.

F. Power Circuit Breakers:

1. Circuit breakers: Removable, electrically operated, vacuum interrupter type with stored energy trip/close mechanism, mounted in a heavy gauge steel frame with a

removable front panel cover. The following mechanical indicators and devices shall be visible and accessible through the front cover:

a. Manual trip/close pushbutton

b. Open/close indicator

c. Operations counter

d. Spring charge indicator

e. Manual charging arm

f. Racking screw

2. Each breaker shall have a self-contained racking mechanism to move the breaker between the TEST/DISCONNECT and CONNECTED positions and to align and secure the primary disconnects in the CONNECTED position.

3. Circuit breakers shall be capable of being racked in or out with the compartment door closed. Provide interlocks to prevent the following operations:

a. Racking a closed breaker into or out of the CONNECTED position.

b. Closing a circuit breaker until it is fully racked into the TEST/DISCONNECT or CONNECTED position.

c. Withdrawing a circuit breaker from the cubicle while the closing springs are charged. The operating springs shall be discharged automatically when the breaker is inserted or removed from the compartment or is moved between the TEST/ DISCONNECT and the CONNECTED position.

d. Insertion of a breaker of incorrect ampere rating or inadequate interrupting capacity.

e. Means shall be provided for padlocking the breaker racking mechanisms in either the CONNECTED or TEST/DISCONNECT position.

4. Each breaker shall have a secondary control power plug which automatically engages a cell mounted mating receptacle in the CONNECTED position and disengages as the circuit breaker is racked out to the TEST/DISCONNECT position. Provide a means to manually engage the control power plug in the TEST/DISCONNECT position.

5. Breaker contacts on the removable element (TOC) auxiliary switch shall be wired to terminal blocks. Provide 5 normally open and 5 normally closed spare auxiliary contacts in addition to the auxiliary contacts required for breaker operation. Normally closed auxiliary contacts shall break before the normally open auxiliary contacts make.

6. Circuit breakers shall be equipped with mechanism operated (MOC) auxiliary switch contacts for remote status indication. Provide 5 spare type "a" and 5 spare "b" contacts wired to terminal blocks.

7. Circuit breaker frame sizes shall be as shown on the Drawings.

8. Cells for future breakers shall be fully equipped with drawout carriage, racking mechanism, primary and secondary contacts and current transformers.

9. Main circuit breaker (52-F1) shall be equipped with a Kirk-Key interlock. The Kirk-Key interlock shall be configured so that the switchger-01 main breaker (52-F1) and utility supply switch (SW1) cannot be closed at the same time.

G. Control Power:

1. Control power for the system circuit breakers shall be provided from interconnected 125 VDC battery cells, mounted in the walk-in type enclosure. The batteries shall be low maintenance, long life, and nickel hydroxide/cadmium type as manufactured by ALCAD; XHP or equal. Batteries shall have at least a 15 year pro-rated warranty and a 1 year full guarantee.

2. Each breaker shall be electrically operated at 125 VDC from the switchgear DC system battery. Breaker operating mechanism shall be electrically charged, stored energy type. Charging motor shall include a limit switch feature and an anti-pump relay. Make provisions for manual charging of the mechanism and for slow closing of the contacts for inspection and adjustment.

3. Cell containers shall be sealed, translucent, shock absorbing, heat-resistant plastic, with electrolyte level marks and spray proof, flame arresting type vents. Battery shall be furnished with all connectors and hardware, lifting device, electrolyte, terminal plates, cables, grease and connectors.

4. A floor mounted structural steel battery rack shall be furnished specifically designed for battery service. The rack shall be finished with an acid and fire resistant epoxy coating and non-metallic rail covers.

5. Battery charger shall be a fully automatic, filtered, float type charger suitable for wall or rack mounting. Input voltage shall be 120 VAC, single phase, 60 Hz. The DC output shall be regulated to within 0.5 percent regardless of fluctuations of the input voltage and shall be current limited at 120 percent of rated output. Accessories shall include DC ammeter and voltmeter (panel type; 2 percent accuracy), adjustable float and equalize controls and toggle switch, AC and DC circuit breakers, AC power failure alarm relay, low DC voltage alarm relay and DC ground fault relay. The charger shall be set up and provided by the battery supplier and installed by the enclosure manufacturer. The battery charge system shall be provided with auxiliary contacts and provide alarm conditions to the switchgear generator controls. This alarm shall also be transmitted to the Plant SCADA system.

6. The battery ampere-hour rating shall be adequate to provide 10 consecutive circuit breaker Open/Close/Trip operations at the end of a 2 hour period, at a battery temperature of 45 degrees F.

H. Secondary Wiring and Control Devices:

1. Wiring: 600 Volt, stranded copper, type SIS, flameproof switchboard wire, minimum size No. 14 AWG for control, No. 12 AWG for power and instrument transformer secondaries. Wiring shall be grouped together with harnesses or in ducts and shall be secured to the structure. Pull out type fuse holders shall be used for control circuits.

2. Identification and termination: Sleeve type wire markers at each termination point. Terminal blocks shall be rated 20 Amps minimum, 600 Volt, screw type with white marking area. Current transformer secondaries shall be wired to shorting type terminal blocks. Transformer terminations shall be with ring type, crimp on wire lugs.

3. Instrument and control switches: 600 Volt switchboard rotary type, rated 20 Amps continuous, with black molded phenolic escutcheon plates, white characters, General Electric, Type SB-1 or equal.

   a. Circuit breaker control switches shall be of the momentary contact, spring return type having mechanical target or flag and a black, fixed, pistol grip handle.

4. Indicator lights: The switchgear manufacturer will provide green, red and amber LED pilot lights for each circuit breaker OPEN, CLOSED and TRIP indication.

I. Control and Metering Transformers:

1. Potential transformers: Two-winding, encapsulated drawout type with primary and secondary fuses. Voltage ratings shall be as required for the application. Thermal rating and metering accuracy per ANSI standards.

2. Current transformers: Toroidal type suitable for mounting on breaker stabs. Continuous thermal current rating, relaying and metering accuracy shall conform to ANSI standards.

3. Control power transformers: Two-winding dry type with primary fuses, secondary circuit breaker, NEMA sized for the application.

J. Instrumentation and Metering (Digital):

1. Microprocessor based metering: At each circuit location shown on the Drawings, furnish a digital microprocessor based metering device capable of monitoring and displaying the functions listed below. The device shall provide the status input functions indicated and communicate data to the system master control monitoring system via a Modbus data highway network. The device shall be UL or CSA listed.

2. All breakers cells shall each be provided with metering equipment that is integrated with the Operator Interface (HMI) provided with the system master control.

3. Metering Functions:

    a. The Digital AC Instrumentation Package shall be capable of measuring, calculating and directly displaying on the front panel display the following information:

        1) Volts on each phase plus average of all three phases

        2) Current on each phase plus average of all three phases

        3) Ground current

        4) Frequency

        5) Power Factor

        6) kVA

        7) kvar

        8) kW

        9) Total kWh as an accumulating total, providing bi-directional (import/export) indication.

        10) Total kvarh as an accumulating total, providing bi-directional (import/export) indication.

        11) The kW demand, user-programmable length of each demand period and the number of periods averaged to match local utility billing method .

        12) Amps Demand

4. Monitoring and Control Functions:

    a. The switchgear manufacturer will provide the following digital inputs into the system master control for each breaker:

        1) Circuit breaker OPEN status

        2) Circuit breaker CLOSED status

        3) Circuit breaker TRIPPED status

        4) Circuit breaker OUT OF SERVICE (withdrawn) status

        5) One auxiliary analog signal (selectable 0-20 mA or 4-20 mA) proportional to any measured parameter for each compartment metering unit.

5. Operational Features:

    a. The switchgear manufacturer will provide the following operating features:

        1) True RMS measurements.

        2) Connect directly to PT's and CT's for systems over 600 Volts.

        3) Provision for a fourth current input for measurement of ground current.

        4) 300 Amp, one second surge protection on all four current inputs.

        5) 3-field, 20 character, high visibility 0.4-in character height vacuum-fluorescent display with a programmable time out feature.

    b. Store in non-volatile memory the following:

        1) A time-stamped alarm and event log of up to fifty events which records event date, time (to 1 second), event type and value for all over/under limit conditions, all status input activity and all relay operations. Log shall be read via the communications port.

        2) A time-stamped minimum/maximum log, which records the value of any parameter exceeding the previous highest or lowest value recorded. Log shall be read from the front panel display or via communication port.

        3) A time-stamped snapshot (historical) log, with a 100 snapshot capacity and user-definable snapshot interval from 1 second to 400 days which records snapshot values for Average Volts, Average Amps, kW, kvar, kW Demand, Power Factor, Frequency, kWh, kWh Reverse, kvarh and Auxiliary Volts Input. Log shall be read via the communications port.

        4) All setup and as-built data.

    c. The device shall be field programmable as follows:

        1) Volts scale, volts mode (wye, delta, single phase), Amps scale, Vaux scale, baud rate and the relay operation shall be programmable from the front panel.

        2) All parameters above, plus additional alarm/event parameters shall be programmable via the communications port using a portable terminal or a computer.

        3) The programming shall be password protected.

6. Waveform Capture:

    a. Provide waveform capture capability allowing any of the eight voltage and current input channels to be digitally sampled at 128 samples/60 Hz cycle. Waveform capture shall be initiated using commands made via the

communications port. Waveform capture data shall be made accessible via the communications port.

7. Data Communications:

   a. Provide a serial communication port which has:

      1) Switchable RS-232C and RS-485 capability.

      2) Addressable polling of multiple units.

      3) Packet transmission.

      4) Selectable transmission at 300 to 19,200 baud.

   b. Provide the necessary software and communication cables for interfacing.

K. Relays:

1. Voltage sensing relays: Adjustable, solid state devices with 5 Amp output contacts and three phase RMS sensing. Relays shall respond to reverse phase and negative sequence voltage conditions. Pick-up and drop-out set points shall be independently adjustable. Relay accuracy shall not be affected by harmonic distortion of the supply waveform. Relays shall be Cutler-Hammer, Type SVM3, or equal.

2. Time delay relays: Electro-pneumatic type, either on-delay or off-delay as required, with calibrated timing head and 20 Amp contacts (120 VAC, resistive).

L. Protective Relaying:

1. Protective relaying for protection of the utility service to the facility, which is in compliance with Orange and Rockland Utilities requirements, shall be provided.

2. The protective relaying shall be mounted in the switchgear. A letter from the utility shall be provided with project submittals verifying that the equipment proposed meets the approval of the utility.

3. The main breaker F2-51 shall be provided with the following utility grade protective functions as minimum, regardless of the local utility requirements. The microprocessor based relays provided shall include the following functions:

   a. Phase sequence (47)

   b. Over/Under voltage relay (27/59).

   c. High speed over and under frequency relay (81 O/U).

   d. Directional Overcurrent Relay (67/67N)

   e. Directional power (32).

f. Phase balance voltage relay (47)

g. Sync check (25)

h. Instantaneous Overcurrent (50)

i. Time Overcurrent Relay (51)

j. Time delay opening relay (62)

k. Lockout relay (86).

l. Multifunction protective relays shall be as manufactured by Schweitzer Engineering Laboratories, Inc., SEL 351-7 or approved equal.

4. 52-G1 through 52-G4 breakers shall be provided with the following utility grade protective functions as minimum. The microprocessor based relays provided shall include the following functions:

a. Overcurrent Relay (51/51V)

b. Ground Overcurrent Relay (51GN)

c. Phase sequence (47)

d. Over/Under voltage relay (27/59).

e. High speed over and under frequency relay (81 O/U).

f. Directional power (32).

g. Phase balance voltage relay (47)

h. Sync check (25)

i. Over current (50/51)

j. Field Relay (40Q)

k. Volts/Hz Relay (24)

l. Phase Balance Relay (47)

m. Field Loss Current Balance Relay (60FL)

n. Phase Balance Relay (46)

o. Generator Thermal Relay (49)

p. Generator Differential Relay (87G)

q. Lockout Relay (86)

r. The protective relay provided can be a multifunction microprocessor based relay. Multifunction protective relays shall be SEL 351-7 as manufactured by Schweitzer Engineering Laboratories, Inc., PowerCommand Control as manufactured by Cummins, or approved equal.

5. Each feeder breaker shall be provided with the following protective devices:

a. Overcurrent Relay (51)

b. Instantaneous Overcurrent Relay (50)

c. Ground Overcurrent Relay (50GS)

d. Lockout Relay (86)

e. The protective relay provided can be a multifunction microprocessor based relay. Multifunction protective relays shall be as manufactured by Schweitzer Engineering Laboratories, Inc., SEL 551 or approved equal.

6. Generator Differential Relays shall be a multifunction microprocessor based relay as manufactured by Schweitzer Engineering Laboratories, Inc., SEL587.

7. Breaker Lockout Circuit Breaker Control Switches shall be as manufactured Electroswitch, General Electric or approved equal.

8. The utility/mains, generator main and feeder protective relaying shall be utility grade equipment, SEL (Schweitzer) or equal. The generator set relaying shall be utility grade equipment, or equipment which is manufactured by the manufacturer of the alternator. In either case, the supplier shall demonstrate that the relays and settings are coordinated with the alternator thermal damage curve.

M. Lightning and Surge Protection:

1. Lightning arrestors: Provide a set of three Station Class, metal oxide type lightning arrestors at each location shown on the Drawings.

2. Surge arrestors: Provide surge protectors on each circuit using a vacuum circuit breaker.

N. Transient Voltage Surge Suppressors (TVSS):

1. TVSS unit shall be MOV (Metal Oxide Varistors) manufactured by Square D rated at 160 kA per phase.

2. The TVSS unit shall be listed under UL 1449-Second Edition and UL 1283 for noise attenuation devices.

3. Unit shall have:

a. Line-Ground connection configuration.

b. One Nanosecond or less response time.

c. Extend noise filtration with a 10 kHZ to 100 MHZ range.

d. Fused internal disconnect switch with 60 Amps, 300,000 AIC rating.

O. Marking and Identification:

1. Provide nameplates on each breaker cell door and for each control or indicating device as shown on the drawings and specified in **Section 26 05 53**. Nameplates shall be screw fastened.

2. Provide permanent master nameplate for switchgear designation, manufacturer's name, model number, order number and voltage, current and interrupting ratings.

3. Provide permanent warning signs marked "DANGER - HIGH VOLTAGE - KEEP OUT" on each rear compartment door. Signs shall be OSHA approved.

35.03 SYSTEMS

A. Miscellaneous Equipment and Requirements:

1. Heaters:

a. An automatic thermostatically controlled generator space heater rated 120 Volt, single phase, shall be provided to maintain not less than 90 degrees F (32 degrees C) temperature with an ambient temperature of 40 degrees F (4.5 degrees C). An alarm for the space heater shall be indicated in the Switchgear PLC controls HMI. This alarm shall be indicated remotely on the Pump Plant SCADA.

b. A separate manual switch shall be provided for each heater to disconnect heater when not required. Each heater shall be properly wired to receive its energy from the load side of the automatic load transfer switch (see lighting panel schedule on Electrical Drawings).

2. General Purpose Dry Type Transformers:

a. Refer to **Section 26 22 00** for low voltage transformer requirements.

b. Transformers shall be dry type, two winding with kVA and voltage ratings as shown on the Drawings.

c. Four full capacity taps shall be furnished, two 2 1/2 percent above and two 2 1/2 percent below rated primary voltage.

d. Maximum temperature rise shall be 115 degrees C. Windings shall be copper.

e. Transformers shall be built in accordance with ANSI C89.2 and NEMA ST 20.

f. Transformers shall be furnished with mounting hardware.

g. Transformers shall be manufactured by the Square D Co.

h. The 30 kVA 208/120 Volt transformer will be installed in the walk-in enclosure by the enclosure manufacturer and the enclosure manufacturer will be required to wire and make final connections.

3. Panelboards:

a. Provide a 480V/277V, three phase panelboard and 120/208V, three phase panel board as shown on the drawings.

b. Refer to **Section 26 24 16** for panelboard requirements.

c. Panelboards shall be in accordance with the Underwriter Laboratories, Inc. "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code.

d. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

e. The 480/277 Volt and 208/120 Volt panelboards will be installed in the walk-in enclosure by the enclosure manufacturer and the enclosure manufacturer will be required to wire and make final connections.

f. Ratings:

1) All panelboards shall be rated for the intended voltage.

2) Circuit breaker panelboards shall be fully rated for the specified circuit breaker fault current interrupting capacity. Series connected short circuit ratings will not be acceptable.

g. Buses:

1) Bus bars for the mains shall be of copper. Full size neutral bars shall be included. Phase bussing shall be full height without reduction. Cross connectors shall be copper.

2) Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

3) Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.

4) Equipment ground bars shall be furnished.

h. Circuit Breakers:

1) Panelboards shall be equipped with circuit breakers.

2) Circuit breakers shall be molded case, bolt in type.

3) Each circuit breaker used in 120/208 Volt panelboards shall have an interrupting capacity of not less than 10,000 amperes, RMS symmetrical.

4) Each circuit breaker used in 480 Volt panelboards shall have an interrupting capacity of not less than 65,000 amperes RMS symmetrical.

5) GFCI (ground fault circuit interrupter) shall be provided for circuits where shown on the Drawings. GFCI units shall be 1 Pole, 120 Volt molded case, bolt on breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the breaker mechanism. The unit shall be UL listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time) and an interrupting capacity of 10,000 Amps RMS.

6) Circuit breakers shall be as manufactured by the panelboard manufacturer.

4. The Panelboards shall have the minimum number of breakers as shown on the drawings.

35.04 CONTROL EQUIPMENT (MASTER CONTROL)

A. Construction:

1. Control equipment shall be designed for front access only.

2. Each section of the paralleling control system shall be listed and labeled under the requirements of UL 891, including all covers, barriers, and supports. Individual control sections shall be isolated from each other by metal or insulating barriers.

3. All wiring shall be UL listed 105 degree C, 600 volt rated, and sized as required. Each wire, device or function shall be suitably identified by silk screen or similar permanent identification.

4. The framework and all other sheet metal components of the system shall be primed with a rust inhibiting primer, and finished with two coats of satin finish ANSI 61 gray enamel.

5. All door mounted control components shall be industrial type oil tight devices with contact ratings a minimum of twice the maximum circuit ampacity they are controlling. Toggle switches and other light duty control devices are not acceptable. Indicator lamps shall be high intensity LED type devices. Indicator lamp condition (on or off) shall be easily visible in bright room lighting conditions.

6. AC control circuits in the switchgear shall be protected with properly sized fuses in safety fuse blocks, with visible fuse blown indication for each fuse. Potential transformers shall be protected on line and load side.

7. All CT installations shall include shorting type terminal blocks.

8. All field control interconnecting wiring shall be sized as specified by system manufacturer (wiring not designated by the system manufacturer shall be minimum 14 AWG copper). All control interconnect wiring shall be stranded.

B. System Control Power:

1. Control power for the paralleling control system shall be derived from the generator set 24VDC starting batteries. A solid state, no break “best battery” selector system shall be provided so that control voltage is available as long as any battery bank in the system is available, and that all battery banks are isolated to prevent the failure of one battery from disabling the entire system.

2. Generator set governing, voltage regulation; load sharing, synchronizing, protection, and control equipment shall be capable of proper operation with battery voltage levels down to 8VDC.

3. A redundant 24VDC control power supply shall be provided for the system master control, including batteries, rack, and charger. The power supply shall be provided with an auxiliary contact and wired directly to the Switchgear PLC to indicate any alarm conditions.

C. Engine Generator and Paralleling Controls located at each of the four generators:

1. Provide a paralleling control panel for each generator set in the emergency/standby power system. The paralleling control functions may be integrated with the generator set control functions (with duplicate functions eliminated). Each paralleling control panel shall contain the components and devices as described in this section.

2. Operator Panel:

a. Each paralleling control panel shall be provided with a panel to allow the operator to view the status and control operation of the specific generator set being paralleled. The operator panel shall be provided with the following features and capabilities.

b. 1% accuracy generator set AC output instruments; Ammeter, Voltmeter, Frequency Meter, Wattmeter, KW-hour meter, Power Factor Meter. Selector switches to allow viewing of voltage and amperes for each phase shall be provided. For 3-phase/4-wire systems the voltmeter shall indicate line to line and line to neutral conditions. Voltmeter and frequency meter shall be analog instruments. Switches and/or other provisions shall be included to allow reading of bus voltage and frequency from this metering set.

c. Synchroscope and “generator set synchronized” indication. Indication may be synchronizing lamps, LED indication, or other provisions, but must be located on the paralleling control panel, adjacent to the paralleling breaker control switches.

d. Running Time Meter, Start Counter.

e. Generator Set Mode Selector Switch: Switch shall provide run, off, and automatic functions for control of the generator set. Run mode causes the generator set to immediately start and accelerate to rated speed and voltage, but paralleling breaker does not automatically close. Off mode prevents generator set from starting, or immediately shuts down the generator set if it is running. Auto mode allows genset starting from a remote control system.

f. Breaker trip/close switch with breaker status indicating lamps: The switch shall be interlocked with the control system such that breaker closure is not possible unless the mode select switch is in the run position and the generator set is synchronized with the system bus.

g. Control Reset push button switch with indicating lamp. Lamp shall flash to indicate that generator set is locked out due to a fault condition.

h. Lamp test push button switch: Operation of this switch shall cause all lamps on the panel to be simultaneously tested.

i. The control panel shall be provided with a set of DC-powered lamps with a switch to allow viewing of all functions on the front panel when normal lighting systems are not available.

j. Emergency Stop switch: The emergency stop switch shall be a red, mushroom head switch which maintains its position until manually reset.

3. Alarm and status indicating panel to indicate the following conditions: Indication can be by annunciator or Color Touchscreen (alarm horn shall be located on master control):

Function	Lamp or Flag Color	Alarm Horn	Shutdown Unit
Low DC Voltage	Amber	*	
High DC Voltage	Amber	*	
Weak Battery	Amber	*	
Fail to Sync	Amber	*	
Low Oil Pressure Alarm	Amber	*	
Low Fuel - daytank	Amber	*	
High Engine Temp Alarm	Amber	*	
Ground Fault	Amber	*	
Overcurrent Alarm	Amber	*	
Breaker Failure	Red	*	*
Breaker Tripped	Red	*	*
Not in Auto	Red	*	*
High Engine Temp	Red	*	*
Low Oil Pressure	Red	*	*
Overcurrent	Red	*	*
Short Circuit	Red	*	*
Loss of Excitation	Red	*	*
Reverse Power	Red	*	*
Overcrank	Red	*	*
Overspeed	Red	*	*
Under Frequency	Red	*	
Under Voltage	Red	*	*
Over Voltage	Red	*	*

Phase Rotation	Red	*	*
Low Coolant Level	Red	*	*
Automatic	Green		
Generator Running	Green		
Breaker Open	Green		
Breaker Closed	Green		
Demand Mode Standby	Green		
Timing for Start	Green		
Timing for Shutdown	Green		
Power Supply Failure	Amber	*	*
Building Low Temperature	Red	*	

4. Internal Controls: The following internal control components or functions shall be provided for each generator set in the system.

   a. Electronic isochronous kW load sharing control to operate the engine governors during synchronizing and to provide isochronous load sharing when paralleled. The control system shall allow sharing of real kW load between all generator sets in the system to within 1% of equal levels, without introduction of frequency droop into the system. The control system shall include all equipment required for kW load sharing with an infinite bus. The infinite bus governing controls shall allow the generator set to synchronize to an infinite bus, parallel, and ramp up to a preset load level on the generator set. Additional controls shall be provided to cause the generator set to ramp up to a kW load level signaled by the system master control PLC. The isochronous load sharing module and engine governor shall be a coordinated system of a single manufacturer.

   b. Load demand governing controls shall be provided to cause the generator set to ramp down to zero load when signaled to shut down in a load demand mode. On a signal to re-start, the load demand governing controls shall cause the generator set to synchronize to the system bus, close, and ramp up to its proportional share of the total bus load. The ramp rate of the generator set shall be operator-adjustable.

   c. Electronic kVAR load sharing control to operate the alternator excitation system while the generator set is paralleled.

   d. The control system shall allow sharing of reactive load between all generator sets in the system to within 1% of equal levels, without introduction of voltage droop into the system. The control system shall include all equipment required for VAR load sharing with an infinite bus in either a constant VAR or constant power factor mode for future application flexibility. (Mode and adjustments selectable by the operator.)

   e. Equipment shall be provided to monitor the generator set as it is starting, and verify that it has reached at least 90% of nominal voltage and frequency before closing to the bus. The equipment provided shall positively prevent out of phase paralleling if two or more engine generator sets reach operating conditions simultaneously by providing a lockout signal to disable breaker closure for generator set(s) in the system which has not been selected to be the first units to close to the bus.

f. Controls to recognize the failure of the first breaker signaled to close, and allow system operation to proceed in spite of this failure shall also be provided (breaker failure alarm). Systems using dead bus relay schemes without a disable signal to positively prevent out of phase paralleling shall not be acceptable under this specification. System shall include an independent backup to automatically operate in the event that the primary system fails.

g. Synchronizer to electronically adjust the engine governor to match the voltage, frequency and phase angle of the bus: Synchronizer shall maintain the engine generator voltage within 1% of bus voltage and phase angle within 20 electrical degrees of the bus for 0.5 seconds before circuit breaker closing. Each unit shall have its own synchronizer; systems using a switching scheme to utilize a single system synchronizer will not be approved. Synchronizers and systems which utilize a motor driven pot for control of AC voltage during the synchronizing process will not be accepted. The system shall be provided with a fail to synchronize time delay that is adjustable from 10-120 seconds. Control logic for fail to synchronize function shall allow field adjustment of function for either alarm or shutdown of the generator set on failure condition:

    1) Controls shall include a permissive relay function to assure that the generator set does not attempt to close out of phase with the bus, due to errant operation of the synchronizer.

    2) Controls shall include a permissive (sync check) function, to be used with “generator synchronized” indicator during manual paralleling, to prevent accidental closure of the breaker with the generator set out of phase with the bus. Provisions to allow manual closure of the first generator set to a de-energized bus shall be included.

h. Control equipment shall contain a system of diagnostic LED’s to assist in analyzing proper system function.

i. Controls shall include three phase sensing reverse power equipment, to prevent sustained reverse power flow into the generator set. The engine manufacturer shall approve the reverse power sensing equipment. When the reverse power condition exceeds 10% of the generator set kW for 3 seconds, the paralleling circuit breaker shall be tripped open and the generator shut down.

j. Controls shall be provided to verify generator set and bus phase rotation match prior to closing the paralleling breaker.

k. Electronic alternator overcurrent alarm and shutdown protection:

    1) This protection is required in addition to the overcurrent relaying on the paralleling breaker, and shall sense current flow at the generator set output terminals. The overcurrent alarm shall be indicated when the load current on the generator set is more than 110% of rated current for more than 60 seconds. The overcurrent shutdown shall match to the thermal damage curve of the generator set, and shall not have an instantaneous function.

2) Electronic alternator short circuit protection: This protection is in addition to the overcurrent trip on the paralleling breaker. The short circuit shall occur when the load current on the generator set is more than 175% of rated current and an aggregate time/current calculation indicates that the system is approaching the thermal damage point of the alternator. The equipment used shall not have an instantaneous function

3) Provide overcurrent and short circuit protection for the feeder connecting the generator set to the paralleling switchgear. This protection may be integrated with alternator protection but must be positively coordinated to prevent tripping of the paralleling breaker prior to the operation of the alternator protective equipment.

4) Controls shall be provided to sense loss of excitation of the alternator while paralleled to the system bus.

5. Hardwire Interface in Engine Genset Controls at each generator:

a. Generator set start contacts rated 10 amps at 32 VDC.

b. Cooldown time delay, adjustable: 0-600 seconds. The control panel shall indicate the time remaining in the time delay period when the generator set is timing for shutdown.

c. Start time delay, adjustable: 0-300 seconds. The control panel shall indicate the time remaining in the time delay period when the generator set is timing for start.

d. The control system shall monitor the paralleling breaker auxiliary contacts, and initiate a fault signal if the breaker fails to close within an adjustable time delay period after the control has signaled it to close (0.5-15 seconds). Breaker failure alarm shall cause the paralleling breaker to trip open, and lock out until manually reset.

e. Controls shall be provided to initiate an alarm condition when generator set is at 90% of rated frequency for more than 20 seconds.

f. Controls shall be provided to shut down generator set and initiate alarm when the generator set is at less than 85% of nominal voltage for more than 15 seconds, more than 110% of nominal voltage for more than 10 seconds, or more than 130% of nominal. All alarm conditions shall be displayed at the Switchgear Controls HMI.

g. Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for reliable system operation, as described herein under “SYSTEM OPERATION”.

D. Master Control System:

1. Provide a system master control to monitor and control the operation of the entire paralleling system, including the generator set controls. The master control panel shall contain the components and functions described in this section.

2. Solid State System Status Panel.

3. A system status panel or Color Touchscreen display shall be provided and shall include the following features and functions.

4. Alarm Silence Push-button Switch

5. Alarm horn

6. LED Indicating lamps or Indications on Color Display to indicate the following conditions:

Function	**Color**	**Alarm Horn**
Generator Set #n On Line. (one for each genset in the system)	Green	
Load Demand Mode	Green	
Priority #n Load On (one for each load add level in the system)	Green	
Load Shed Level n (one for each load shed level in the system)	Red	*
System Test	Green	
Remote System Start	Amber	
Check Generator Set #n (one for each genset in the system)	Red	*
Controller Malfunction	Red	*
Check Station Battery	Red	*
Bus Overload	Red	*
System Not in Auto Mode	Red	*

7. A full color high resolution HMI type operator interface panel (HMI) shall be provided which allows the operator to monitor and control the onsite power system. The HMI shall have a minimum viewing area of 100 square inches. The components shown on the HMI shall all be designated as shown on the drawings. All data shall be configurable for display in either US standard or metric indications. The HMI shall include the following screens and/or functions:

   a. Screens shall be configured in a typical WindowsTM format, with a pop-up menu in the lower left corner of the screen providing access to various screens. There shall not be a close program “button” in the upper right corner of any screen. (Closing the program shall be accomplished only through the menu structure.)

   b. One Line Diagram Screen: The one-line diagram screen shall display a system message (to advise the operator of needed or optional control operations), and shall also show the system status by a combination of animation, changing screen color, text messages, and pop-up indicators. Conditions visible on the screen shall include:

c. Generator set(s), and bus configuration, with generator set, parallel breaker and bus energized/de-energized indication (red indicating energized, green indicating de-energized).

d. Generator set designation. Control, data, and performance summary screens shall be accessible through hot keys (links) located on or adjacent to the genset icon.

e. Generator set mode (run/off/auto)

f. Generator set status (normal/warning/shutdown/load demand stop/% load).

g. Paralleling breaker status (open/closed/tripped)

h. Bus condition (energized or de-energized)

i. Access to other system control and monitoring functions through a menu button with pop-up option display

j. Help “button” to allow access to information concerning the specific screen viewed, or concerning current system status.

k. System Control. The system control screen shall provide the operator with the ability to enable or disable load demand operation; initiate test (with or without load); control the shutdown sequence for the generator sets in the load demand mode; set the load demand time delays; set the load demand operation set points; and display and modify the automatic load add and shed sequence.

l. Genset Control:

1) The genset control screen shall be a popup control screen to allow the operator to manually start and stop the genset, and manually open and close the genset - paralleling breaker. It shall also display generator set status and percent load.

m. Genset Data Display:

1) The genset data display shall provide the operator with information on the status and condition on the generator set. It shall include all data displayed at the local generator set control panel. As a minimum shall include: engine rpm, oil pressure, coolant temperature, DC voltage, engine hours, genset MW hours, number of starts, line to line and line to neutral voltage on all phases, bus line to line, and line to neutral voltage on all phases, genset and bus frequency, load current, power factor, kVAR and kW, local control switch status, and genset status. It shall also provide display of all active faults in the local generator set control. The screen shall include a strip chart function that allows the operator to add any monitored data point to a scrolling screen to develop an active graphical display of conditions on that generator set.

n. Genset Status Summary:

1) The genset status summary shall provide an analog and graphical display of critical generator set operating parameters. The screen shall include generator set state display (stopped, time delay start, idle speed state, rated volts/hz, synchronizing, load share, or load govern); analog AC metering for generator set, including 3-phase AC volts and current, frequency, kW, and power factor; and 3-phase AC bus voltage and frequency. The screen shall also include a strip chart function that allows the operator to add any function or value on to the strip chart to provide an active display of the condition of the system.

o. Load Control:

1) The load control screen shall provide an analog display of system load as a percent of available capacity of the generator sets that are operating in parallel on the bus. The screen shall also provide an alphanumeric display of this data. It shall also display the name, status and priority of each load block (whether on or off), and the total load of that block. The screen shall allow the operator to manually add and shed loads in any sequence desired.

p. Trending:

1) The Touchscreen shall be capable of providing real time trend charts for any monitored value in the system, with up to 4 monitored points at any time.

q. Alarms:

1) Any alarm on any generator set or in the system shall result in a pop-up screen display that describes the equipment where the fault has occurred, and the name of the fault. The screen shall allow the operator to attempt to reset the fault from the HMI. It shall also offer direct access to manuals.

r. Service Information:

1) The service information pop-up screen shall include the name, address, and phone number for the local service point for the equipment

s. Transfer Controls:

1) Transfer Pair Screen:

a) A transfer control screen shall be provided for the transfer breaker pair in the system. The transfer control screens shall provide status information on the condition of the normal service and generator service at each device (service available), which source is connected to the load, as well as transfer control status. Information to be provided shall include:

t. Indication on the Color Display, not in auto, test/exercise mode, load shed, transfer inhibit, retransfer inhibit, fail to close, fail to disconnect.

u. AC data at the transfer pair, including line to line and line to neutral AC Volts for all phases of both sources, frequency of both sources, load current, power factor, kW, and kVA for the load.

v. Test “pushbutton” and fault reset “pushbutton”.

w. The screen shall also display status of all active time delays and all active faults.

8. Programmable controller (PLC):

a. The PLC shall be by Alan Bradley, Modicon, GE FANUC or approved equal.

b. For interface with HMI, and to provide load demand, load pick up, and load shed functions. Documentation provided with the equipment shall include PLC program documentation.

c. Load pick up output contacts, rated 10 A at 600 VAC (3 contacts per level). Provide direct control for all feeder breakers in the system (14 total)

d. Load shed output contacts, rated 10 A at 600 VAC (3 contacts per level). Provide direct control for all feeder breakers in the system (14 total)

e. Digital Transducer(s), PT’s, and CT’s and other equipment required to provide bus condition information to the PLC.

f. Provide all other components required, such as properly sized current transformers, transducers, terminal blocks, etc., for proper and reliable system operation.

35.05 PANEL CONSTRUCTION

A. General:

1. Control panels shall be front aligned with the switchgear to present a uniform appearance.

2. The face of the panel shall include meters, controls and indicators as specified, each with descriptive lamicoid nameplates. The back of the panel shall have metal cabinet doors with continuous hinge and a cabinet type locking latch.

3. The generator control panel shall be fabricated from sheet steel. All cutting, fitting and welding shall be neat, and all edges shall be ground smooth. The panel interior shall be painted white. The panel exterior shall be cleaned and primed and given a final finish coat to match the switchgear.

4. Breaker transfer pair control switches shall be 600-volt, 20 ampere, multi-stage rotary type with black handles. Each switch shall have a fixed modern pistol grip

handle with an engraved black plastic escutcheon plate. Switches shall be as manufactured by Electroswitch or approved equal.

5. Interposing control relays shall be heavy duty plug-in socket type with a transparent dust cover. The relay shall be equipped with an indicating light to indicate when its coil is energized. The relays shall have 10 ampere minimum unless otherwise specified, 120/230-volt AC contacts. The mechanical life of the relay shall be 10,000 operations minimum.

6. All panel equipment shall be mounted and wired on or within the cabinet. Wiring shall comply with latest National Electric Code. All wiring within the panel shall be grouped together with harnesses or ducts and secured to the structure. All wiring shall be numbered in accordance with the numbering system used on the wiring/connection diagrams. Wiring and connection diagrams shall be submitted as part of the shop drawings for approval of the Engineer.

7. Terminal blocks shall be grouped in the instrument and control compartment for easy accessibility unrestricted by interference from structural members and instruments. Sufficient space shall be provided on each side of each terminal block to allow an orderly arrangement of all leads to be terminated on the block.

8. Panel wiring shall be stranded copper conductor, 600 volt class, insulation and jacketed, General Electric Type SIS, or equal. Minimum size for analog and discrete signal wiring shall be No. 14 AWG for AC power wiring and No. 16 AWG for DC control wiring.

B. Marking and Identification:

1. The switchgear manufacturer will provide nameplates on each breaker cell door and for each control or indicating device. Nameplates shall be engraved as specified on the Drawing or as directed, using lettering approximately 3/8-in high for unit identification nameplates and 1/4-in high elsewhere. The nameplates shall be white on black laminated phenolic material. The engraving shall extend through the white exterior lamination to the black core. Nameplates shall be screw fastened.

2. The switchgear manufacturer will provide permanent master nameplate for switchgear designation, manufacturer's name, model number, order number and voltage, current and interrupting ratings.

3. The switchgear manufacturer will provide warning signs marked "DANGER - HIGH VOLTAGE - KEEP OUT" on each rear compartment door. Signs shall be adhesive backed Mylar, OSHA approved.

35.06 SURFACE PREPARATION AND SHOP COATINGS

A. All non-current carrying metal parts of the switchgear assembly shall be cleaned of all weld spatters and other foreign material and given a hot iron-phosphate chemical treatment. Apply a rust inhibitive, heat cured epoxy primer prior to finish coat.

B. Indoor equipment shall be painted with one finish coat of manufacturers standard air dried enamel.

C. Outdoor equipment shall be painted with two finish coats of polyurethane or epoxy enamel, 1 to 2 mil thicknesses. Exterior color shall be dark green.

D. Unpainted non-current carrying parts shall receive a protective zinc plating to prevent corrosion. Printed circuit boards shall be coated with a protective conformal epoxy. All device contacts shall be silver plated.

35.07 SHOP TESTING

A. The switchgear manufacturer will perform manufacturers standard production testing and inspection in accordance with ANSI Standards C37.09 and C37.20.2. If requested by the Engineer, the manufacturer shall submit certified copies of test results.

B. The BIL rating of the integrated switchgear assembly shall be established by test on switchgear of the type and kind to be furnished under this Section. Submit certified copies of these test reports, if requested by the Engineer.

C. The system manufacturer shall perform a complete operational test on the paralleling system (including generator sets, paralleling controls, and power switchgear) prior to shipping from the factory. A certified test report shall be provided, and permanently retained by the system manufacturer. No exceptions to this factory testing requirement will be allowed.

35.08 SERVICE AND SUPPORT

A. The manufacturer of the paralleling equipment shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.

B. The paralleling system, including generator sets and paralleling equipment, shall be serviced by a single local service organization that is trained and factory certified in both generator set and paralleling equipment service. The technicians serving the site shall be specifically trained and certified by the manufacturer in the diagnosis and repair of the synchronizing, paralleling, and load sharing equipment provided. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year. The response time for an emergency call shall be within 4 hours of initiating the emergency support call.

C. The manufacturer shall maintain model and serial number records for the paralleling equipment for at least 20 years.

PART 36 EXECUTION

36.01 INSTALLATION

A. The switchgear equipment will be provided by the Owner. The Contractor is responsible for coordination of delivery, unloading, rigging into place, anchoring,

installation, (including all excavation, concrete and backfill) interconnection control conduits and wiring, power conduits and wiring, locations and installations of conduit stub ups, duct banks, coordination of factory representatives for testing, setup and training, and final cleaning. The Contractor is responsible for assisting the switchgear manufacturer during the commissioning and testing phase of the project.

B. The equipment shall be leveled and anchored directly to a concrete equipment pad or finished floor as shown on the Drawings. The Contractor shall provide hardware and metal shims for installation. Grout and caulk all voids beneath the equipment base. Anchor bolts shall be 5/8-in galvanized steel, minimum.

C. C. The Contractor shall install the equipment in accordance with the manufacturer's instructions.

D. The Contractor shall remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.

E. The Contractor shall make wiring interconnections between shipping splits.

F. The Contractor shall install bus splice plates and torque the connections.

G. The Contractor shall caulk seams, cracks and openings in outdoor enclosures.

H. The Contractor shall insulate the primary cable connections to bus pads and lightning and surge arrestors. Fill voids around bolted connections with 3M Brand SCOTCHFIL electrical putty and apply tape insulation or heat shrink insulating boots in accordance with the switchgear manufacturer's installation instructions.

I. The Contractor shall install primary cables in accordance with **Section 26 05 13**. Bond cable sheaths to the switchgear ground bus.

36.02 FIELD TESTING

A. The Contractor shall engage the services of a recognized independent testing firm to inspect and test the installed equipment prior to energization. The testing firm shall provide all material, labor, equipment and technical supervision to perform the tests and inspection. Notify the Owner at least 2 weeks prior to scheduling any testing.

B. Equipment testing and inspection shall be performed in accordance with NETA Standard ATS-2005 and shall include the following.

1. Visual and mechanical inspection.

2. Phasing check.

3. Ratio and polarity tests on current and voltage transformers.

4. Ground resistance test.

5. Current injection tests on each circuit.

6. Insulation resistance tests (phase-to-phase and phase-to-ground).

7. Over potential test on each bus section (phase-to-ground).

8. Meter calibration.

9. Circuit breaker contact resistance test.

10. Insulation power factor and resistance test for surge arresters.

C. In the event of an equipment fault, notify the Owner immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, the Engineer, the Owner and the equipment manufacturer's factory service technician. Repair or replace the equipment as directed by the Engineer & Owner prior to placing the equipment back into service.

36.03 ADJUSTMENT

A. The switchgear manufacturer shall provide the services of a factory trained service technician for a minimum of two (2) trips for a minimum of two weeks for installation and training. The first trip shall be coordinated with the field testing. The second trip shall include any necessary follow-up or punch list work, and technical instruction for the Owner's designated personnel. The manufacturer's service technician shall demonstrate all operational features of the installed switchgear. The Contractor is responsible for the coordinating with the switchgear manufacturer's provided services.

B. The switchgear manufacturer's factory service technician shall make the following test and adjustments:

1. Calibrate and test all protective relays and controls per the final version of the Coordination Study as specified in 1.10.

2. The selected bidder shall keep the as-built records on site, and provide the Owner with a hard copy before leaving the site that will include the final copy of the left settings.

3. Adjust and lubricate circuit breaker operating mechanisms and contacts.

36.04 CLEANING

A. The Contractor shall remove all rubbish and debris from inside and around the switchgear. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

End of Section 26 13 13

APPENDIX A

EQUIPMENT MANUFACTURER'S CERTIFICATE OF INSTALLATION TESTING AND INSTRUCTION

Owner: Seattle Public Utilities

Project: Morse Lake Pump Plant Stand-by Generators Medium Voltage Paralleling Switchgear

Contract No. _____

CDM No. 37817-65952

EQUIPMENT SPECIFICATION **SECTION 26 13 13 Medium-Voltage Circuit Breaker Switchgear**

EQUIPMENT DESCRIPTION - Stand-by Generator Paralleling Switchgear for <name>t

I_____ , Authorized representative of (Print Name)

_____

(Print Manufacturer's Name)

hereby CERTIFY that_____

(Print equipment name and model with serial No.)

installed for the subject project have been installed in a satisfactory manner, have been satisfactorily tested, are ready for operation, and that Owner assigned operating personnel have been suitably instructed in the operation, lubrication, and care of the units on Date: _____ Time: _____.

CERTIFIED BY: _____ DATE: _____

(Signature of Manufacturer's Representative)

OWNER'S ACKNOWLEDGMENT OF MANUFACTURER'S INSTRUCTION

We the undersigned, authorized representatives of the Seattle Public Utilities and/or Plant Operating Personnel have received classroom and hands on instruction on the operation of the subject equipment and are prepared to assume normal operational responsibility for the equipment:

_____ DATE: _____

_____ DATE: _____

_____ DATE: _____

SUMMARY SHEET

Section name: Medium-Voltage Metal-Clad Drawout Circuit Breaker and SCL Metering

Section number: 26 13 19

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: December 2009

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	01/01/07	Insert

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 37 GENERAL

37.01 SUMMARY

A. This section includes requirements for design, fabrication, delivery, installation, commissioning and testing of the 27 kV rated metal-clad switchgear lineup, including Seattle City Light (SCL) metering and incoming assembly section and the main breaker and auxiliary sections.

B. Related Documents: The provisions and intent of the Contract, the General and Supplementary Conditions, and Division 1 Specification Sections, apply to the Work as specified in this Section.

C. Related Sections:

1. Division 16, Section 16071 “Seismic Controls for Electrical Work” for enclosure and cabinet supports.

2. Division 16, Section 16075 “Electrical Identification”.

3. Division 16, Section 16124 “Medium-Voltage Cables” for cable terminations.

4. Division 16, Section 16290, “Electrical Power Monitoring and Data Gathering” for power monitoring interface.

5. Division 16, Section 16491 “Fuses” for fuse type.

6. Division 16, Section 16950 “Acceptance Testing”.

D. The equipment in this specification is being pre-purchased by the Owner, and installed by the Contractor.

37.02 REFERENCES

A. ANSI C12.2 Code for Electricity Metering (2001)

B. ANSI C37.20.2 IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear (1999)

C. ANSI C37.04 IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (1999)

D. ANSI C37.04 IEEE Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (1999

E. ANSI C37.011 IEEE Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (1999

F. ANSI C37.012 IEEE Application Guide for Capacitance current Switching of AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (2005)

G. ANSI C37.1 IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control Data Acquisition and Automatic Control (1996)

H. ANSI C37.2 IEEE Standard Electrical Power System Device Function Number (2001)

I. ANSI C37.100 IEEE Standard Definitions for Power Switchgear (1992)

J. ANSI/IEEE C37.90 - Relays and Relay Systems Associated with Electric Power Apparatus (1989).

K. ANSI/IEEE 48 Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations (I996).

L. ANSI/IEEE C57.|2.26 IEEE Standard for Pad-mounted Compartmental-Type, Self-cooled, Three-phase Distribution Transformers for Use with Separable Insulated High-voltage Connectors (1992).

M. ANSI IEEE C57.12.28 IEEE Standard for Pad-Mounted Equipment-Enclosure Integrity (2005).

N. ANSI/IEEE C 57.13 Requirements for Instrument Transformers (1993).

O. Except as modified by this specification, the metering equipment furnished shall comply with the material and testing requirements of the latest revisions of applicable ANSI, IEEE, NEMA and NETA standards.

P. NETA ATS (Inter-National Electrical Testing Association) – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (2007).

Q. NFPA 70 - National Electrical Code, as adopted and administered by the Authority Having Jurisdiction (2008)

37.03 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories Listed and Labeled as defined in NFPA, Article 100, by a testing agency acceptable to the authorities having jurisdiction and marked for the intended use.

B. Manufacturer Qualifications: Engage a firm experienced in manufacturing switchgear acceptable to the City of Seattle and metering cabinets acceptable to Seattle City Light similar to those indicated for this Project and with a greater than 10-year record of successful in –service performance.

C. Testing Agency Qualifications: Testing agency meeting OSHA criteria for accreditation of testing laboratories, Title 29,Part 1907 or a member company of the InterNational Electrical Testing Association(NETA) and that is acceptable to Authority Having Jurisdiction.

D. Testing Agency's Field Supervisor: Person meeting criteria to be certified by the InterNational Electrical Testing Association or the National Institute for Certification in

Engineering Technologies to supervise on-site testing specified in Division 16, section16950 "Acceptance Testing".

E. Source Limitations: Obtain switchgear and metering enclosure through one source from a single manufacturer.

F. Product Options: Drawings indicate size, elevations, and dimensional requirements of switchgear and utility metering equipment. Refer to Division I, Section 01630 "substitutions".

G. Comply with NFPA 70, as adopted and administered by the Authority Having Jurisdiction

H. Comply with NEMA standards.

37.04 SUBMITTALS

A. Comply with Division 1, Section 01330, “Submittal Procedures"

B. Provide all submittals shop drawings, testing and documentation in accordance with Specification Section "Electrical Work - General", and Utility (Seattle City Light (SCL)) requirements.

C. Product Data: provide dimensions; mounting arrangements; location for cable entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings, characteristics and finishes. Include the following:

1. Features, characteristics, and ratings of individual switches.

2. Time-current characteristic curves for over current protective devices, including fusible devices if required.

3. Statement of compliance with IBC seismic requirements ratings as amended by the State of Washington.

D. Equipment Supplier shall utilize manufacturer's guidelines to provide a detailed plan for installation of the metal-enclosed switchgear and utility metering equipment. On-site disassembly and reassembly of the equipment shall be performed by the Installation contractor under the supervision of the Field Service Engineer. Address pick points, lifting and setting methods, and methods for transportation inside the building.

E. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances and method of field assembly, components, and location and size of each field connection. Include the following:

1. Master drawing index.

2. Front view elevation.

3. Floor plan.

4. Nameplate Schedule.

5. Nameplate diagram per ANSI requirements.

6. Single-Line Drawings.

7. Three-Line Wiring Diagrams: Detail power, signal, and control wiring specific to this Project, Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.

8. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.

9. Continuous current ratings of buses and major components.

10. Short-circuit ratings of switchgear and utility metering equipment and major components.

11. Conduit entry/exit locations.

12. Cable terminal sizes.

13. Mounting and anchoring devices recommended by manufacturer to resist seismic forces specified in Section 16071 “Seismic Controls for Electrical Work".

F. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear and utility metering equipment where pipe and ducts are prohibited. Show switchgear and utility metering equipment layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

G. Test Reports: Provide certified results of factory tests and field acceptance tests.

H. Manufacturer Seismic Qualification Certification: Submit certification and calculations, signed and stamped by a registered Professional Structural Engineer, licensed in the state of Washington, stating that equipment will withstand seismic forces defined in Division 16-Section 16071 "Seismic Controls for Electrical Work." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation:

   a. The term "withstand" means the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.

2. Dimensioned Outline Drawings of Equipment Units: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements,

4. Seismic Anchoring: Install Switchgear and utility metering equipment on concrete base and meet IBC seismic requirements as amended by the State of Washington. Refer to Division 16, Section16071 “Seismic Controls for Electrical Work." Equipment Supplier shall provide complete Seismic Anchorage design and details for each of the switches. A Structural Engineer licensed in the state of Washington shall stamp the Seismic Anchorage design.

I. Operations and Maintenance Data: Comply with Division, 1 Section 01780-"Operations and Maintenance Data." Include the following at a minimum:

1. AII approved Shop Drawings showings witch dimensions, layout, weights, nameplates, and internal components.

2. Instructions for operating the switchgear, including all interlocks.

3. Instructions for maintaining the switches.

4. Bill of Material for each switch, identifying manufacturer, and catalog number of each significant component or assembly.

37.05 DELIVERY, STORAGE, AND HANDLING

A. Refer to Division 1 specification Section 01650 “Delivery, Storage and Handling and individual Division 16 specification sections to identify delivery, storage and handling requirements for electrical equipment and materials.

B. Equipment Supplier shall deliver equipment FOB to Project Site. Equipment Supplier is responsible for arranging and paying for insurance for freight, shipping, and handling equipment between Seattle area delivery point and final installation, including storage prior to installation.

C. Equipment Supplier shall attach Impact-O-Graph (Catalog No. OMNIG3G) shock indicator (or approved equal rated for 3G), to X, Y, and Z axes of each unit shipped. The installation and OWNER's representatives will jointly open and inspect the impact recorders. Attach shock indicators to the equipment enclosure itself, not the shipping container.

D. In the event that any shock detector is found to have been activated, the Equipment Supplier shall inspect and test the affected equipment to evaluate and identify the nature and extent of any damage to the switchgear. Perform this evaluation at no cost to the City of Seattle.

E. Equipment Supplier shall furnish written certification of the as-found status of all shock detectors on all transformers along with findings recommended courses of action to rectify damaged switchgear.

F. Equipment that is identified as pre-purchased by Seattle Public Utilities will be stored locally, and delivered to jobsite by Seattle Public Utilities upon 7 days notice from the Electrical Contractor.

G. Seattle Public Utilities will unload all Seattle Public Utilities pre-purchased equipment to a designated “Point of First Drop” as identified by the General Contractor and Division specification Section 01650.

H. The Electrical Contractor will be responsible for signing documentation indicating date of receipt of pre-purchased equipment at the "Point of First Drop" location.

I. The Electrical Contractor will assume all responsibility for equipment storage and handling from the designated "Point of First Drop" and will be responsible for the move of the equipment from this designated "Point of First Drop" to the equipment's final installed position.

J. Prior to installation, store and handle in accordance with manufacturer's recommendations and maintain equipment in a clean and dry condition.

K. Store so condensation will not form on or inside equipment enclosures.

L. Apply temporary heat where required to obtain suitable service conditions.

M. Handle switchgear and utility metering section using factory-installed lifting provisions.

N. Switchgear and utility metering equipment may have to be disassembled for ease of installation. Equipment Supplier to submit manufacturer's instructions for delivery, handling, and storage so as not to void listing of equipment.

O. See Division 1 for Seattle Public Utilities representative inspection requirements. Coordinate SCL inspection and approval requirements with SPU and SCL.

37.06 COORDINATION

A. Coordinate installation of switchgear and utility metering equipment with Seattle City Light, SPU and with other construction trades.

B. Comply with Seattle City Light requirements for providing power and communication services to the Utility Metering equipment.

37.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents:

1. Breaker Truck: 1 breaker truck for each breaker for each line-up for removal of breakers.

PART 38 PRODUCTS

38.01 MANUFACTURERS

A. Eaton/Cutler-Hammer products or as specified in documents:

1. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

38.02 SWITCHGEAR ASSEMBLY

A. The switchgear assembly shall consist of individual vertical sections housing the main incoming and utility metering section, and main circuit breaker and auxiliaries sections, bolted to form a rigid metal-clad switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit. Hinged rear doors, complete with provisions for padlocking, shall be provided.

B. The switchgear shall be designed for operation on a 26 kV, three-phase, 4 wire, 60-hertz system. The rating of the entire switchgear assembly shall be 27 kV.

C. The entire switchgear assembly shall have a continuous current rating of 600 amperes. It shall have a minimum, one-time, fault-closing, duty cycle of 25,000 amperes asymmetrical at 27 kV.

D. Insulation:

1. The basic impulse insulation level shall be 125 kV BIL.

2. The maximum Radio Influenced Voltage (RIV) at 1,000 kHz shall be 100 microvolts when energized.

E. Enclosure

1. The switchgear described in these specifications shall be weatherproof, aisleless construction for outdoor service. Each shipping group shall be mounted upon an integral base frame with a weatherproof enclosure for assembly in the field into a complete metal enclosed switchgear assembly with a weatherproof door provided on the breaker drawout side of each vertical section.

2. The entire underside of the roof shall be coated with a "no-drip" asphalt base mastic, minimum 1/8" thick.

3. Where outdoors switchgear is shown, each vertical section of switchgear shall be provided with space heaters, tubular type heaters operated at half voltage for long life shall be supplied, 500 volt or 250 volt rated heaters shall be used at 240 or 120

volts respectively. Power for space heater shall be provided as indicated on the drawings.

4. Heaters shall be wired to provide temporary heating during storage.

F. A copper ground bus shall extend the entire length of the switchgear

G. The main bus shall be copper with fluidized bed epoxy flame-retardant and track resistant insulation. The bus supports between units shall be flame-retardant, track-resistant cycloaliphatic epoxy. The switchgear shall be constructed so that all buses, bus supports and connections shall withstand stresses that would be produced by currents equal to the momentary ratings of the circuit breakers. Main bus shall be rated 600 amperes. Insulated copper main bus shall be provided and have provisions for future extension. All bus joints shall be plated, bolted and insulated with easily installed boots. The bus shall be braced to withstand fault currents equal to the close and latch rating of the breakers. The temperature rise of the bus and connections shall be in accordance w with ANSI standards and documented by design tests.

H. Paint Finish - Utility Metering Section:

1. The color of the finish coat will be Munsell 7GY 3.29/L 5 padmount green.

2. The paint coating system shall meet all of the enclosure coating system performance requirements of ANSI C57.12.28.

I. Finish - Main breaker and Auxiliary Sections:

1. The finish shall consist of a coat of gray (ANSI-61), thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray.

J. Corona Free Design:

1. The switchgear shall be corona free by design and shall be tested for partial discharges in accordance with EEMAC standard G l l-1. The corona discharges measured during the tests shall be less than 100 picocoulombs.

38.03 MAIN INCOMING AND UTILITY METERING SECTION

A. The main incoming and utility metering section shall be designed, fabricated and installed in accordance with SCL standards for primary metering. Refer to Seattle City Light drawing SCL-401A and contract drawings. All work to be inspected and approved by SCL prior to fabrication, installation, and energization.

B. SCL primary feeders shall enter utility metering section from below.

C. Voltage and Current Transformers:

1. Seattle City Light will provide and install the voltage transformers and the current transformers.

2. The metering cabinet shall be designed for the installation of three General Electric outdoor type JVW-6 voltage transformers and three General Electric outdoor type JKW-6 current transformers.

D. Surge Arrestors:

1. Seattle City Light will provide and install the Surge Arrestors

E. Fuse provisions:

1. Seattle City Light will provide and install the fuses.

2. The metering assembly shall have provisions for three fuses for the voltage transformers. The fuse mountings shall be Cooper Power Products catalog number FABOL D8, mounting code number 6.

F. Primary Bushings:

1. The primary bushings shall consist of 27 kV bushing wells with replaceable studs. The bushing wells shall have a rating of 600 amperes, 125k V BIL and shall be suitable for operation on a 26,400 Grd.Y/15,240 volt system. The bushing wells shall meet the applicable requirements of the latest revision of ANSI/IEEE 386.

2. The bushing wells shall include hold down bails tabs. For clamp-type bushing wells that include bail tab holes in the clamping ring, the bail tab holes shall be on the same plane as the surface of the bushing well.

3. The bushing wells shall have a cover or cap to prevent the entrance of moisture or dirt during shipping or storage.

4. Load break parking stands per ANSI C57.1 2.26-1987, Section 7.2.3 and Figure 5 shall be provided. The parking stands shall not be coated with paint or other materials that preclude the installation of a standoff bushing.

G. Interlocks and Barriers:

1. Each metering cabinet shall have a removable back barrier to guard against inadvertent contact with the live parts.

2. All phase separation panels and barriers shall be of inert material.

H. Neutral Bushing:

1. The metering cabinet shall have one insulated neutral bushing which extends through the equipment firewall.

2. The fault duty capability of the neutral bushing shall be a minimum of 25,000 amperes for 12 cycles.

3. The neutral bushing shall have a copper pad on each end. The two copper pads shall each be 2" x 3-½" with two 9/16" holes spaced 1- ¾" on center.

I. Grounding Pads:

1. The metering cabinet shall have two grounding pads, one on each side of the equipment.

2. The fault duty capability of each grounding pad shall be a minimum of 25,000 amperes for 12 cycles.

3. The grounding pads shall consist of an unpainted, copper-faced steel or stainless steel pad, 2 "x 3- ½ " with two 9/16" - l3 NC holes spaced on a 1-3/4" center. The pads shall be welded to the frame, one in each of the two compartments.

J. Utility Metering Section Enclosure:

1. The enclosure shall meet all of the requirements for enclosure security required by ANSI C57.12.28.

2. Access to the unit for maintenance shall be through the rear doors. The doors shall be secured with a padlock shackle and penta headbolts for back-up protection.

3. The cabinet shall be 300 series stainless steel 11 gauge (0.12 inches) minimum thickness.

4. A hole for a 3l4" bushing shall be punched in the firewall near the bottom of the cabinet adjacent to the neutral bushing.

5. The minimum inside depth of the dead front side of the cabinet shall be 16".

6. The maximum enclosure width shall be 66". The maximum enclosure depth shall be 75".

K. Identification:

1. Comply with SCL Requirements.

L. Miscellaneous:

1. Refer to SCL drawing SCL-401A and contract documents for additional requirements.

38.04 SWITCHGEAR MAIN BREAKER AND AUXILIARY EQUIPMENT

A. Each circuit breaker shall have the following ratings:

Maximum Voltage	27 kV
BIL rated	125 kV Peak
Continuous Current (27 kV)	600 Amperes
Short –Circuit Current at rated Maximum kV	25 kA RMA sym
Rated Voltage Range Factor K	1.0
Closing and Latching Capability	68 kA Peak
Maximum Symmetrical	25 ka RMS sym

Interrupting and 3-Second Rating	
Nominal 3-Phase MVA Class	750 MVA
Rate Interrupting Time	50 ms (3 cycle)

B. The stationary primary contacts shall be silver-plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell. Provide rails to allow withdrawal of the 27 kV circuit breaker for inspection and maintenance without the use of a separate lifting device.

C. The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations and a minimum of 10% spare terminals shall be provided. One control circuit cutout device shall be provided in each circuit breaker housing. Switchgear secondary wire shall be #14 AWG, type SIS rated 600 volt, 90 degrees C, furnished with wire markers at each termination. Wires shall terminate on terminal blocks with markers trips numbered in agreement with detailed connection diagrams.

D. Incoming line and feeder cable lugs of the type and size indicated elsewhere shall be furnished.

E. The circuit breaker shall be horizontal drawout type, capable of being withdrawn on rails. The breaker shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

F. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. The vacuum interrupter pole unit shall be mounted on cycloaliphatic epoxy supports. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate a viable contact life, shall be easily visible when the breaker is removed from its compartment. The current transfer from the vacuum interrupter moving stem to the breaker main conductor shall be a non-sliding design. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.

G. The secondary contacts shall be silver-plated and shall automatically engage in the breaker operating position, which can be manually engaged in the breaker test position.

H. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker shall be secured positively in the housing between and including the operating and test positions.

I. The breakers shall be electrically operated by the following control voltages:

1. 48-volt DC close and 48-volt DC trip.

J. Each breaker shall be complete with control switch and red and green indicating lights to indicate breaker contact position.

K. DC control voltage shall be supplied by internal 48V battery.

L. The switchgear manufacturer shall furnish and install, in the metal-clad switchgear, the quantity, type and rating of protection relays as indicated on the drawings and described hereafter in this specification.

M. Protective Relays: Comply with ANSI/IEEE C37.90, types and settings as indicated; with test blocks and plugs:

1. Reverse Power Relay (ANSI Standard Device 32) Basler Model BE3-32 Reverse Power Relay to monitor the direction of power. If current flow becomes reversed and exceeds the adjustable setting, the relay will trip.

2. Instantaneous vercurrent, Time-Delay Overcurrent, Ground Fault (ANSI Standard Device 5 0/51, 5 lG) Basler Model B EI-50/51B. Provided with external time delay control with adjustment from 20 ms to 2 seconds to provide overcurrent and ground fault protection.

3. Relay shall have communication port for data and control communication.

4. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door, or behind glass cover for exterior applications.

N. Auxiliary Devices:

1. Voltage and control power transformers of the quantity and ratings indicated in the detailed specification shall be supplied. Voltage transformers shall be mounted in drawout drawers contained in an enclosed auxiliary compartment. Control power transformers for 27 kV class shall be fixed mounted with primary fuses in drawout drawers. Rails shall be provided as applicable for each drawer to permit easy inspection, testing and fuse replacement. Shutters shall isolate primary bus stabs when drawers are withdrawn.

2. A mechanical interlock shall be provided to require the secondary breaker to be open before the CPT drawer or CPT primary fuse drawer can be withdrawn.

3. Partial Discharge Sensing Equipment:

a. The switchgear breaker section shall be equipped with factory installed partial discharge sensors and relay for continuous monitoring of the partial discharges under normal operation. The purpose of partial discharge sensing is to identify potential insulation problems (insulation degradation) by trending of PD data over time so that corrective actions can be planned and implemented before permanent insulation deterioration develops.

O. The PD sensing and monitoring system shall consist of sensors and relay specifically developed for such applications, such as Eaton's RFCT sensor and InsulGard relay, or equivalent. One RFCT sensor shall be installed over floating stress shields of specially designed bus or line side primary bushings, at every two vertical sections for detection of partial discharges within the switchgear compartments. An RFCT sensor shall also be provided for installation around ground shields of the incoming or outgoing power

cable termination for detection of PD activity in the cables up to 100 feet from the switchgear. Output signals from each RFCT shall be factory wired to PD monitoring relay for continuous Power Monitoring (Metering):

1. Microprocessor-based power monitoring system shall be Schneider Electric Power Logix power monitor and energy meter model ION7550 with Ethernet connection and open communication protocol capable of Ethernet based remote monitoring utilizing a TCP/IP interface. Reference specification Section 16290 “Electrical Power Monitoring and Data Gathering.”

2. Mounting: Display and control unit flush or semi-flush mounted in separate auxiliary instrument compartment door or behind glass cover for exterior applications". Provide all internal wiring and connections per manufacturer’s requirements factory wired to master terminal block in assembly for direct communication to SPU SCADA monitoring system.

3. Provide metering devices as shown on the drawings. Provide a separate metering compartment with front hinged doors. Include associated instrument transformers.

4. Provide current transformers for metering as shown on the drawings. Current transformers shall be wired to shorting type terminal blocks.

5. Provide potential transformers including primary and secondary fuses with disconnecting means for metering as shown on the drawings.

6. Metering will be powered from an external power source (not part of equipment).

P. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for #8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for the duty required.

Q. Nameplates:

1. Engraved nameplates mounted on the face of the assembly shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background, and secured with screws. Characters shall be 3/16-inch high, minimum. Furnish master nameplate for each switchgear lineup giving information in accordance with IEEE Std. C 37.20.2-1999, Section 7.4.l. Circuit nameplates shall be provided with circuit designations as shown on purchaser's single-line diagrams.

2. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturers' wiring diagrams.

R. Accessories:

1. The switchgear manufacturer shall furnish accessories for test inspection, maintenance and operation, including:

    a. One – Maintenance tool for manually charging the breaker closing spring and manually opening the shutter.

    b. One - Levering crank for moving the breaker between test and connected positions.

    c. One - Test jumper for electrically operating the breaker while out of its compartment.

    d. One- Breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails, when applicable.

    e. One- Set of rail extensions and rail clamps, w hen applicable.

    f. One- Portable lifting device for lifting the breaker on or off the rails,

    g. One - Ramp for rolling breaker mounted in lower compartment directly on the floor.

    h. One - Test cabinet for testing electrically operated breakers outside housing.

    i. One - "Dockable" transport dolly for moving breaker about outside its compartment.

    j. One -Electrical levering device.

38.05 BILLS OF MATERIAL

A. The metal-clad switchgear main incoming and utility metering sections shall include the following:

1. Aisleless Construction suitable for outdoor installation.

2. Rear access door. Rain shields over door entrances.

3. Externally-mounted filter covering vents to minimize dirt ingress and maintenance.

4. Grounded baseplate inside the termination compartment predrilled for mounting surge arrestors.

5. Lifting eyes for metering CTs.

6. Provisions for three fuses for power transformers.

7. 27 kV bushing wells with replaceable studs.

8. Bushing wells rated 600 Amperes.

9. Load break parking stands per ANSI C57.12.26-1987, Section 7.2.3 and Fixture 5.

10. Transparent, full-length, hot-stick operable, hinged and removable barrier (fiberglass reinforced polyester or equivalent) to comply with WAC 296-45-325, Table l.

11. Locking provision on the doors for a padlock shackle and penta headbolt as back-up protection.

12. Phase landing pads(two sets) predrilled for conductors and connections to surge arrestors.

13. Neutral Bushing.

14. Neutral pad. Copper pad predrilled and insulated for phase to ground voltage passing between termination compartment and the metering compartment.

15. Ground bus inside termination compartment, two separate locations.

16. Grounding horns(3) provided on each phase landing pad.

17. Vertically mounted unistrut brackets (2) on each side of termination compartment. Horizontal unistrut bracket(1) between vertical brackets for mounting adjustable cable support brackets.

18. Power Company Metering Panel Test Switch Cover Plate.

19. Thermostat.

20. Space heater.

21. Paint coating meeting requirements of ANSI C57.12.28.

22. Additional requirements as shown on Seattle City Light drawing SCL-401A.

23. Additional requirements as shown on the drawings.

B. The metal-clad switchgear auxiliary section for control and instrumentation shall include the following:

1. Aisleless Construction suitable for outdoor installation.

2. Front and rear access doors. Rain shields over door entrances.

3. Three (3) Line-to-ground voltage transformers. Standard accuracy

4. Three (3) Current transformers. Standard accuracy.

5. One-1000V A Single-phase control power transformer.

6. Power supply with auxiliary battery supply for vacuum circuit breaker operating mechanism

7. Reverse Power Relay (ANSI Standard Device 32) Basler Model BE3-32 Reverse Power Relay to monitor the direction of power. If current flow becomes reversed and exceeds the adjustable setting, the relay will trip.

8. Instantaneous Overcurrent, Time-Delay Overcurrent, Ground Fault relay (ANSI Standard Device 5 0/51, 51G).Basler Model BEI-50/518, Provided with external time delay control with adjustment from 20 ms to 2 seconds to provide overcurrent and ground fault protection.

9. One-Microprocessor-based metering system Schneider Electric Power Logix. See specification Section 16290.

10. Thermostat.

11. Space heater.

12. Receptacle

13. Additional requirements as shown on the drawings.

C. The metal-clad switchgear main circuit breaker section for control of the main circuit breaker shall include the following:

1. Aisleless Construction.

2. Breaker Cell, 27 kV, 600A - 25 kA.

3. Drawout power circuit breaker rated 600 amperes.

4. Hinged front and rear door.

5. Upper Sectionalizing Bus 600A.

6. Lower Vertical Bus 6004.

7. Upper Vertical Bus 600A.

8. 3-pt Latch with provision for padlock.

9. MOC switch 9 poles,

10. Breaker Control Switch, Electroswitch Series 2 4.

11. Light assembly, Quantity 2 (Red and Green).

12. Fuse protection for motor, close and trip circuits.

13. Fuse Blocks.

14. Thermostat.

15. Space heater.

16. Receptacle.

17. Current transformers, single ratio standard accuracy.

18. Power supply with battery backup.

19. Short circuit terminal block.

20. Device nameplate.

21. Accessories standard set.

22. Certified test report.

23. Additional requirements as shown on the drawings.

PART 39 Execution

39.01 INSTALLATION

A. Locations and Layout: Exact locations and physical layout of equipment and components may be varied as required to suit manufacturer's design and as approved, provided the required functions and operations are accomplished; follow the identification of the units indicated on Drawings exactly.

B. Anchor each switchgear section to at least two 4-inch, channel-iron floor sills arranged in accordance with manufacturer's written recommendations and IBC seismic requirements as amended by State of Washington, Attach by tack welding or bolting:

1. Sills: Select to suit equipment at assembly; level and grout flush into floor or concrete or mounting base.

2. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 2 inches in all directions beyond the maximum dimensions of the switchgear, unless otherwise indicated. Comply with Division 3, Section "Cast-in-Place Concrete".

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear and utility metering equipment.

D. The manufacturer shall provide at least two week’s notice to allow Seattle City Light and SPU representatives to inspect the metering cabinet during its manufacture, or prior to final delivery to site if requested. See Division 1 for details.

E. Comply with equipment installation requirements in NECA 1.

F. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extending rounding connections as required by utility company.

39.02 CONNECTIONS

A. Connect switchgear and utility metering equipment ground bus to ground grid as indicated on the drawings,

B. Refer to Division 16, Section16124, " Medium-Voltage Cable" for types of medium-voltage cable terminations.

C. Connect energy meter to external switch as identified on Contract documents, to permit Ethernet connection to Power monitoring network.

D. Tighten bus joint, connector, and terminal bolts according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and U L 4868:

1. Mark lugs after torquing with red paint such that paint will be visibly disturbed if lugs are disturbed.

39.03 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 16, Section 16075, “Electrical Identification".

B. Identify equipment name, designation, power source, source location and voltage rating.

C. Identify all devices, controls, and wiring.

D. Provide warning and caution signs where indicated or required by the Authority Having Jurisdiction.

E. Diagram and Instructions: Frame under clear acrylic plastic on the front of switchgear:

1. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.

2. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of the maintenance manual.

3. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

F. Provide identification of Utility Metering section in accordance with SCL requirements.

39.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Engage a factory-authorized service representative to assist in installation and start-up of the equipment. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. Testing Agency: SPU shall engage a qualified independent testing firm to perform field quality-control testing as specified in Division 16, "Acceptance Testing".

1. Electrical Contractor shall accompany the independent re sting firm field service technician and assist as required during field tests.

2. Electrical Contractor shall provide 1 week notice prior to testing and commissioning to ensure equipment is ready and prepared for Testing Agency testing and commissioning.

C. Manufacturer's Certification of proper installation is required.

39.05 FIELD TESTING

A. Equipment Supplier's Field Service Engineer is responsible for performing acceptance testing in accordance with Section 16950 "Acceptance Testing”

B. Contractor shall assist the Field Service Engineer during the testing period. Coordinate testing assistance with SPU’s Resident Engineer.

C. Perform the following field tests and inspections prior to acceptance testing:

1. Inspect accessible component for cleanliness, mechanical and electrical integrity, and damage or deterioration. Verify that temporary shipping bracing has been removed. Verify that no tools or loose parts are left in the equipment.

2. Inspect bolted electrical connections for completion and tightness.

3. Perform a ground resistance test.

4. Check the operation at interlocks and switch mechanism.

D. Infrared Testing:

1. Infrared Scanning: Perform an infrared scan of switchgear and utility metering equipment two weeks after Substantial Completion and before Final Acceptance. Installation Contractor shall make bus joints and connections accessible to a portable scanner. Scanning shall be performed during a period of normal working load as advised by SPU.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Use a scanner that is NIST traceable and furnish a certificate of NIST approval.

3. Record of Infrared Scanning: Prepare a certified report that identifies connections checked and describes scanning results. Include notation of deficiencies detected, remedial actions taken, and observations after remedial action.

39.06 ADJUSTING

A. Protective-Relay Settings:

1. A protective relay coordination study will be provided by a licensed Electrical Engineer in the State of Washington.

2. Verify that settings shown on Drawings are appropriate for final system configuration and parameters. Where discrepancies are found, recommend final relay settings for approval before making final adjustments.

3. The relays shall be set in the field by a qualified representative of the manufacturer retained by the Contractor, in accordance with settings designated in a coordinated study required elsewhere in the specifications.

B. Metering: Engage a certified integrator with 5 years of experience on SQ-D ION type meters to configure, program, test and commission the metering system.

C. Fuse Characteristics: Verify that fuse size and types shown on Drawings are appropriate for final system configuration and parameters. Where discrepancies are found, recommend fuse selection for approval before making final adjustments.

39.07 CLEANING

A. Inspect interior and exterior of installed switchgear and utility metering equipment. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

39.08 PROTECTION

A. Temporary Heating: Apply temporary heat to switchgear and utility metering equipment, according to manufacturer's written recommendations, throughout periods when environment is not controlled for temperature and humidity within manufacturers' stipulated service conditions.

39.09 DEMONSTRATION AND TRAINING

A. The Equipment Supplier shall provide a factory-authorized service representative to train SPU's maintenance personnel in the following:

1. In accordance with Division 1, Section 01820 "training" the equipment supplier's field service engineer shall train SPU's maintenance personnel on this equipment including procedures and schedules related t o startup and shutdown, troubleshooting, servicing, and preventive maintenance for two normal workdays at the jobsite.

2. Review data in the maintenance manuals. Refer to Division 1, Section 01780 "Operations and Maintenance".

3. Schedule training with SPU with at least seven days' advance notice

39.10 OPERATION AND MAINTENANCE MANUALS

A. Comply with Division 1, Section 01780 "Operation and Maintenance Data" and Part 1 of this specification.

B. Gather record drawings and as-furnished information for switchgear and utility metering equipment (including appurtenances) and generate an "integrated, unit-specific, operations and maintenance manual", complete with schematic diagrams of upstream/downstream systems feeding and being fed by this system:

1. Location of devices, PTs, CTs, relays, metering for this switchgear and utility metering equipment shall be clearly identified and the functions of each unit in the overall scheme explained.

2. A binder containing a collection of generic device cut sheets and disjointed O&M guidelines does not meet this requirement.

PART 40 Measurement and Payment

40.01 MEASUREMENT AND PAYMENT

A. No separate measurement or payment will be made for the Work required by this section. The cost for this portion of the Work will be considered incidental to, and included in the Contract Lump sum price, unless otherwise specified in the Construction Bidding Manual, Section 06, Accounting Procedures for specific Measurement and Payment requirements, Schedule of Values requirements, and the Contractor's Bid Form Subcontract A

End of Section 26 13 19

NOTE: THE BLUE NOTE TEXT WILL NOT APPEAR WHEN YOU PRINT THE DOCUMENT. DELETE THESE TAGS AND NARRATION BEFORE ISSUING THE SPECIFICATIONSUMMARY SHEET

Section name: MEDIUM-VOLTAGE VACUUM INTERRUPTER SWITCHGEAR

Section number: 26 13 19

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: May 2007

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other

standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

This specification was originally developed for the Morse Lake Power Supply Project.

PART 42 general

42.01 SCOPE OF WORK

A. Furnish and install the 5 kV and 26 kV elbow-connected, pad-mounted switchgear as shown on the Drawings and as specified herein.

B. Switchgear shall be furnished in accordance with Seattle City Light Standard Number U10-5.

C. Refer to SCL material standard number 2501.65 for SF6 switching requirements.

42.02 RELATED WORK

A. Equipment mounting hardware and seismic calculations shall conform to Section 26 05 33.

B. Concrete for equipment pad is included in City of Seattle Standard Specifications Division 6 (omitting all references to Division 1) and shall be in accordance with Seattle City Light Standard Number U10-5.2.

C. Grounding shall be in accordance with Seattle City Light Standard Number U10-5.2.

D. Delivery, Storage and Handling are included in Section 00 72 00.

E. Site preparation is included in City of Seattle Standard Specifications Division 2 (omitting all references to Division 1)

42.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 10, shop drawings and product data, for the following:

1. Equipment shop drawings showing elevation and plan views, compartment arrangement, dimensions, weight, shipping splits and metering layouts.

2. Single line diagrams, point to point compartment wiring diagrams for metering, relay and control circuits. Show wire and terminal numbers.

3. Bus material, ratings and insulation details.

4. Product data sheets and catalog numbers for circuit breakers and fused switches. List all options, trip adjustments and accessories furnished specifically for this project.

5. Itemized bill of material for metering, protective relays, accessories and control equipment.

B. Submit bound operating and maintenance manuals in accordance with the Section 00 72 00. Manuals shall include the following as a minimum:

1. A comprehensive index.

2. A complete "As Built" set of approved shop drawings.

3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.

4. Full specifications on each item.

5. System schematic drawings "As Built", illustrating all components, piping and electric connections of the systems supplied under this Section.

6. Detailed service, maintenance and operation instructions for each item supplied.

7. Special maintenance requirements particular to this switchgear shall be clearly defined, along with special calibration and test procedures.

8. The operating instructions shall also incorporate a functional description of the entire system, with references to the schematic drawings and instructions.

9. Complete parts list with stock numbers, including spare parts.

42.04 REFERENCE STANDARDS

A. Switchgear shall be designed, built, and tested in accordance with the latest editions and revisions of Seattle City Light Standard Number U10-5, NEMA, and Underwriters' Laboratories (UL). Switchgear shall also comply with any applicable ANSI and IEEE Standards and the requirements of the National Electric Code (NEC).

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

42.05 QUALITY ASSURANCE

A. The equipment furnished under this Section shall be the product of a manufacturer who has produced this same type of equipment for a period of at least 10 consecutive years.

B. The switchgear shall be designed, assembled and tested by the manufacturer of the circuit protective devices used in the switchgear.

42.06 MANUFACTURER’S SERVICES

A. The switchgear manufacturer shall furnish the services of a factory trained engineer that has complete knowledge of proper operation and maintenance of the equipment furnished under this Section. Services shall be provided for one working day to instruct the Owner on the operation and maintenance of the equipment. This instruction may be done at the same time as the inspection of the installation and field test run provided that: (1) the test is successful and (2) the operating and maintenance manuals have been previously furnished to and approved by the Engineer.

42.07 SYSTEM DESCRIPTION

A. Switchgear shall be as manufactured by S&C Electric Company or equal.

42.08 SPARE PARTS

A. Provide the following spare parts in the quantities specified:

1. One dozen each of cover bolts, spring nuts and door fasteners.

2. One quart of touch up paint.

B. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with manufacturers name, description and part number.

PART 43 PRODUCTS

43.01 RATINGS

A. Service: 5 kV and 26.4 kV, 3 Phase, 3 Wire, 60 Hz.

B. The switchgear and protective devices shall be fully rated for a short circuit current of 14,000 rms symmetrical amperes. Systems employing series connected ratings shall not be used. Main and feeder devices shall be coordinated for selective tripping.

43.02 CONSTRUCTION

A. Structure:

1. PME Series pad-mounted switchgear shall have elbow connected encased components and be free-standing, self supporting construction with provisions for cable entrance and exit through the bottom. Enclosures shall meet the requirements of ANSI C57.12.28 (enclosure integrity). Access to termination compartments shall be controlled by a latch mechanism (S&C Penta-Latch Mechanism) which provides automatic door latching and permits padlocking only when the door is securely latched. The door shall only be capable of being opened with a pentahead socket wrench or tool.

2. The enclosure roof shall be undercoated with an insulating no-drip compound. The bottom flange shall be gasketed to isolate it from the alkalinity of a concrete foundation. The component compartment floor shall consist of 22 gauge galvanized sheet steel to exclude foliage, animals and varmints. The entire enclosure shall be protected from corrosion with an olive green finish.

3. Switch terminals shall be equipped with 600 Amp bushing and fuse terminals shall be equipped with 200 Amp bushing wells. Bushing and bushing well interfaces shall be in accordance with ANSI/IEEE Standard 386 (ANSI Standard C119.2) to accept all standard separable insulated connectors and inserts. Parking stands shall be provided adjacent to each bushing and bushing well.

4. Grounding provisions suitable for use with separable insulated connectors and related accessories shall be located in each termination compartment.

5. Full length steel barriers shall separate adjoining termination compartments. Fuse components shall be completely encased in an inner grounded steel compartment. Fiberglass-reinforced polyester barriers shall be provided where required to achieve published BIL ratings.

6. Each fuse termination compartment door shall have an instruction manual holder and storage racks for spare fuse units, refill units or interrupting modules.

7. Three pole live switching of three-phase source circuits shall be accomplished through an external operating handle. A folding switch-operating handle shall be secured inside the switch-operating-hub pocket.

8. The main section shall also include a utility metering compartment. Metering compartment shall include CT bus bars, door with concealed hinges, 3 point catch and lock, handle seal, and top, bottom and rear barriers. Metering sequence and compartment shall conform to the requirements of the Seattle Public Utilities and shall be complete with all equipment required by the Power Co.

B. Main Circuit Protective Device:

1. Main disconnect switch shall be quick make/quick break, medium voltage, stationary type, manually operated fused high pressure contact switch with stored energy closing mechanism.

2. Main device shall be equipped with contacts for remote status and trip indication. Device rating shall be as shown on the Drawings.

3. Main device shall have line side at bottom.

C. Feeder Protective Devices:

1. Fuse handling mechanisms with mechanical interlock shall limit access to the fuse before opening the load break separable insulated connector at the fuse terminal. The fuse shall be accessible only when de-energized and isolated. Full-view non-load break disconnection and removal shall be possible with a shotgun stick.

2. Fuses shall be S & C Power Fuses Types SME-20. Sizes shall be as determined from the short circuit coordination study.

3. Single barrel current-limiting fuses shall be Westinghouse Type CXN. S & C fuse holders shall be Catalog Number 3122, 3122-A1, 3123, or 3123-A1 as required.

D. Wiring:

1. Low voltage instrument and control wiring shall be copper, Type SIS, flameproof switchboard wire identified with shrink on marker sleeves at each end. Low voltage wiring terminal blocks shall have marking strips and shall be mounted vertically in an accessible location. All terminal lugs shall be of the full loop type.

E. Marking and Identification:

1. Nameplates shall be provided on all doors for unit load description and for each control or indicating device. Nameplates shall be engraved as shown on the Drawing or as directed, using lettering approximately 3/8 in high for unit identification nameplates and 1/4 in high elsewhere. The nameplates shall be black and white laminated phenolic material. The engraving shall extend through the black exterior lamination to the white core. Nameplates shall be screw fastened.

2. A manufacturer's plaque shall be fastened to the front of the switchgear. The plaque shall indicate model number, serial number, amperes, volts, short circuit rating, etc.

3. Each switch shall be furnished with a sign marked "DANGER – HIGH VOLTAGE", “CALL BEFORE YOU DIG” and “Certified NON-PCB”. Install the switch number on the upper left corner of the switch door and compartment identifying letters on the outside of each switch compartment near the top of the door. Letters shall be 2-7/8 in high, 1/4 in stroke. Signs shall be adhesive backed reflective Mylar and OSHA approved.

PART 44 EXECUTION

44.01 INSTALLATION

A. Switch, shall be mounted on continuous 4 in structural steel channels furnished under this Section, set flush with the equipment pad and level in all directions. The switchgear shall be bolted to the channels with not less than 1/2 in bolts. Provide anchor bolts, shims and hardware in accordance with the details shown on the Drawings.

B. Installation shall be in accordance with the manufacturers' instructions.

C. Field wiring shall be grouped by circuit and tie wrapped. Terminations shall not be stressed.

44.02 FIELD TESTING

A. Make the following minimum tests and checks before energizing the equipment:

1. Megger terminals and buses at two times rated voltage, phase to phase and phase to ground after disconnecting devices sensitive to megger voltage.

2. Remove all current transformer shunts after completing secondary circuit.

3. Check all mechanical interlocks for proper operation.

4. Vacuum clean all interior equipment.

5. Adjust and test all switches for proper operation.

6. Submit megger test reports to Engineer for approval.

End of Section 26 13 19

SUMMARY SHEET

Section name: LOW-VOLTAGE TRANSFORMERS

Section number: 26 22 00

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

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PART 45 GENERAL

45.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions Specification Sections, apply to this Section.

45.02 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 225 kVA:

1. Distribution transformers.

45.03 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section 26 05 48, "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

45.04 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

45.05 COORDINATION

A. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 46 PRODUCTS

46.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; Schneider Electric.
2. ACME Electric Corporation; Power Distribution Products Division.
3. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
4. Eaton Electrical Inc.; Cutler-Hammer Products.
5. Siemens Energy & Automation, Inc.
6. Sola/Hevi-Duty.

46.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

46.03 TRANSFORMERS

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

B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Totally enclosed, nonventilated, NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Manufacturer’s standard.

F. Taps for Transformers Smaller Than 3 kVA: None.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

I. Wall Brackets: Manufacturer's standard brackets.

1. Fungus Proofing: Permanent fungicidal treatment for coil and core.

46.04 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with stainless steel screws. Nameplates and label products are specified in Division 26 Section 26 05 53 "Identification for Electrical Systems."

B. Source Quality Control

C. Test and inspect transformers according to IEEE C57.12.91.

PART 47 EXECUTION

47.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

47.02 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Division 26 Section 26 05 48, "Vibration and Seismic Controls for Electrical Systems.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions and requirements in Division 26 Section 26 05 48, "Vibration and Seismic Controls for Electrical Systems."

47.03 CONNECTIONS

A. Ground equipment according to Division 26 Section 26 05 26, "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

47.04 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.

3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

47.05 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

47.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

End of Section 26 22 00

SUMMARY SHEET

Section name: SWITCHBOARDS

Section number: 26 26 13

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

WARNING: The standards and guidelines being provided do not relieve the licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any

contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 48 GENERAL

48.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

48.02 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.

2. Transient voltage suppression devices.

3. Disconnecting and overcurrent protective devices.

4. Instrumentation.

5. Control power.

6. Accessory components and features.

7. Identification.

48.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to [**SEI/ASCE 7**] <**Insert requirement**>.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[**and the unit will be fully operational after the seismic event**]."

48.04 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Detail short-circuit current rating of switchboards and overcurrent protective devices.

5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.

6. Detail utility company's metering provisions with indication of approval by utility company.

7. Include evidence of NRTL listing for series rating of installed devices.

8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

10. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Qualification Data: For qualified [**Installer**] [**testing agency**].

D. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

48.05 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 891.

48.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and [install temporary electric heating (250 W per section)] to prevent condensation.

C. Handle and prepare switchboards for installation according to [**NECA 400**] [**NEMA PB 2.1**].

48.07 PROJECT CONDITIONS

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

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

   b. Altitude: Not exceeding 6600 feet (2000 m).

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet (2000 m).

D. Interruption of Existing Electric Service: Do not interrupt electric service to SPU facilities unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than [**seven**] <**Insert number**> days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Construction Manager's written permission.

4. Comply with NFPA 70E.

48.08 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

48.09 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 49 PRODUCTS

49.01 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. Square D; a brand of Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

4. Siemens Energy & Automation, Inc.

5. <**Insert manufacturer's name**>.

C. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: [**Panel**] [**Fixed, individually**] mounted.

2. Branch Devices: Panel mounted.

3. Sections front and rear aligned.

D. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.

2. Branch Devices: Panel mounted.

3. Sections front and rear aligned.

E. Front- and Rear-Accessible Switchboards:

1. Main Devices: [**Fixed, individually**] [**Drawout**] mounted.

2. Branch Devices: [**Panel**] [**Fixed, individually**] [**Panel and fixed, individually**] [**Fixed and individually compartmented**] [**Individually compartmented and drawout**] mounted.

3. Sections [**front and rear**] aligned.

F. Nominal System Voltage: [480Y/277 V] [208Y/120 V] <Insert system voltage>.

G. Main-Bus Continuous: [**5000**] [**4000**] [**3000**] [**2500**] [**2000**] [**1600**] [**1200**] <**Insert ampere rating**> A.

H. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

I. Indoor Enclosures: Steel, NEMA 250, [**Type 1**] [**Type 5**].

J. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's [**standard gray**] [**custom color**] finish over a rust-inhibiting primer on treated metal surface.

K. Outdoor Enclosures: [Type 3R].

1. Finish: Factory-applied finish in manufacturer's [**standard**] [**custom**] color; undersurfaces treated with corrosion-resistant undercoating.

2. Enclosure: [**Flat**] roof; [**bolt-on rear covers**] for each section, with provisions for padlocking.

3. Doors: Personnel door at each end of aisle, minimum width of [**30 inches (762 mm)**] <**Insert value**>; opening outwards; with panic hardware and provisions for [**padlocking**] [**cylinder lock**].

4. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.

5. Walk-in Aisle Heating and Ventilating:

a. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of [**40 deg F (5 deg C)**] <**Insert temperature**> with outside design temperature of [**104 deg F (40 deg C)**] <**Insert temperature**>.

b. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of [**100 deg F (38 deg C)**] with outside design temperature of [**23 deg F (minus 5 deg C)**].

c. Ventilating openings[complete with replaceable fiberglass air filters].

d. Thermostat: Single stage; wired to control heat and exhaust fan.

6. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer within the switchboard. Supply voltage shall be [**120/240**].

7. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.

L. Barriers: Between adjacent switchboard sections.

M. Insulation and isolation for [**main bus of main section and**] main and vertical buses of feeder sections.

N. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: [Thermostats to maintain temperature of each section above expected dew point].

2. Space-Heater Power Source: [Transformer, factory installed in switchboard] [120-V external branch circuit].

O. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

P. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.[**Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.**]

Q. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

R. Removable, Hinged Rear Doors and Compartment Covers: Secured by [**standard bolts**], for access to rear interior of switchboard.

S. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

T. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.

2. Set back from front to clear circuit-breaker removal mechanism.

3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.

4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.

5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

U. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, with tin-plated aluminum or copper feeder circuit-breaker line connections.

2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with [**mechanical**] [**compression**] connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.

3. Ground Bus: [**1/4-by-2-inch- (6-by-50-mm-)**] [**Minimum-size required by UL 891,**] hard-drawn copper of 98 percent conductivity, equipped with [**mechanical**] connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.

5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with [**mechanical**] [**compression**] connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

V. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

W. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

X. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

49.02 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <**Insert manufacturer's name; product name or designation**> or comparable product by one of the following:

1. Square D; a brand of Schneider Electric.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Siemens Energy & Automation, Inc.
5. <**Insert manufacturer's name**>.

C. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, [**wired-in**] [**plug-in**] [**bolt-on**], solid-state, parallel-connected, [**modular (with field-replaceable modules)**] type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch.
4. Redundant suppression circuits.
5. Redundant replaceable modules.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
10. [**Six**]-digit, transient-event counter set to totalize transient surges.

D. Peak Single-Impulse Surge Current Rating: [160 kA per mode/320 kA per phase].

E. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

F. Protection modes and UL 1449 SVR for grounded wye circuits with [**480Y/277**] [**208Y/120**]-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: [800 V for 480Y/277] [400 V for 208Y/120].

2. Line to Ground: [800 V for 480Y/277] [400 V for 208Y/120].

3. Neutral to Ground: [800 V for 480Y/277] [400 V for 208Y/120].

G. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

1. Line to Neutral: 400 V, 800 V from high leg.

2. Line to Ground: 400 V.

3. Neutral to Ground: 400 V.

H. Protection modes and UL 1449 SVR for 240-, 480-, three-phase, three-wire, delta circuits shall be as follows:

1. Line to Line: [2000 V for 480 V] [1000 V for 240 V].

2. Line to Ground: [1500 V for 480 V] [800 V for 240 V].

49.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with [**series-connected rating**] [**interrupting capacity**] to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.

b. Long- and short-time pickup levels.

c. Long- and short-time time adjustments.

d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.

6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.

    b. Lugs: [**Mechanical**] style, suitable for number, size, trip ratings, and conductor material.

    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

    d. Ground-Fault Protection: [**Integrally mounted**] relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

    f. Communication Capability: [**Din-rail-mounted**] communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [**55**] [**75**] percent of rated voltage.

    h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

    i. Auxiliary Contacts: [**One SPDT switch**] [**Two SPDT switches**] with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

    j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): [**80**] [**100**] percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. [**Fixed**] [**Drawout**] circuit-breaker mounting.

2. Two-step, stored-energy closing.

3. [**Standard**] [**Full**]-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

   a. Instantaneous trip.

   b. Long- and short-time time adjustments.

   c. Ground-fault pickup level, time delay, and I^2t response.

   d. <Insert settings>.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

5. Remote trip indication and control.

6. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

8. Control Voltage: [40-V dc] [125-V dc] [250-V dc] [120-V ac].

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

   a. Square D; a brand of Schneider Electric.

   b. Boltswitch, Inc.

   c. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

   d. Pringle Electrical Manufacturing Company, Inc.

   e. Siemens Energy & Automation, Inc.

   f. <Insert manufacturer's name>.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.

3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

    a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

    b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.

5. Service-Rated Switches: Labeled for use as service equipment.

6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

    a. Configuration: [**Integrally mounted**] [**Remote-mounted**] relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

    b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.

    c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.

    d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.

1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

    a. Square D.

    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.

3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.

5. Service-Rated Switches: Labeled for use as service equipment.

6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

a. Configuration: [**Integrally mounted**] [**Remote-mounted**] relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.

c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.

d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

E. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

F. Fuses are specified in Division 26 Section "Fuses."

49.04 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, [**single**] [**tapped**] [**double**] secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.

2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; [**wound**] [**bushing**] [**bar or window**] type; [**single**] [**double**] secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 1 percent.

b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.

c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.

d. Megawatts: Plus or minus 2 percent.

e. Megavars: Plus or minus 2 percent.

f. Power Factor: Plus or minus 2 percent.

g. Frequency: Plus or minus 0.5 percent.

h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.

i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.

j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.

1. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.

2. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

D. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.

2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

F. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.

2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.

3. Suitable for connection to three- and four-wire circuits.

4. Potential indicating lamps.

5. Adjustments for light and full load, phase balance, and power factor.

6. Four-dial clock register.

7. Integral demand indicator.

8. Contact devices to operate remote impulse-totalizing demand meter.

9. Ratchets to prevent reverse rotation.

10. Removable meter with drawout test plug.

11. Semiflush mounted case with matching cover.

12. Appropriate multiplier tag.

G. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.

2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.

3. Cyclometer.

4. Four-dial, totalizing kilowatt-hour register.

5. Positive chart drive mechanism.

6. Capillary pen holding a minimum of one month's ink supply.

7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.

8. Capable of indicating and recording [**five**] [**15**] [**30**] <**Insert time period**>-minute integrated demand of totalized system.

49.05 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Control Circuits: <**Insert control voltage**>-V dc.

D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

49.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

49.07 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 50 EXECUTION

50.01 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to [**NECA 400**] [**NEMA PB 2.1**].

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

50.02 INSTALLATION

A. Install switchboards and accessories according to [**NECA 400**] [**NEMA PB 2.1**].

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "[**Cast-in-Place Concrete**] [**Miscellaneous Cast-in-Place Concrete**]."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

50.03 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

50.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

50.05 FIELD QUALITY CONTROL

A. Testing Agency: [**SPU will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove [**front**] [**front and rear**] panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Switchboard will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

50.06 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges [as indicated.] [as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."]

50.07 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

50.08 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] SPU's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories[**, and to use and reprogram microprocessor-based trip, monitoring, and communication units**].

End of Section 26 24 13

SUMMARY SHEET

Section name: PANELBOARDS

Section number: 26 24 16

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted in SPU Contracts style

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 51 GENERAL

51.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions Specification Sections, apply to this Section.

51.02 SUMMARY

A. A. Section Includes:

1. Distribution panelboards.

2. Lighting and appliance branch-circuit panelboards.

51.03 DEFINITIONS

A. The following standard acronyms are used throughout the Bid Documents:

1. SVR: Suppressed voltage rating.

2. SPD: Surge Protection Device.

51.04 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

51.05 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Short-circuit current rating of panelboards and overcurrent protective devices.

5. Include evidence of NRTL listing for series rating of installed devices.

6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

7. Include wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 **Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."** Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field Quality-Control Reports:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Panelboard Schedules: Submit final versions after load balancing in both printed and electronic format.

F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in **Section 00 72 00,** include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

51.06 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. NEC requires a minimum 36-in workspace in front of panel.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Delivery, Storage, And Handling

G. Handle and prepare panelboards for installation according to NECA 407.

51.07 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 0 deg F to plus 104 deg F.

b. Altitude: Not exceeding 6,600-ft.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6,600-ft.

3. Comply with NFPA 70E.

51.08 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

51.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

51.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.

2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

PART 52 PRODUCTS

52.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 **Section 26 05 48, "Vibration and Seismic Controls for Electrical Systems."**

B. Enclosures: Surface-Mounted Cabinets:

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.

5. Finishes:

a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

b. Back Boxes: Same finish as panels and trim.

c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

C. Incoming Mains Location: Bottom

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Main and Neutral Lugs: Mechanical type.

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

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals but in no case less than 22,000AIC.

52.02 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; a brand of Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

1. Doors: Secured with vault-type latch with tumbler lock; keyed alike. Select one of first two options in first paragraph below for panelboards with main overcurrent protective devices; select third option for panelboards with only main lugs for the incoming feeder. Consult manufacturers for limitations on ratings for each type of device selected.

C. Mains: Circuit breaker.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

52.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; a brand of Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Siemens Energy & Automation, Inc.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity rating to meet available fault currents but not less than 22,000AIC.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger with let-through ratings less than NEMA FU 1, RK-5.

2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.

   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

   c. Application Listing: Appropriate for application, Type SWD for switching fluorescent lighting loads and Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

4. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

52.04 PANELBOARD SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D; a brand of Schneider Electric.

2. Current Technology; a subsidiary of Danahar Corporation.

3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

4. Liebert Corporation.

5. Siemens Energy & Automation, Inc.

B. Surge Protection Device: IEEE C62.41-compliant, external mounted only, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

2. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.

   a. Line to Neutral: 70,000A.

   b. Line to Ground: 70,000A.

   c. Neutral to Ground: 50,000A.

3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:

   a. Line to Neutral: 800 V for 480Y/277.

   b. Line to Ground: 800 V for 480Y/277

   c. Neutral to Ground: 800 V for 480Y/277.

5. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:

   a. Line to Neutral: 400 V.

   b. Line to Ground: 400 V.

   c. Neutral to Ground: 400 V.

PART 53 EXECUTION

53.01 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NECA 407.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

53.02 INSTALLATION

A. Install panelboards and accessories according to NECA 407.

B. Install anchor bolts to elevations required for proper attachment to panelboards.

C. Attach panelboard to the vertical finished or structural surface behind the panelboard.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

E. Comply with mounting and anchoring requirements specified in Division 26 **Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."**

F. Mount panelboard per NEC height requirements.

G. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

H. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

I. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

J. Comply with NECA 1.

53.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 **Section 26 05 53, "Identification for Electrical Systems."**

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in **Division 26 Section 26 05 53 "Identification for Electrical Systems."**

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 **Section 26 05 53 "Identification for Electrical Systems."**

53.04 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

B. Panelboards will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Legibly print name, sign, and date each sheet before submitting to construction manager.

53.05 ADJUSTING

A. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

53.06 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

End of Section 26 24 16

SUMMARY SHEET

Section name: MOTOR CONTROL CENTERS

Section number: 26 24 19

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	101/30/09	Entire document formatted in SPU Contracts style

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PART 54 GENERAL

54.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

54.02 SUMMARY

A. This Section includes motor-control centers for use on ac circuits rated 600 V and less.

B. Related Sections include the following:

54.03 SUBMITTALS

A. Product Data: For each type of controller and each type of motor-control center. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each motor-control center.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.

   b. Nameplate legends.

   c. Short-circuit current ratings of buses and installed units.

   d. Vertical and horizontal bus capacities.

e. UL listing for series rating of overcurrent protective devices in combination controllers.

f. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for class and type of motor-control center. Provide schematic wiring diagram for each type of controller.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around motor-control centers where pipe and ducts are prohibited. Show motor-control center layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that motor-control centers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For manufacturer.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For motor-control centers, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for motor-control centers and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

54.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain motor-control centers and controllers of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for motor-control centers, including clearances between motor-control centers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

54.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver motor-control centers in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Handle motor-control centers according to the following:

1. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."

2. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."

54.06 COORDINATION

A. Coordinate layout and installation of motor-control centers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of motor-control centers, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each motor-control center, each controller, and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 55 PRODUCTS

55.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D.

2. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

3. Eaton Corporation; Cutler-Hammer Products.

4. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.

5. Siemens/Furnas Controls.

55.02 MOTOR-CONTROL CENTERS

A. Wiring: NEMA ICS 3, Class I, Type A.

B. Enclosures: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.

2. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners. Interlocks on combination controller units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.

3. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in motor-control center; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

4. Wiring Spaces: Wiring channel in each vertical section for vertical and horizontal wiring to each unit compartment; supports to hold wiring in place.

C. Short-Circuit Current Rating for Each Section: Equal to or greater than indicated available fault current in symmetrical amperes at motor-control center location but in no case less than 22,000A.

55.03 BUSES

A. Material: Plated hard-drawn copper, 98 percent conductivity.

B. Ampacity Ratings: As indicated for horizontal and vertical main buses.

C. Neutral Buses: Half size, neutral pad, or none.

D. Equipment Ground Bus: Noninsulated, horizontal configuration; adequate for equipment ground conductors; bonded to enclosure.

E. Horizontal Bus Arrangement: Main phase, neutral and ground buses extended with same capacity the entire length of motor-control center, with provision for future extension at both ends by bolt holes and captive bus splice sections or equivalent.

F. Short-Circuit Withstand Rating: Same as short-circuit current rating of section, but in no case less than 22,000A.

55.04 FUNCTIONAL FEATURES

A. Description: Modular arrangement of controllers, control devices, overcurrent protective devices, transformers, panelboards, instruments, indicating panels, blank panels, and other items mounted in compartments of motor-control center.

B. Controller Units: Combination controller units of types and with features, ratings, and circuit assignments indicated.

1. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

2. Provide units with short-circuit current ratings equal to or greater than short-circuit current rating of motor-control center section.

3. Equip units in Type B and Type C motor-control centers with pull-apart terminal strips or drawout terminal boards for external control connections.

4. Controller Disconnecting Means: Factory-assembled combination disconnect and controller.

a. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

C. Overcurrent Protective Devices: Individual feeder-tap units through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

D. Transient Voltage Surge Suppressors: Connect to motor-control center bus.

E. Spaces and Blank Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.

F. Spare Units: Type, sizes, and ratings indicated; installed in compartments indicated "spare."

55.05 ACROSS-THE-LINE CONTROLLERS

A. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. When control power is from the control transformer, one side of the secondary shall be grounded.

2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

55.06 REDUCED-VOLTAGE CONTROLLERS

A. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.

2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

3. LED indicators showing motor and control status, including the following conditions:

a. Control power available.

b. Controller on.

c. Overload trip.

d. Loss of phase.

e. Shorted silicon-controlled rectifier.

4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.

5. Motor running contactor operating automatically when full voltage is applied to motor.

55.07 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, pulse-width-modulated, variable frequency controller; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of [**standard**] [**premium**]-efficiency motor as defined by NEMA MG 1.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Isolation Transformer: Match transformer voltage ratings and capacity to system and motor voltages; and controller, motor, and load characteristics.

D. Output Rating: 3-phase; 6 to [60 Hz, with voltage proportional to frequency throughout voltage range] [66 Hz, with torque constant as speed changes] [120 Hz, with horsepower constant throughout speed range].

E. Unit Operating Requirements:

1. Input ac voltage tolerance of [208 V, plus or minus 5] [380 to 500 V, plus or minus 10] [525 to 575 V, plus or minus 10] percent.

2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

3. Minimum Efficiency: 96 percent at 60 Hz, full load.

4. Minimum Displacement Primary-Side Power Factor: 96 percent.

5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus or minus 1 percent.

8. Ambient Temperature: 0 to 40 deg C.

F. Isolated control interface allows controller to follow control signal over an 11:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V.

2. Pneumatic Signal: 3 to 15 psig (20 to 104 kPa).

G. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 2 to a minimum of 22 seconds.

4. Deceleration: 2 to minimum of 22 seconds.

5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

H. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors.

2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

3. Motor Overload Relay: Adjustable and capable of NEMA 250, Class [**10**] [**20**] [**30**] performance.

4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

5. Instantaneous line-to-line and line-to-ground overcurrent trips.

6. Loss-of-phase protection.

7. Reverse-phase protection.

8. Short-circuit protection.

9. Motor overtemperature fault.

I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Restarting during deceleration shall not damage controller, motor, or load.

K. Power-Interruption Protection: Prevents motor from re-energizing after a power interruption until motor has stopped.

L. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.

2. Run.

3. Overvoltage.

4. Line fault.

5. Overcurrent.

6. External fault.

M. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

N. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate controller output current, voltage, and frequency.

O. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected.

P. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

Q. Integral Disconnecting Means: [NEMA AB 1, instantaneous-trip circuit breaker] [NEMA AB 1, molded-case switch] [NEMA KS 1, nonfusible switch] [NEMA KS 1, fusible switch] with lockable handle.

R. Isolating Switch: Non-load-break switch arranged to isolate variable frequency controller and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

S. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

55.08 FEEDER OVERCURRENT PROTECTION

A. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

1. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.

55.09 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.

F. Meters: If shown on the drawings, include a digital power meter with concurrent display of six values, volts, amps, etc; min/max and fault memory; and Ethernet connection.

1. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door or in JIC box adjacent to unit.

G. Phase-Failure and Undervoltage Relays for Bypass Controllers: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

55.10 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested, motor-control centers before shipping.

PART 56 EXECUTION

56.01 EXAMINATION

A. Examine areas and surfaces to receive motor-control centers for compliance with requirements, installation tolerances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

56.02 APPLICATIONS

A. Select features of each controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

56.03 INSTALLATION

A. Anchor each motor-control center assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with motor-control center mounting surface.

B. Install motor-control centers on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section 26 05 48, "Vibration and Seismic Controls for Electrical Systems."

56.04 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

56.05 IDENTIFICATION

A. Identify motor-control center, motor-control center components, and control wiring according to Division 26 Section 26 05 53, "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for motor-control centers, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of motor-control centers.

56.06 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

56.07 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

56.08 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each motor-control center element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except for optional tests, stated in NETA ATS "Motor Control Centers." Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

56.09 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

56.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain components of motor-control centers including any solid-state controllers. Refer to Division 01 Section "Demonstration and Training."

End of Section 26 24 19

SUMMARY SHEET

Section name: ENCLOSED BUS ASSEMBLIES

Section number: 26 25 00

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted in SPU Contracts style

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other

standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 57 GENERAL

57.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

57.02 SUMMARY

A. This Section includes the following:

1. Feeder-bus assemblies.

2. Plug-in bus assemblies.

3. Bus plug-in devices.

57.03 DEFINITIONS

A. TVSS: Transient voltage surge suppressor.

57.04 SUBMITTALS

A. Shop Drawings: For each type of [**bus assembly**] [**and plug-in device**].

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.

2. Show fittings, materials, fabrication, and installation methods for [**listed fire-stop barriers**] [**and**] [**weather barriers**].

3. Indicate required clearances, method of field assembly, and location and size of each field connection.

4. Detail connections to switchgear, switchboards, transformers, and panelboards.

5. Wiring Diagrams: Power[and signal] [and control] [, signal, and control] wiring.

6. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting seismic restraints.

b. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

B. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.

2. Clearances for access above and to the side of enclosed bus assemblies.

3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.

4. Support locations, type of support, and weight on each support.

C. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.

D. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.

E. Manufacturer Seismic Qualification Certification: Submit certification that enclosed bus assemblies,[**plug-in devices,**] accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data: For [professional engineer] [and] [testing agency].

G. Field quality-control test reports.

H. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

57.05 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the

InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

C. Source Limitations: Obtain enclosed bus assemblies[**and plug-in devices**] through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA BU 1, "Busways."

F. Comply with NFPA 70.

57.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

57.07 PROJECT CONDITIONS

A. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding [**122 deg F (50 deg C)**] [**140 deg F (60 deg C)**] <**Insert ambient temperature**>.

57.08 COORDINATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 03.

57.09 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Plug-in Units: [**10**] <**Insert number**> percent of amount installed[**for each size indicated**], but no fewer than <**Insert number**> unit(s).

PART 58 PRODUCTS

58.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Products.

3. General Electric Company; Electrical Distribution & Control Division.

4. Siemens Energy & Automation, Inc.

58.02 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.

1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure

2. Voltage: [120/208] [240] [480] [277/480] V; 3 phase; [100] [200] [percent neutral capacity].

3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.

4. Bus Materials: Current-carrying [**copper**] [**aluminum**] conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.

5. Ground:

a. 50 percent capacity integral with housing.

b. 50 percent capacity internal bus bars of material matching bus material.

c. 50 percent capacity isolated, internal bus bar of material matching bus material.

6. Enclosure: [Steel with manufacturer's standard finish] [Aluminum with manufacturer's standard finish] [Weatherproof, steel or aluminum with manufacturer's standard finish, sealed seams, drains, and removable closures].

7. Fittings and Accessories: Manufacturer's standard.

8. Mounting: Arranged flat, edgewise, or vertically without derating.

B. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.

1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for switchboards with reinforcement strong enough to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure.

2. Voltage: [120/208] [240] [480] [277/480] V; 3 phase; [100] [200] [percent neutral capacity].

3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.

4. Bus Materials: Current-carrying [**copper**] [**aluminum**] conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.

5. Ground:

a. 50 percent capacity integral with housing.

b. 50 percent capacity internal bus bar of material matching bus material.

c. 50 percent capacity isolated, internal bus bar of material matching bus material.

6. Enclosure: [Steel, with manufacturer's standard finish, plug-in openings **24 inches (610 mm)** o.c., and hinged covers over unused openings] [Aluminum, with manufacturer's standard finish, plug-in openings **24 inches (610 mm)** o.c., and hinged covers over unused openings].

7. Fittings and Accessories: Manufacturer's standard.

8. Mounting: Arranged flat, edgewise, or vertically without derating.

58.03 PLUG-IN DEVICES

A. Fusible Switches: NEMA KS 1, heavy duty; with [**R-type rejection**] [**J-type**] [**L-type**] fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. See Division 26 Section "Fuses" for fuses and fuse installation requirements.

B. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.

C. TVSS: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate TVSS from busway. TVSS product and installation requirements are specified in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."

D. Motor Controllers: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from [**integral control power transformer**] <**Insert source of control power**> with a control power [**transformer**] [**source**] of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

2. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.

a. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with [**R-type rejection**] [**J-type**] fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction. See Division 26 Section "Fuses" for fuses and fuse installation requirements.

b. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.

c. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

3. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, [**Class 10**] [**Class 20**] [**Class 30**] tripping characteristic. Overload relays shall have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

4. Adjustable Overload Relay: Dipswitch selected for motor running overload protection with NEMA ICS 2, [**Class 10**] [**Class 20**] [**Class 30**] tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Adjustable overload relays shall have Class II ground-fault protection with start and run delays to prevent nuisance trip on starting.

E. Multispeed Motor Controllers: Match controller to motor type, application, and number of speeds; include the following accessories:

1. Compelling relay ensures motor starts only at low speed.

2. Accelerating relay ensures properly timed acceleration through speeds lower than that selected.

3. Decelerating relay ensures automatically timed deceleration through each speed.

F. Accessories: Hookstick operator, adjustable to maximum extension of [**14 feet (4.3 m)**] <**Insert dimension**>.

PART 59 EXECUTION

59.01 INSTALLATION

A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

2. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.

3. Support bus assembly to prevent twisting from eccentric loading.

4. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.

5. Fasten supports securely to building structure according to Division 26 Section "Hangers and Supports for Electrical Systems."

B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

C. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Section "Penetration Firestopping."

D. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Division 07 Section "Joint Sealants" for materials and application.

E. Install a concrete curb at least 3 inches (75 mm) high around bus-assembly floor penetrations.

F. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

G. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

H. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

59.02 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

59.03 FIELD QUALITY CONTROL

A. Testing Agency: [**SPU will engage**] [**Engage**] a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests and inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of bus assembly including joints and plug-in units.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Substantial Completion.

3. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

59.04 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges[**and overload relay trip settings**] as indicated.

59.05 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

59.06 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

End of Section 26 25 00
SUMMARY SHEET

Section name: WIRING DEVICES

Section number: 26 27 26

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

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This section should be edited and issued with almost all construction projects. It includes light switches, receptacles and control stations. It is a good place to put odd hardware that comes up as the job develops.

PART 60 GENERAL

60.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions Specification Sections, apply to this Section.

60.02 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.

2. Snap switches.

3. Control stations.

60.03 DEFINITIONS

A. The following standard acronyms are used throughout the Bid Documents:

1. GFCI: Ground-fault circuit interrupter.

60.04 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

60.05 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

PART 61 PRODUCTS

61.01 LIGHT SWITCH AND RECEPTACLE MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).

2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

3. Leviton Mfg. Company Inc. (Leviton).

4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

61.02 STRAIGHT BLADE RECEPTACLES

A. A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; 5351 (single), 5352 (duplex).

b. Hubbell; HBL5351 (single), CR5352 (duplex).

c. Leviton; 5891 (single), 5352 (duplex).

d. Pass & Seymour; 5381 (single), 5352 (duplex).

61.03 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; GF20.

b. Pass & Seymour; 2084.

61.04 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).

b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).

c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).

d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).

61.05 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Unfinished Spaces: Cast cover to match cast box required in **Section 26 05 33.**

61.06 CONTROL STATIONS

A. Heavy duty oil tight 30mm operators with NO/NC contact blocks in cast hub-type boxes.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

a. Square D / Sneider Electric

b. Eaton Corp / Cutler-Hammer

c. Siemens

d. Allen-Bradley

PART 62 EXECUTION

62.01 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Existing Conductors:

   a. Cut back and pigtail, or replace all damaged conductors.

   b. Straighten conductors that remain and remove corrosion and foreign matter.

   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

C. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6-in in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.

7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.

8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

10. Devices shall be securely mounted to outlet box or mud ring in a tight manner. Loose outlet shall be shimmed with approved shims to prevent the well plate from breaking.

62.02 IDENTIFICATION

A. Comply with Division 26 Section 26 05 53 "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

62.03 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instrument: Similar to Ideal Suretest 61-164 or Fluke 87.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.

2. Percent Voltage Drop under 15-A Load: A value of 3 percent or higher is not acceptable.

3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943 (5 mA maximum).

5. Using the test plug, verify that the device and its outlet box are securely mounted.

C. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

End of Section 26 27 26

SUMMARY SHEET

Section name: FUSES

Section number: 26 28 13

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines

Revision #	Date	Paragraph(s) revised

1	10/30/09	Insert

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 63 GENERAL

63.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions Specification Sections, apply to this Section.

63.02 SUMMARY

A. This Section includes the following:

1. Cartridge fuses rated 600 V and less for use in switches.

63.03 SUBMITTALS

A. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

2. Let-through current curves for fuses with current-limiting characteristics.

3. Time-current curves, coordination charts and tables, and related data.

4. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in **Section 00 72 00,** include the following:

a. Let-through current curves for fuses with current-limiting characteristics.

b. Time-current curves, coordination charts and tables, and related data.

c. Ambient temperature adjustment information.

63.04 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

63.05 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 0 degrees F or more than 104 degrees F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

63.06 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

63.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Quantity equal to 10 percent of each fuse type and size, but no fewer than 3 of each type and size.

PART 64 PRODUCTS

64.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Bussman, Inc.

2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.

3. Ferraz Shawmut, Inc.

4. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

64.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 65 EXECUTION

65.01 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

65.02 FUSE APPLICATIONS

A. Feeders: Class RK1, time delay.

B. Motor Branch Circuits: Class RK1, time delay.

C. Other Branch Circuits: Class RK1, time delay.

65.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

65.04 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

End of Section 26 28 13

SUMMARY SHEET

Section name: ENCLOSED SWITCHES AND CIRCUIT BREAKERS

Section number: 26 28 16

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contract style

PART 66 GENERAL

66.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions Specification Sections, apply to this Section.

66.02 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers.
4. Enclosures.
5. Manual transfer switches for generator use are in **Section 26 13 13**.

66.03 DEFINITIONS

A. The following standard acronyms are used throughout the Bid Documents:

1. GD: General duty.
2. GFCI: Ground-fault circuit interrupter.
3. HD: Heavy duty.
4. RMS: Root mean square.
5. SPDT: Single pole, double throw.

66.04 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current rating.
4. UL listing for series rating of installed devices.

5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

B. Shop Drawings: Diagram for power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosed switches and circuit breakers, accessories, and components will withstand seismic forces defined in Division 26 **Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems"** Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control test reports including the following:

1. Test procedures used.

2. Test results that comply with requirements.

E. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in **Section 00 72 00**, include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

2. Time-current curves, including selectable ranges for each type of circuit breaker.

66.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and

adjacent surfaces and other items. NEC requires 30-in wide clear space in front of device for service.

66.06 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not less than 0 deg F and not exceeding 104 deg F.

2. Altitude: Not exceeding 6,600-ft.

66.07 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 67 PRODUCTS

67.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

67.02 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:

1. Square D/Group Schneider.

2. Eaton Corporation; Cutler-Hammer Products.

3. General Electric Co.; Electrical Distribution & Control Division.

4. Siemens Energy & Automation, Inc.

B. Fusible Switch, 600A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

1. Fuses installed shall meet the fuse requirements listed in **Section 26 28 13.**

C. Nonfusible Switch, 600A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

67.03 ACCESSORIES:

A. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

67.04 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.

2. General Electric Co.; Electrical Distribution & Control Division.

3. Moeller Electric Corporation.

4. Siemens Energy & Automation, Inc.

5. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.

2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.

3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

67.05 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R.

2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

PART 68 EXECUTION

68.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

68.02 INSTALLATION

A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

B. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

C. Comply with mounting and anchoring requirements specified in Division 26 **Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."**

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

68.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 **Section 26 05 53 "Identification for Electrical Systems."** An arc-flash warning label is required on every stand-alone disconnect switch or circuit breaker.

B. Enclosure Nameplates: Label each enclosure with laminated-plastic nameplate as specified in Division 26 Section **26 05 53 "Identification for Electrical Systems."**

68.04 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:

1. Inspect mechanical and electrical connections.

2. Verify switch and relay type and labeling verification.

3. Verify rating of installed fuses.

B. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification. perform the following field tests and inspections and prepare test reports:

C. Perform the following field tests and inspections and prepare test reports:

1. Test mounting and anchorage devices according to requirements in Division 26 **Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."**

2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Infrared Scanning:

   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.

   b. Follow-Up Infrared Scanning: Perform an additional follow-up infrared scan of each unit 11 months after date of Substantial Completion.

   c. Instruments, Equipment and Reports:

      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

      2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

68.05 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

68.06 CLEANING

A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.

B. Inspect exposed surfaces and repair damaged finishes.

End of Section 26 28 16

SUMMARY SHEET

Section name: ENCLOSED CONTROLLERS

Section number: 26 29 13

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

PART 69 GENERAL

69.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

69.02 SUMMARY

A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:

1. Across-the-line, manual and magnetic controllers:full voltage non-reversing (FVNR).

2. Reduced-voltage solid-state controllers (RVSS).

3. Variable frequency controllers are specified in Section 26 29 23.

69.03 SUBMITTALS

A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each enclosed controller.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.

b. Nameplate legends.

c. Short-circuit current rating of integrated unit.

d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical components and adjacent structural and mechanical

elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosed controllers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

F. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

69.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100-miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. NEC requires 30-in wide free space in front of starters for maintenance.

69.05 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

69.06 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

69.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.

2. Indicating Lights: Two of each type installed.

PART 70 PRODUCTS

70.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D/Sneider Electric.

2. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

3. Eaton Corporation; Cutler-Hammer Products.

4. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.

5. Siemens/Furnas Controls.

70.02 ACROSS-THE-LINE ENCLOSED CONTROLLERS

A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from integral control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.

1. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

70.03 REDUCED-VOLTAGE SOLID-STATE ENCLOSED CONTROLLERS

A. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.

2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

3. LED indicators showing motor and control status, including the following conditions:

    a. Control power available.

    b. Controller on.

    c. Overload trip.

    d. Loss of phase.

    e. Shorted silicon-controlled rectifier.

4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.

5. Motor running contactor operating automatically when full voltage is applied to motor.

70.04 ENCLOSURES

A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.

2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

3. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

70.05 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Buttons, Pilot Lights, and Selector Switches: NEMA ICS 2, 30-mm, heavy-duty type.

C. Stop Push-Button

70.06 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 71 EXECUTION

71.01 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

71.02 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

71.03 INSTALLATION

A. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosed Controller Fuses: Install per section 26 28 13 “Fuses.”

71.04 IDENTIFICATION

A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

71.05 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

71.06 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

71.07 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, "Motor Control - Motor Starters." Certify compliance with test parameters.

C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

End of Section 26 29 13

SUMMARY SHEET

Section name: VARIABLE FREQUENCY MOTOR CONTROLLERS

Section number: 26 29 23

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Dec 2007

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	10/30/09	Entire document formatted to SPU Contracts style

The NEC 2008 refers to Variable Frequency Drives as Variable Frequency Motor Controllers. For that reason, we have chosen this title.

PART 72 GENERAL

72.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

72.02 SUMMARY

A. This Section includes solid-state, PWM, VFDs for speed control of three-phase, squirrel-cage induction motors.

72.03 DEFINITIONS

A. IGBT: Integrated gate bipolar transistor.

B. PID: Control action, proportional plus integral plus derivative.

C. PWM: Pulse-width modulated.

D. VFD: Variable frequency drive now called Variable Frequency Motor Controllers.

72.04 SUBMITTALS

A. Product Data: For each type of VFD. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFD.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.

   b. Nameplate legends.

   c. Short-circuit current rating of integrated unit.

   d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFDs. Provide schematic wiring diagram for each type of VFD.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs where pipe and ducts are prohibited. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that VFDs, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For manufacturer.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For VFDs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for VFDs and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

72.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100-mi of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, minimum clearances between VFDs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances. NEC requires 30-in wide access space in front of controller.

72.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFDs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFDs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

72.07 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 0 to 40 deg C.

2. Humidity: Less than 90 percent (noncondensing).

3. Altitude: Not exceeding 6,600-ft.

72.08 COORDINATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 73 PRODUCTS

73.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Square D.
2. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
3. Baldor Electric Company (Graham).
4. Eaton Corporation; Cutler-Hammer Products.
5. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
6. Toshiba International Corporation.

73.02 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of standard-efficiency 1.25s.f. motor as defined by NEMA MG 1.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:

1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.

5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V.

F. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 2 to a minimum of 22 seconds.

4. Deceleration: 2 to a minimum of 22 seconds.

5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

6. Resonant skip frequencies: minimum 2.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors.

2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance. Note requirement for mechanical overload relay.

4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

5. Instantaneous line-to-line and line-to-ground overcurrent trips.

6. Loss-of-phase protection.

7. Reverse-phase protection.

8. Short-circuit protection.

9. Motor overtemperature fault.

H. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

I. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

J. Input Line Conditioning: As required to meet IEEE 519 with point of common coupling being the station service entrance.

K. VFD Output Filtering: As required to supply standard (not invertor-duty) motor.

L. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

M. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

N. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals:

    a. 0 to 10-V dc.

    b. 0-20 or 4-20 mA.

    c. Potentiometer using up/down digital inputs.

    d. Fixed frequencies using digital inputs.

    e. Keypad display for local hand operation.

3. Output Signal Interface:

    a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

        1) Output frequency (Hz).

        2) Output current (load).

        3) DC-link voltage (VDC).

        4) Motor torque (percent).

        5) Motor speed (rpm).

        6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

    a. Motor running.

    b. Set-point speed reached.

    c. Fault and warning indication (overtemperature or overcurrent).

    d. PID high- or low-speed limits reached.

O. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.

P. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

73.03 ENCLOSURES

A. NEMA 1.

73.04 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

73.05 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFDs before shipping.

PART 74 EXECUTION

74.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

74.02 APPLICATIONS

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled, but not less than 1.25 s.f. motor nameplate horsepower.

74.03 INSTALLATION

A. Wall mount or anchor each VFD assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

C. Provide plastic covers or barriers to cover all exposed energized metal parts to avoid contact.

74.04 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

74.05 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

74.06 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

74.07 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."

74.08 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

74.09 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

74.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Demonstration and Training."

End of Section 26 29 23

SUMMARY SHEET

Section name: ENGINE GENERATORS

Section number: 26 32 13

Prepared by: Tim Kim

Reviewed by: Carter Le

Date issued: Oct 2009

Description: SPU Design Standards and Guidelines (DSG)

Revision #	Date	Paragraph(s) revised
1	01/01/07	Insert

WARNING: The standards and guidelines do not relieve licensed engineers from their responsibilities as outlined by the code of ethics and rules of practice. All specifications require editing and review by the project's licensed engineer and must be tailored to the conditions and needs of the project. The guidelines provide policy, clarity, and advice on how design should be conducted by and for Seattle Public Utilities. However, it remains the responsibility of the licensed engineer to properly interpret and apply the guidelines as appropriate to meet the

needs of the project. If these standards and guidelines contain any contradictions with other standard engineering practices, the licensed engineer is responsible for identifying and resolving them.

This specification is based on specification **26 32 12,** which was developed for the Morse Lake Power Supply Project. Unlike specification 26 32 12, this specification is for a generic project.

PART 75 GENERAL

75.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

75.02 SUMMARY

A. This Section includes packaged engine-generator sets for standby power supply with the following features:

1. Diesel engine.

2. Unit-mounted cooling system.

3. Unit-mounted control and monitoring.

4. Outdoor enclosure.

B. Related Sections include the following:

1. Division 26 Section 26 36 00, "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

75.03 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

75.04 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.

2. Time-current characteristic curves for generator protective device.

B. Design Data:

1. The generator manufacturer shall submit design data for engine, generator, and accessories in format indicated in Paragraphs B2 through B13 (For rated kW capacity).

2. Engine Data:

a. Manufacturer

b. Model

c. Number and arrangement of cylinders

d. RPM

e. Bore x stroke

f. Maximum power at rated rpm

g. BMEP at rated kW (including any parasitic loads and generator efficiency)

h. Piston speed, fpm

i. Make and model of governor

j. Make and model of overspeed shutdown device.

3. Generator Data:

a. Manufacturer

b. Model

c. Rated KVA (Standby & Prime)

d. Rated KW (Stand-by & Prime)

e. Voltage

f. Temperature rise above 40 degrees C ambient:

1) Stator by thermometer degrees C

2) Field by resistance degrees C

3) Class of insulation degrees C

4. Generator efficiency including excitation losses and at 80 percent PF:

a. Full load percent

b. Three-quarters load percent

c. Half load percent

5. Guaranteed fuel consumption rate (at generator terminals/138,000 BTU/gallon):

a. Full load, gal/hr

b. Three-quarter load, gal/hr

c. Half load, gal/hr

6. Generator unit and accessories:

a. Weight of skid mounted unit in the enclosure with and without the full load of fuel

b. Overall length

c. Overall width

d. d. Overall height

e. Exhaust pipe size

7. Exhaust gas emissions data, maximum values at loads varying from full to 1/4 load:

a.	Temperature	[_____] degrees F
b.	Flow	[_____] ACFM (mass and volume)
c.	Carbon Monoxide (CO)	[_____] grams/BHP-hr
d.	Nitrogen Oxides (NOx)	[_____] grams/BHP-hr
e.	Hydrocarbons (HC)	[_____] grams/BHP-hr
f.	*Sulfur Dioxide (SO2)	[_____] grams/BHP-hr

g. *Based on 0.3 percent sulfur content by weight in the fuel.

8. CFM of air required for combustion and ventilation based upon inlet air temperature of 40 degrees C: [___] cfm

9. Heat radiated to room by engine and generator: [____] BTU/min

10. Heat rejected to lubricating oil and intercooler: [____] BTU/min

11. Height from bottom of skid required for removing piston with connecting rod; (also for removing cylinder liner): [____]-ft

12. Is the unit guaranteed to be adequate for the connected motor starting requirement?

a. Yes [___] No [___]

13. Radiator (engine driven or remote located) fan cooling air volume and required BHP: [_____] CFM [_____] BHP

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.

2. Wiring Diagrams: Power, signal, and control wiring.

D. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section 260548, "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For installer.

F. Source quality-control test reports.

1. Certified summary of prototype-unit test report.

2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.

5. Report of sound generation.

6. Report of exhaust emissions showing compliance with applicable regulations.

7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

I. Warranty: Special warranty specified in this Section.

75.05 REFERENCE STANDARDS

A. Design, manufacturing and assembly of elements of the equipment herein specified shall be in accordance with, but not limited to, published standards of the following, as applicable:

1. American Gear Manufacturers Association (AGMA)
2. American Institute of Steel Construction (AISC)
3. American Iron and Steel Institute (AISI)
4. American Society of Mechanical Engineers (ASME)
5. American National Standards Institute (ANSI)
6. American Society for Testing and Materials (ASTM)
7. American Welding Society (AWS)
8. American Bearing Manufacturers Association (ABMA)
9. Institute of Electrical and Electronics Engineers (IEEE)
10. National Electrical Code (NEC)
11. National Electrical Manufacturers Association (NEMA)
12. Occupational Safety and Health Administration (OSHA)
13. The Society for Protective Coatings (SSPC)
14. Underwriters Laboratories (UL)
15. Instrument Society of America (ISA)

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

75.06 SERVICES OF MANUFACTURER’S REPRESENTATIVE

A. Equipment furnished will include the services of a factory trained representative of the manufacturers of all equipment to supervise the installation, adjustment and testing of the equipment and to instruct the Owner's operating personnel on operation.

1. Installation: to assist in location of anchor bolts; setting, leveling and field erection; coordination of piping, electrical, miscellaneous utility connections: 2 man-days.

2. Start-up, testing and calibration: should be specific to the size of the gen-set.

3. Operation instruction: should be specific to the size of the gen-set.

B. A certificate in the form provided in Appendix A, and Appendix B, from the manufacturer and signed by Owner's representative stating that the installation of the equipment is satisfactory, that the unit has been satisfactorily tested, is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the unit shall be submitted for each piece of equipment indicated above.

C. For equipment furnished under other Divisions, furnish the services of accredited representatives of the manufacturer only when some evident malfunction or over-heating makes such services necessary in the opinion of the Engineer.

D. The Contractor is required to coordinate with the generator manufacturer for the dates required for the services required in this Contract.

75.07 OPERATING MANUALS

A. Six complete sets of operation and maintenance instructions covering all equipment furnished shall be provided by the generator manufacturer.

1. The manual for each piece of equipment shall be a separate document with the following specific requirements:

a. Contents:

1) Table of contents and index

2) Brief description of each system and components

3) Starting and stopping procedures

4) Special operating instructions

5) Routine maintenance procedures

6) Manufacturer's printed operating and maintenance instructions, parts list, illustrations, and diagrams

7) One copy of each wiring diagram

8) One copy of each approved shop drawing and the Vendor's coordination and layout drawing for each unit.

9) Name, address, and telephone numbers of local service representatives.

b. Material:

1) Loose leaf on 20 lb punched paper

2) Holes reinforced with plastic cloth or metal

3) Page size, 8-1/2-in by 11-in

4) Diagrams, illustrations, and attached foldouts as required, of original quality, reproduced by dry copy method

5) Covers: oil, moisture, and wear resistant 9 by 12 size

c. Submittals to the Engineer:

75.08 CONTENTS, EACH VOLUME

A. Table of Contents: Provide title of project, names, addresses and telephone numbers of Engineer, schedule of products and systems, indexed to content of the volume.

B. For Each Product or System: List names, addresses and telephone numbers of suppliers; including local source of supplies and replacement parts.

C. Product Data: Mark each sheet to clearly identify specific products and component parts and data applicable to installation. Delete inapplicable information.

D. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams. Do not use Project Record Documents as maintenance drawings.

E. Type Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified.

75.09 MANUAL FOR MATERIALS AND FINISHES

A. Instructions for Care and Maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods and recommended schedule for cleaning and maintenance.

B. Moisture Protection and Weather Exposed Products: Include product data listing, applicable reference standards, chemical composition, and details of installation. Provide recommendations for inspections, maintenance, and repair.

C. Additional Requirements: As specified in individual product specifications.

75.10 MANUAL FOR EQUIPMENT AND SYSTEMS

A. For each Item of Equipment and Each System the generator manufacture shall provide the following:

1. Overview of System and description of unit or system and component parts. Identify function, normal operating characteristics and limiting conditions. Include

performance curves, with engineering data and tests and complete nomenclature and commercial number of replaceable parts.

2. Panelboard Circuit Directories including electrical service characteristics, controls and communications and color coded wiring diagrams as installed.

3. Operating Procedures: Include start-up, break-in and routine normal operating instructions and sequences; regulation, control, stopping, shut-down and emergency instructions; and summer, winter and any special operating instructions.

4. Maintenance Requirements:

   a. Routine procedures and guide for trouble-shooting; disassembly, repair and reassemble instructions; and alignment, adjusting, balancing and checking instructions.

   b. Servicing and lubrication schedule and list of lubricants required.

   c. Manufacturer's printed operation and maintenance instructions.

   d. Sequence of operation.

   e. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.

5. Control diagrams as installed.

6. Test reports as specified.

75.11 INSTRUCTION OF OWNER PERSONNEL

A. Before final inspection, the generator manufacturer representative will instruct Owner's designated personnel in operation, adjustment, and maintenance of equipment and systems, at agreed upon times.

B. The generator manufacturer representative will instruct on the use, operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

C. The generator manufacturer or their representative will prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instruction.

75.12 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.

2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200-mi of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with ASME B15.1.

F. Comply with NFPA 37.

G. Comply with NFPA 70.

H. Comply with NFPA 99.

I. Comply with NFPA 110 requirements for Level 1 emergency power supply system. This is not an emergency power supply system.

J. Comply with UL 2200.

K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

L. The engine-generator set shall be the standard product, as modified by this Section, of a manufacturer regularly engaged in the production of this type of equipment and which maintains a permanent service organization and supply of spare parts in place at the time of the bid within 150 miles of the project site. The unit to be furnished shall be built from components which have proven compatibility, reliability and are coordinated to operate as a unit.

M. The standby generator manufacturer will coordinate his/her design with the Pump Sation harmonic loads such as variable frequency drives, to assure that sufficient generator reactance is provided to limit the line harmonics to acceptable levels as specified in IEEE Standard 519 and to assure that the generator voltage control system will provide stable operation in the presence of such harmonics.

N. All mechanical equipment shall be designed and built for 24 hour continuous service at any and all points within the specified range of operation without overheating or excessive vibration or strain, and require only that degree of maintenance generally accepted as peculiar to the specific type of equipment required. All parts and components of all units shall be designed and built for interchangeability so that replacement parts may be installed without any additional fitting or machining.

O. Components of mechanical and electrical equipment shall be the products of manufacturers who can produce evidence of their ability to promptly furnish any and all interchangeable replacement parts as may be needed at any time within the expected life of the equipment.

P. Submit information on torsional forces on the engine generator and upon request, any additional information that the Engineer may deem necessary to determine the ability of the manufacturer to produce the specified equipment.

75.13 UNIT PERFORMANCE

A. The voltage regulation shall be within plus or minus 1 percent from zero load to full-rated load. Upon application or removal of full-rated load in one step, the transient voltage and recovery to steady state operation shall be within 3 seconds.

B. Stable or steady state operation is defined as operation with the frequency variation not exceeding plus or minus 0.22 percent (0.15 Hz) and voltage variation plus or minus 1 percent of their mean value for constant load from zero load to full rated load. A rheostat shall provide a minimum of plus or minus 5 percent voltage adjustment from rated voltage.

C. The generator manufacturer shall coordinate with the Engineer to provide generator reactance data for harmonic analysis and shall insure that the generator voltage control system will provide stable operation in the presence of such harmonics.

75.14 DELIVERY, STORAGE AND HANDLING

A. The generator manufacturer shall ship the equipment and material complete except where partial disassembly is required by transportation regulations or for protection of components.

B. All mechanical and electrical equipment shall be coated, wrapped and otherwise protected from snow, rain, drippings of any sort, dust, dirt, mud, flood and condensed water vapor during shipment and while installed in place during construction. The protective coverings shall remain in place until the work areas are substantially free of all construction dust and debris. Full details of proposed protective measures shall be submitted for approval to the Engineer prior to shipment.

C. All units shall be properly packaged for ocean shipment and especially treated for long periods of storage before use.

D. The Contractor shall coordinate delivery of the generator unit, provide the concrete mounting pad, unload, rig into place, wire, and connect all of the generator components to provide a complete and operational generator system as outlined in the project specifications.

75.15 PROJECT CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 0 deg F to 104 deg F.

2. Relative Humidity: 0 to 100 percent (rain and fog, rare snow).

3. Altitude: Sea level to 3000-ft.

75.16 MAINTENANCE SERVICE

A. Service Agreement:

1. The Engine Generator Manufacturer shall provide a 2 year maintenance service agreement, at the time of the bid, for the engine generators included under this specification. The Service Agreement shall include comprehensive maintenance and preventive maintenance including labor, parts materials, expenses, travel and equipment. There shall be no deductibles applied to the Comprehensive Service Agreement. The agreement shall commence on the date of acceptance of the units by the Owner.

2. The maintenance agreement shall include the services of factory trained technicians to diagnose/inspect the faulty equipment in the shortest possible time.

3. The Service Agreement shall include a minimum of four site visits per year scheduled in advance with the Owners operations personnel. The first three visits will focus on preventive maintenance and the fourth will be a comprehensive maintenance inspection and service visit. The same schedule will be applied each year of the agreement.

4. Throughout the duration of the service agreement remote support over the telephone will be provided by the manufacturer for operational issues.

5. The agreement shall include all labor, materials,, equipment and all special tools required for the normal operation and maintenance of the engine driven generator unit and shall be spelled out in the agreement. Throughout the duration of the service agreement all spare parts and materials shall be readily available as required. All required costs for expediting spare parts not readily on stock shall be borne by the maintenance service agreement provider on its entirety. A price list of all spare parts shall be supplied with the agreement that is guaranteed for a minimum of year. Any increase in the price of spare parts shall be provided to the Owner on a yearly basis.

75.17 WARRANTY

A. Base Warranty:

1. The complete electrical power system (generator controls, generator set, associated switches, switchgear, and accessories) as provided by the single source manufacturer, shall be warranted by the manufacturer against defects in materials and workmanship for a period of one (1) year from the date of system acceptance by the Owner. The warranty coverage shall include parts, labor, travel expenses and labor to remove/install said equipment per the manufacturer’s published limited warranty.

B. Extended Comprehensive Warranty:

1. The complete electrical power system (generator controls, generator set, associated switches, switchgear, and accessories) as provided by the single source manufacturer, shall be warranted by the manufacturer against defects in materials and workmanship for a period of five (5) years or 2500 hours, whichever occurs first from the date of system acceptance by the Owner. The warranty coverage shall include parts, labor, travel expenses and labor to remove, install said equipment per the manufacturer's published limited warranty. There shall be no deductibles applied to the extended comprehensive warranty.

75.18 COORDINATION

A. Coordinate size and location of concrete bases for package engine generator. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 07 Section "Roof Accessories."

PART 76 PRODUCTS

76.01 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Onan/Cummins Power Generation; Industrial Business Group.

2. Caterpillar; Engine Div.

3. Kohler Co.; Generator Division.

4. Spectrum Detroit Diesel.

76.02 GENERAL

A. The engine-generator sets shall be factory assembled units, specifically designed and equipped for operation on No. 2 diesel fuel oil and shall be:

1. The engine and generator shall be directly connected with a semi-flexible steel coupling, shall be free from injurious torsional or other vibration and shall be mounted on vibration isolators with a heavy steel sub-base. The diesel engine shall be vertical in-line, not over eight cylinders, two or four stroke cycle, turbo-charged with intercooler using engine jacket water, full diesel, and mechanical injection, arranged for direct connection to an alternating current generator.

B. The unit shall operate at a rotational speed of not more than 1800 rpm and shall develop its full kW rating including radiator fan power, if so equipped at a BMEP not to exceed the following:

1. Four stroke cycle turbocharged with after cooler 318 psi using engine jacket water for aftercooler.

2. The piston speed shall not exceed 1875 fpm.

3. Units offered at ratings in excess of their published ratings are not acceptable and will not be approved.

C. The engine shall be rigid, neat in appearance, and shall allow easy access to the various parts for maintenance purposes. The bed plate and frame shall be of heavy construction. All parts shall be properly enclosed to prevent the throwing or dripping of oil.

D. The engine-generator set shall be pre-piped and pre-wired insofar as possible. Separate pre-wired terminal boxes shall be provided on the engine-generator skid for AC and DC wiring.

76.03 ENGINE-GENERATOR SET

A. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

2. The complete engine-generator unit shall be free from harmful torsional or other vibration throughout the entire operation range of speed and load.

B. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated on drawings.

2. Output Connections: Three-phase, four wire, unless indicated differently in the drawings.

3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

C. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: Comply with NFPA 110, Type 10, system requirements.

76.04 ENGINE

A. General:

1. The engine shall be capable of withstanding a 10 percent overload for 2 hours out of every 24 hours without harmful detonation, overheating, or other evidence of distress.

2. The engine manufacturer shall make, or have made, the mass-electric system analysis of the complete engine-generator unit, and shall submit to the Engineer a complete report which shall show where any critical speed will be encountered, together with the order, the frequency, and magnitude of any critical speed.

3. Minimum sound attenuation of 25 dB at 500 Hz.

4. Sound level measured at a distance of 10-ft from exhaust discharge after installation is complete shall be 85 dBA or less.

B. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

C. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: 60-seconds.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.

7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.

    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.

    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

76.05 EQUIPMENT

A. Governor:

1. Governor shall be Woodward, Type EGB or equal, electro-hydraulic isochronous governor, with external manual adjustment for speed droop, speed setting and load limit and with self-contained oil supply. Speed control shall be Woodward No. 2301, or equal, mounted in the generator control panel.

2. Furnish also a separate overspeed shutdown device which shall, in case of predetermined overspeed or the operation of various protective devices as later specified, instantly stop the engine without the fuel injection system losing its prime.

B. Supporting Structure:

1. The engine-generator shall be directly bolted, doweled, and aligned on a rigid, fabricated steel base, suitably sized to maintain the correct alignment, supported by Korfund or equal heavy duty spring type vibration isolators, anchored to the level surface of a concrete pad.

76.06 FUEL OIL STORAGE

1. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 24 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.

2. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.

3. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.

4. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.

5. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.

6. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

76.07 SYSTEMS

A. Fuel Oil System:

1. The generator manufacture will provide a dual wall sub base fuel storage tank with 24 hours continuous operation at 100% rated power output capacity. The tank shall be constructed of corrosion resistant steel and shall be UL listed. The equipment, as installed, shall meet all local and regional requirements for above ground tanks.

    a. Manufacturer Qualifications:

        1) Manufacturer shall have a minimum ten years experience in the design and construction of Underwriters Laboratories (UL) listed day tank systems.

    b. Construction:

        1) The sub base tank shall be manufactured by IBI Tanks or approved equivalent and constructed in accordance with Underwriters Laboratories Standard UL-142. The sub base tank shall be constructed in accordance with Flammable and Combustible Liquids Code, NFPA 30; The Standard for Installation and use of Stationary Combustible Engine and Gas Turbines, NFPA 37; and The Standard for Emergency and Standby Power Systems, NFPA 110.

        2) The tank shall be designed and constructed with a rectangular shape and sized to provide 24 hour continued service at full load. The sub base tank shall match the generator skid dimensions.

        3) The sub base tank shall include reinforced steel box channel for generator support, with load rating of 5,000 lbs. per generator set mounting hole location. Full height gussets shall be provided at generator set mounting holes.

        4) The sub base tank shall be pressure washed with an iron phosphate solution. The interior shall be coated with a solvent-based film rust preventative, providing inter-operational protection.

        5) The sub base tank shall be shipped with a certificate of Structural/Mechanical Integrity, certifying that it has met standards through rigorous testing and has demonstrated specified capabilities.

    c. Sub Base Tank Painting:

        1) The paint and paint process used will have met the following standards:

            a) Tank exterior coating tested to withstand continuous salt spray testing at 100% exposure for 244 hours to a 5% salt solution at 92°-97° F. Coating has been subjected to full exposure humidity testing to 100% humidity at 100° F for 24 hours. Tests conducted in accordance with The American Standard Testing Methods Society.

            b) The tank shall be pressure washed with a solution of super refined mineral spirits so as to remove all traces of oil, dirt, grease, and

markings, and also scour the metal surfaces on a microscopic level to facilitate paint adhesion. The tank shall be wiped with a tack cloth to remove any particles missed in the initial wash.

c) A corrosion-resistant, epoxy-based primer approved for use on steel or aluminum surfaces shall be applied to the tank exterior prior to application of finish paint.

d) A high gloss, alkyd acrylic enamel finish coat of paint shall be applied to the tank exterior. The tank finish shall be visually inspected prior to shipment and repairs made as necessary.

d. Sub Base Tank Testing:

1) Primary tank sections shall be pressurized at 3-5 psi and leak-checked to ensure integrity of sub base weld seams per UL-142 standards. Containment basin shall be leak-checked by means of weld penetrant and ultraviolet light.

e. Sub Base Tank Fittings:

1) The sub base tank shall include the following fittings:

a) Appropriately sized NPT fuel supply

b) Fuel return fitting

c) 1-1/4" NPT for normal vent

d) NPT for emergency vent, sized as appropriate

e) 2" NPT for manual fill

f) NPT for level gauge, sized as appropriate.

g) 3/8" NPT basin drain

h) 2" NPT for level alarm

i) NPT fitting for leak detection alarm, sized as appropriate.

f. Fuel Level Gauge:

1) The sub base tank shall include a direct-reading fuel level gauge.

g. Fuel Containment Basin:

1) Sub base tank shall include a welded steel containment basin, sized at a minimum of 110% of the tank capacity to prevent escape of fuel into the environment in the event of a tank rupture.

h. Leak Detection System:

1) A fuel containment basin leak detector switch shall be provided.

i. Sub Base Tank Venting:

1) Normal venting:

a) Normal venting shall be sized at 1-1/4" NPT for tanks through 2,499 gallons; 1-1/2" NPT for 2,500 to 3,000 gallons; 2" NPT for 3,001 to 10,000 gallons in accordance with The American Petroleum Institute Standard No. 2000, for venting atmospheric and low pressure storage tanks. Tank shall be provided with atmospheric (normal) vent cap with screen.

2) Emergency Venting:

a) The emergency vent NPT fitting shall be sized to accommodate the total capacity of both normal and emergency vents, and is not less than that derived from NFPA 30, Table 2-8, based on wetted surface area of the tank (calculated based on 100% of primary tank). A zinc-plated emergency pressure relief vent cap shall be furnished. The vent shall be spring-pressure operated. Opening pressure shall be 0.5 psig; full opening pressure shall be 2.5 psig. Limits shall be marked on top of each vent. A second emergency vent fitting shall be provided for the secondary containment portion of the tank if applicable.

2. The fuel piping between the sub base tank and the engine shall be black steel and of a size recommended by the engine manufacturer and shall include flexible hose connections in both the supply and return piping. A Preferred or equal 1-in size Fusomatic valve shall be installed in the engine suction supply line between the tank and the diesel engine.

3. All parts of the fuel system shall meet the approval of and be installed in complete compliance with, all applicable Federal, State, and local codes, laws and regulations.

4. The Contractor will coordinate with the Owner for the first complete filling of the fuel tank with No. 2 diesel fuel. The Contractor will schedule with the Owner to refuel after testing, start-up, training, demonstration, and operation of the generators. The fuel tanks will be full when turned over to the owner at substantial completion.

5. The sub base tank shall include the following items:

a. Float switch for control of fuel supply pump.

b. Float switch for control of fuel return pump.

c. Low level switch.

d. Low-low level switch.

e. High Level switch.

6. All diesel fuel filters shall be provided with the engine-generator set, sized per the manufacturer.

B. Electric (Battery) Starting System:

1. Starting shall be accomplished by an engine mounted, solenoid shift electric starter, capable of withstanding four consecutive continuous cranking periods of 15 seconds duration each separated by 15 seconds rest periods before shutting down completely and sounding the alarm.

2. The starting batteries shall be low maintenance, long life, lead calcium type, especially designed for diesel engine cranking service and of a capacity as recommended by the battery manufacturer for cranking the engine being furnished, for the necessary break-away current as required and the spinning current for four consecutive starts of 15 seconds of cranking on each start, without being recharged, with a battery temperature of 45 degrees F and with the SAE 30 oil in the engine maintained at 60 degrees F. The batteries shall be low maintenance, long life, nickel hydroxide/cadmium type as manufactured by ALCAD; XHP or equal. An insulated protective covering, battery rack and suitable cables shall be provided.

3. Cell containers shall be sealed, translucent, shock absorbing, heat resistant plastic with electrolyte level marks and spray proof, flame arresting type vents. Battery shall be furnished with all connectors and hardware, lifting device, electrolyte terminal plates, cables, grease, hydrometer and brushes for cleaning posts and connectors.

4. A floor mounted structural steel battery rack shall be furnished by the generator manufacturer specifically designed for battery service. The rack shall be finished with an acid and fire resistant epoxy coating and non-metallic rain covers.

5. Battery charger shall be a UL listed, fully automatic, filtered, float-type, charger suitable for wall or rack mounting. Input voltage shall be 120 VAC, single phase, 60 Hz. The DC output shall be regulated to within 1 percent with plus or minus 10 percent fluctuations of the input voltage and shall be current limited at 120 percent of rated output. Accessories shall include DC ammeter and voltmeter (panel type; 2 percent accuracy), adjustable float and equalize controls and toggle switch, AC and DC circuit breakers, AC power failure alarm relay, low DC voltage alarm relay and DC ground fault relay. The charger shall be Chloride, Model SCR-F; LaMarche, Model A11 or equal.

C. Air Intake System:

1. The engine shall be equipped with suitably sized dry type air intake filter(s) to protect working parts of the engine from dirt and grit with replaceable type filter element(s). A crankcase breather shall be included.

D. Lubrication System:

1. The engine shall be provided with a full pressure lubricating oil system arranged to cool the pistons and to distribute oil to all moving parts of the engine including the turbocharger bearings and including full flow filter of the replaceable element type and a suitably sized shell and tube type oil cooler and an AMOT or equal automatic temperature regulator. An engine driven lubricating oil circulating pump shall be provided for the engine. This pump shall be of the positive displacement type, and shall have ample capacity to circulate the amount of lubricating oil and cooling oil required by the engine and turbocharger. The engine shall be provided with a sump type crankcase arrangement of sufficient capacity to suit the requirements of the engine.

2. Furnish a motor driven prelube pump which shall be automatically deactivated when the engine is started.

3. The engine shall be furnished with a Kenco or equal float operated oil level controller with engine mounted integral oil storage tank. It shall be installed in such a position that it will maintain a constant crankcase oil level as recommended by the engine manufacturer and visually indicate the oil level.

E. Engine Cooling System:

1. The unit shall be radiator cooled with a blower or pusher type fan mechanically driven by the engine. Fan and belts shall be completely guarded in accordance with OSHA regulations. The cooling system shall be adequate for cooling the unit at full rated load and for installation in a climate where freezing temperatures are encountered, shall be adequate for proper cooling in summer with a 50 percent ethylene glycol anti-freeze solution in the radiator and with an ambient temperature of 104 degrees F while maintaining a maximum 155 degree F air outflow temperature. A pressurized radiator cap, if used, shall be rated for not more than 6 psi on the cooling system. Furnish and install a suitable air discharge duct from the face of the radiator to the enclosure wall and incorporate in the enclosure automatic motorized discharge dampers which shall automatically open when the unit starts and automatically close when the unit stops. Any louvers or openings shall be properly screened to prevent the entry of rodents, insects, or birds and shall limit noise level of the radiator.

   a. Attached engine driven, centrifugal jacket water pump equipped with a mechanical seal and capable of circulating the required amount of jacket water through the remote located radiator and required additional piping, to be suitably sized and furnished by engine manufacturer.

   b. A suitably sized full flow lubricating oil cooler.

   c. Provide AMOT or equal automatic temperature regulators for the engine jacket water and lubricating oil which shall maintain pre-set temperature without restricting the rates of flow through the engine.

F. Exhaust System:

1. The exhaust silencer shall be as manufactured by Maxim; Donaldson; Nelson, or equal, of aluminized steel construction, and mounted and piped inside the

enclosure. The silencer shall attenuate the sum of the octave band levels converted to A-weighted sound pressure levels such that the noise level from the engine exhaust plus mechanical noise from the enclosure will conform to the noise limitation specified in Paragraph 2.08. There shall be no puretone. The engine supplier shall size the silencer to operate within the maximum allowable backpressure of the engine, when installed in the exhaust piping system as furnished. Provide a threaded drain tap at the low point of the silencer and a Schedule 40 black steel drain pipe connection from the silencer drain tap to a valved drain outlet to the exterior of the enclosure.

2. Furnish a stainless steel bellows type expansion joint as recommended by the engine manufacturer to connect the exhaust silencer to the engine. The flexible connection shall adapt to the engine exhaust outlet connection, and provide a flanged connection to the silencer. The connector shall be of Type 321 stainless steel and designed for an operating temperature of 1200 degrees F.

3. Exhaust pipe within the enclosure shall be ASTM A106, Schedule 40 black steel with flanged and welded fittings. Exhaust pipe shall be of the size recommended by the engine manufacturer. All exhaust line elbows shall be long radius.

4. The roof penetration through the enclosure shall be with an insulated Type 321 stainless steel or aluminum roof jack designed to accommodate the specified exhaust pipe and allow a minimum 1 inch air gap between the exhaust pipe and the roof thimble. There shall be no heat conduction path between the exhaust pipe and the roof. The roof thimble shall project above the finished roof and shall include Type 321 stainless steel or aluminum exterior rain flashing. Roof jack shall be as manufactured by GT Exhaust Systems or equal. The open space between the exhaust pipe and the roof jack shall allow for ventilation and shall include screening or mesh to prevent the entrance of insects.

5. The exterior portion of the exhaust pipe shall extend vertically to a vertical open discharge. The exhaust outlet shall be not less than one half the overall height of the enclosure (including the fuel tank), and not less than ten feet above the enclosure roof. The vertical exhaust pipe shall include the pipe itself, and a rain collar extension to the outlet.

    a. Exterior exhaust pipe shall be ASTM A312, Type 316L, stainless steel, welded, shop fabricated, of Schedule 10S wall thickness. Size shall be as required for the engine.

    b. Assemblies of pipe and fittings shall be shop fabricated with welded joints, and shall be field joined by flange joints. Field welding of stainless steel exhaust pipe will not be allowed. Flange pattern shall be ANSI B16.1, 125 lbs. Flanges shall have stub ends or rolled angle rings, of the same stainless steel as the pipeline, welded to the pipe end and shall utilize stainless steel back-up rings and Type 316 stainless steel bolts. Where the pipe stub is to pass through a sleeve during installation, a split-type back up flange shall be used. Flange gaskets shall be suitable for operating temperatures to 1200 degrees F.

c. Fabricate the exhaust outlet utilizing a pipe one pipe size larger than the exhaust pipe as a rain collar. The top outlet of the rain collar shall be set at the elevation above the enclosure roof as specified herein. The rain collar shall extend at least six pipe diameters (of the exhaust pipe) above the end of the exhaust pipe, and shall overlap the top of the exhaust pipe by 12-in. Weld the rain collar to the exhaust pipe using spacers of the same material as the pipe to allow an opening for the rain collar to drain on the outside of the exhaust pipe.

d. Support the exterior exhaust pipe extension on the structure of the enclosure. Provide bracing or cable stays as required to assure stability of the exhaust pipe outlet with a wind load of up to 115 mph. All bracing, cable stays, hardware, and fittings shall be of stainless steel.

6. Cover the interior exhaust system, including the flexible section, the exhaust silencer, and the first four feet of the silencer drain with insulation of a non-combustible type. The insulation shall be insulating blanket, consisting of high density fiberglass insulation, 11 pounds per cubic foot, rated to 1200 degrees F, totally encapsulated in Type 304 stainless steel mesh. The exterior shall have a weather barrier of silicone rubber coated fiberglass cloth. Wrap the blanket around the exhaust pipe and secure with Type 304 stainless steel clips and wire. The insulation blanket shall meet the following standard specifications: MIL-I-16411E-Type II, NRC 136, U.S. Coast Guard Certificate No. 164.009/94/0, UL 492 (self-extinguishing), and NFPA A 255. Provide complete external insulation coverage of silencers even if the silencers contain interior insulation. Surface temperature of any portion of the interior exhaust system shall not exceed 150 degrees F when the unit is operating at full load.

7. Furnish and install all required steel support framing and hanger bands for supporting the silencer and exterior exhaust pipe extension from the roof of the enclosure.

G. Miscellaneous Equipment and Requirements:

1. Heaters:

a. An automatic thermostatically controlled heater(s), rated 120 Volt, single phase, shall be provided to maintain not less than 90 degrees F temperature with an ambient temperature of 40 degrees F (4.5 degrees C) for the engine jacket water (and engine lubricating oil) system(s).

b. An automatic thermostatically controlled heater rated 120 Volt, single phase, shall be provided for the battery to maintain the battery temperature at a minimum of 50 degrees F (10 degrees C) and shall automatically shut off when the battery temperature attains 90 degrees F (32 degrees C).

c. An automatic thermostatically controlled generator space heater rated 120 Volt, single phase, shall be provided to maintain not less than 90 degrees F (32 degrees C) temperature with an ambient temperature of 40 degrees F (4.5 degrees C).

d. A separate manual switch shall be provided for each heater to disconnect heater when not required. Each heater shall be properly wired to receive its energy from the load side of the automatic load transfer switch (see lighting panel schedule on Electrical Drawings).

e. All heaters shall be automatically deactivated when the engine generator unit is in operation.

2. Field Piping:

a. All required field piping except for engine fuel, exhaust, and air starting piping shall be seamless copper, Type L and sizes as recommended by the engine manufacturer and shall have approved fittings with soldered joints. Flanges or unions shall be provided as required to make disassembly for repairs easy. All connections to the engine shall be made with flexible metal hose of an approved type. Fuel, exhaust, and air starting piping shall be as specified herein.

3. Hearing Protection:

a. Two circumaural hearing protection devices MSA Noisefoe Mark IV ear muffs or equal shall be furnished for the protection of operating personnel. Provide with high impact plastic window type cabinet, suitable for wall mounting.

4. Flexible all-metal connectors for all field-piped connections to the engine.

5. The Contractor shall provide wire and conduit to supply power to each of the generator outdoor enclosure panelboards from the paralleling switchgear 480 Volt panelboard. Refer to the project drawings for locations, conduit size, wire size and to these specifications for wire type.

76.08 ENGINE INSTRUMENTATION AND CONTROLS

A. Generator Control Panel:

1. The generator manufacturer will furnish and install a free-standing NEMA 1 generator control panel of a size not greater than 36-in wide by 30-in deep and 90-in high. All related equipment and controls will be provided by the generator manufacturer.

2. The Contractor shall provide wiring and conduit to each of the generator control panels as shown on the Owner provided Paralleling Switchgear equipment shop drawings and as indicated in the Contract drawings.

3. The face of the panel shall include meters, controls and indicators as specified, each with descriptive lamacoid nameplates. The back of the panel shall have metal cabinet door(s) with continuous hinge and a cabinet type locking latch.

4. The generator control panel shall be fabricated from code gauge sheet steel. All cutting, fitting and welding shall be neat and all edges shall be ground smooth.

The panel interior shall be painted white. The panel exterior shall be cleaned and primed, and given a final finish coat of light gray polyurethane.

5. The engine starting controls and alarms shall be powered by the 48 VDC batteries specified herein.

6. Equipment controlled by the generator control panel shall include, but not be limited to:

   a. Starting air solenoid valve.

   b. Jacket water heater.

   c. Generator space heater.

   d. Cooling water supply valves.

7. Controls switches shall be 600 Volt, 20 Amps, multi-stage rotary type with black handles. Each switch shall have a fixed modern pistol grip handle with an engraved black plastic escutcheon plate. Switches shall be General Electric, Type SB-1; Westinghouse, Type W2 or equal.

8. All indicating instruments shall be of the (4-1/2-in) square, concentric scale type, with white scales, black markings and black pointers or indicators. Accuracy shall be 1 percent.

9. Control relays and timers shall be heavy duty plug-in socket type with a transparent dust cover. The relay shall be equipped with an indicating light to indicate when its coil is energized. The relays shall have 10 Amps minimum unless otherwise specified, 120/230 VAC contacts. The mechanical life of the relay shall be 10,000 operations minimum.

10. All panel equipment shall be mounted and wired on or within the cabinet. Wiring shall comply with latest ANSI C1 National Electric Code. All wiring within the panel shall be grouped together with harnesses or ducts and secured to the structure. All wiring shall be numbered in accordance with the numbering system used on the wiring/connection diagrams. Wiring and connection diagrams shall be submitted as part of the shop drawings for approval of the Engineer.

11. Terminal blocks shall be grouped in the instrument and control compartment for easy accessibility unrestricted by interference from structural members and instruments. Sufficient space shall be provided on each side of each terminal block to allow an orderly arrangement of all leads to be terminated on the block.

12. Panel wiring shall be strained copper conductor, 600 Volt class, insulation and jacketed, General Electric, Type SIS or equal. Minimum size shall be No. 14 AWG for AC power wiring and No. 16 AWG for DC control wiring. Wire for voltage regulator power and field circuits shall be shielded.

B. Generator Control Panel Functions:

1. The General Control Panel (GCP) provided by the generator manufacturer shall include all controls for initiating automatic engine start-up and shutdown, including all controls for related auxiliary systems. The panel shall also include controls of components necessary to keep the engine in a ready condition for automatic operation.

    a. The cranking limiter shall disconnect the starting motor(s) from the air supply after completing a total of four 15 second cranking periods separated by four 15 second rest periods before shutting down completely and sounding the alarm.

    b. An adjustable 0 to 30 minute cool-down timer shall be provided.

2. The following devices shall be mounted on the panel:

    a. Emergency stop-pull switch - two position (pull to stop) mushroom head switch. Controls hard-wired contacts to initiate a controlled immediate stop of the engine.

    b. Elapsed time meter - 0 to 99999.9 hours.

    c. Engine speed meter, rpm, digital display.

    d. Voltage raise/lower switch - three positions "LOWER-OFF-RAISE" spring return to center switch.

    e. Engine running status light indicates that the engine is running.

    f. Cooling water booster pump running status light.

    g. Raw water inlet valve(s) open/closed status lights.

3. An alarm annunciator system shall be mounted on the panel consisting of the following:

    a. Twenty-four point, triple window type alarm annunciator, with DC power supply, by Rochester Instrument Systems; Ronan or equal. Provide 16 YELLOW indicators for warnings and 8 RED indicators for shutdowns.

    b. Annunciator horn - 48 VDC Sonalert, or equal, with time delay horn cutout relay to prevent battery drain.

    c. Test pushbutton - tests all annunciator and status lights.

    d. Silence/Acknowledge pushbutton - operation changes flashing first out point to steady on and silences annunciator horn.

    e. Alarm indication shall be provided for the following points:

Condition	Warning (Yellow)	Shutdown (Red)

Condition	Warning (Yellow)	Shutdown (Red)
Generator Breaker Tripped	X	
Emergency Stop		X
Fail to Start		X
Low Start Air Pressure	X	
Battery Charger Malfunction	X	
High Lube Oil Temperature	X	X
Low Lube Oil Pressure	X	X
Sub Base Tank Approaching Low Level		X
Engine Overspeed	X	
High Jacket Water Temperature	X	X
Sub Base Tank High Level	X	
Sub Base Tank Rupture	X	
Low Jacket Water Temperature	X	
Low Jacket Water Coolant Level	X	
Low Cooling Water Flow	X	
Low Fuel Shutdown	X	

f. All engine warning conditions shall be grouped to provide a common alarm to the station instrument panel. All shutdown alarms shall be grouped to provide a common alarm to the station instrument panel. Provision shall be made for a remote emergency stop button in the generator room.

C. Engine Instrument Panel:

1. The engine manufacturer shall provide jacket water, fuel and lube oil pressure gauges, jacket water and lube oil temperature gauges and combustion air filter manometer mounted on a common vibration isolated panel as part of the engine skid.

2. Gauges shall be as manufactured by Frank W. Murphy Manufacturing Company or equal. The gauges shall have a sealed case pulsation dampener and shall be a minimum of 2-in in diameter. The scale range shall be as required for the particular application.

3. A digital-type multiple circuit exhaust pyrometer shall be furnished and mounted with the gauges to measure the exhaust temperature from each cylinder and the combined exhaust temperature. The pyrometer shall be mounted on the engine instrument panel and back connected with terminal connections to a thermocouple on each individual cylinder and combined exhaust connection, plus at least one spare connector point. The Fahrenheit temperature scale shall read from 0 to 1200 degrees.

4. Temperature gauges, with graduations appropriate to the service, shall be installed on the raw cooling water inlet and outlet piping as shown on the Drawings.

5. Pressure and temperature switches shall be Honeywell; United Electric or equal, with adjustable range and differential. Switches shall be located as required to accommodate the control functions previously specified.

6. Engine coolant level switch shall be Murphy, Model L-150 or equal.

D. Each generator control panel will be interfaced with the Master Controller located in the MV Paralleling Switchgear. Each generator control panel will connect with the Master panel via a LONWORKS data highway network. The Contractor will install and place into operation the data communication cables as required.

76.09 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: SE-rated molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.

2. Trip Rating: Matched to generator rating.

3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.

4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.

2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.

4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

76.10 GENERATOR AND EXCITATION SYSTEM

A. The generator shall be of the drip-proof, guarded, bracket type, especially designed for connection to the specified engine and shall be for 277/480 Volt, 3 Phase, 60 Hz, 4 Wire operation and shall be "Y" connected. The neutral shall connect to a generator manufacturer sized and supplied, Contractor installed neutral grounding resistor. The generator shall be mechanically and torsionally matched to the engine driver and shall be designed to withstand inherent pulsating torques of the engine.

B. The generator shall have a forged or cast alloy steel flanged shaft for direct connection through a suitable flywheel type coupling to the engine, or with suitable adapter and disc coupling and shall be of the single bearing type with anti-friction bearing. Full load efficiency of the combined generator, exciter, and regulator shall be not less than 93 percent.

C. The generator windings, insulation and excitation system shall be braced to withstand any possible short-circuit stresses and shall be designed to withstand any overheating or stresses caused by harmonics generated by the variable frequency drives. The excitation and voltage control system shall sustain at least 300 percent rated generated current for 10 seconds when a three phase symmetrical short-circuit is applied at the generator terminals. The unit shall be "Radio Interference Proof" (RIP) and the "Telephone Influence Factor" (TIF) shall be within the limits of Section 9, ANSI C50.12.

D. The generator shall utilize a brushless, rotating field, Permanent Magnetic Generator (PMG) type excitation system with an electronic closed loop voltage regulator. The exciter rotor and field windings shall have Class F insulation, rated for Class B temperature rise.

E. The generator armature and field windings shall have Class F vacuum/pressure impregnated (VPI) epoxy insulation, limited to Class B (80 degrees C) temperature rise.

F. The generator stator core shall be built up of low carbon steel laminating precision punched, deburred, and individually insulated. Stator coils shall be all copper, random or form wound and inserted in insulated core slots. Wound core shall be repeatedly treated a minimum of three times with thermosetting synthetic varnish and backed for maximum moisture resistance, high dielectric strength and high bonding qualities. Armature lamination followers and frame ribs shall be welded integral with frame.

G. The generator shall be furnished with 120 Volt anti-condensation space heaters, designed to hold a minimum temperature of 90 degrees F.

H. Generator rotor poles shall be built up of individually insulated steel punchings. Poles shall be wound and bonded with high strength varnish, then baked. Cage connections shall be brazed for strong construction and permanent electrical characteristics. Each pole shall be dovetailed and keyed to rotor shaft. The rotor shall be dynamically balanced for all speeds up to 125 percent of rated speed per NEMA standards.

1. The entire rotor assembly shall be 100 percent epoxy resin vacuum pressure impregnated, then baked.

I. A cooling fan shall be mounted on the rotor to draw air from exciter end, over rotor poles and through louvered openings in drive end.

J. The generator shall have an oil lubricated anti-friction bearing. The designed bearing life, based on B-10 curve of the ABMA, shall not be less than 40,000 hours.

K. Voltage regulator shall be hermetically sealed, silicon controlled rectifier type and shall employ a zener reference and three phase sensing. The voltage regulator shall provide automatic protection of the entire unit on three phase short-circuits. The voltage regulator shall include automatic overexcitation and underfrequency protection. Input isolation transformers and filters shall be provided to minimize disturbances caused by line harmonics. Exciter shall be fast response type with a rotating rectifier and surge suppressor, three phase, full-wave bridge. It shall feature low time constant design to minimize voltage transients under severe load changes.

L. Voltage regulation shall be within plus or minus 1 percent of rated voltage from no load to full load. Steady-state modulation shall not exceed plus or minus 1/2 percent. Instantaneous voltage dip shall not exceed 20 percent of rated voltage when full load at rated power factor is applied. Recovery of stable operation shall occur within 1 second.

M. The voltage regulator and associated equipment shall be mounted in the generator terminal box. Manual voltage adjustment potentiometer shall be mounted in the generator control panel.

N. Generator stator leads shall be connected to copper bus bars in an oversize terminal box. Differential, ground fault protection and current transformers shall be furnished by the generator manufacturer.

76.11 MAIN GENERATOR CIRCUIT BREAKER

A. Furnish one molded case, three pole, circuit breaker for three phase overloads and/or short circuit protection. Current ratings shall be as required to protect the generator unit from overload or short circuit and shall be as shown on the Electrical Drawings. The circuit breaker shall operate both manually for normal switching functions and automatically during overload and short circuit conditions. Circuit breaker shall be UL listed as 100 percent continuous rated to carry the full ampere load of the generator. The circuit breaker shall include contacts wired to the generator control panel to provide alarm if the breaker is in the “Tripped” or “Off” position.

B. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection.

C. The circuit breaker shall meet standards established by Underwriter’s Laboratories.

D. Mount the circuit breaker in a NEMA-3R housing attached to the alternator terminal box or wall mounted, and located for easy access. Provide NEC minimum clearances of 3.5-ft to grounded components and walls. The circuit breaker shall not obstruct

movement of personnel within the generator enclosure. Use of the open door of the enclosure will not be considered an acceptable means to achieve NEC clearances to the face of the circuit breaker. NEC clearances shall be achieved with the enclosure doors closed.

76.12 AUXILIARY EQUIPMENT

A. Weatherproof Housing - walk-in type:

1. A weatherproof, walk-in type enclosure shall be provided to house the skid-mounted close-coupled generator with engine driven fan cooled radiator and including starting batteries, battery charger, generator controls and the housing roof designed to support the internal mounted exhaust silencer.

2. The enclosure shall be constructed as per Pritchard Brown Standards No. 9910 and No. 9930 or equal. The skid mounted engine generator shall be mounted on spring type vibration isolators, mounted and supported by a heavy duty welded steel sub-base designed to support the combined weight of the enclosed equipment and the entire perimeter of the enclosure, which will be mounted and anchored to a level surface concrete pad. Provide and install four steel lift rings in each corner of the welded steel supporting sub-base designed and capable of lifting 125 percent of the maximum combined weight of all equipment including the weatherproof enclosure. The supporting subbase shall be drilled to accommodate eight (3/4-in) L type anchor bolts, four per side, which will be supplied by the manufacturer.

3. The housing should be complete with two fully gasketed access doors, providing a weathertight perimeter seal, with stainless steel locking door handles, and duplicate keys. All exposed screws, bolts and nuts, if used, shall be Type 302 stainless steel. A bolt-in-place removable end wall panel located at the generator end shall also be included. Provide a motorized air intake damper, to open when unit starts and close when unit stops. Both motorized intake and gravity dampers shall be screened and enclosed by an acoustical baffle arrangement.

4. Provide one exhaust fan with gravity damper, four vapor tight 100 watt incandescent lights, located in each corner, two duplex 20 Amps, 2 Pole, 3 Wire receptacles, one on either side. Each of these electrical devices shall be operated by a manual on-off switch wired to a distribution panelboard receiving its energy from the load side of the automatic transfer switch.

5. The sound insulation shall comply with the UL Standard 94HF-1 Flammability Test, covering all the inside walls of the enclosure and shall consist of the type, thickness and number of baffles required to limit the resulting noise level of the unit operating at full load to not more than 68 dBA at a distance of 5-ft from the housing in any direction in an open field test. There shall be no puretones.

6. Provide engine mounted thermostatically controlled heater for the engine jacket water system set to maintain 90 degrees F temperature with an ambient temperature of 0 degrees. An automatic, thermostatically controlled heater rated 120 Volt, single phase, shall be provided for the battery to maintain the battery temperature at a minimum of 50 degrees F and shall automatically shut off when

the battery temperature attains 90 degrees F. Heaters, battery charger, exhaust fan, motorized louver, lighting, and receptacles shall be wired to branch circuit breakers provided in the panelboard to be furnished with the generator and located within the housing as specified above. Both heaters shall be wired to receive energy from the load side of the automatic transfer switch. Both heaters shall be automatically deactivated while the engine generator is in operation.

76.13 SURFACE PREPARATION AND SHOP PAINTING

A. The engine generator set and associated equipment shall be shop primed and finished coated in accordance with the manufacturer's standard practice prior to shipment. Color shall be selected by the Engineer and an adequate supply of touch-up paint shall be supplied by the manufacturer.

76.14 SHOP TEST

A. A complete engine generator unit and the generator control panel shall be shop tested prior to shipment. Four copies of the complete certified test record shall be submitted to the Engineer within 30 days after the completed test.

B. These tests for the unit shall be sufficient to assure that the unit will operate successfully and meet all specified operational requirements. The manufacturer shall furnish all necessary instruments, filters, starting air, fuel gas, cooling water, electric power, and load banks for the test.

C. Each of the automatic shutdown devices shall be tested and their respective values recorded at the time the devices stop the engine.

D. The shop test shall consist of, but not be limited to, four continuous hours of operation. Voltage and frequency regulation and transient response shall be tested and recorded to show full compliance with this Section. During the shop test, readings shall be taken and recorded every thirty minutes for each of the following:

1. Time
2. Ambient temperature
3. Volts for each phase
4. Load:
    a. Amps for each phase
    b. kW
    c. Power factor
    d. Frequency
    e. Engine jacket water temperature

f. Cooling water temperature (in and out)

g. Intake manifold pressure

h. Lubricating oil pressure

i. Crankcase pressure

j. Lube oil temperature

k. Intake manifold temperature

l. Exhaust gas temperature

m. Raw water cooling flow (required only for heat exchanger systems)

n. Gallons of fuel consumed per hour

o. Sound attenuation evaluation per section 1.01

E. The generator shall be shop tested in accordance with IEEE Standard 115. Testing shall include the following:

1. Cold resistance of all windings

2. Insulation resistance of all windings

3. Polarity of field coils

4. High potential on all windings

5. Open circuit saturation

6. Air gap measurement

7. Regulation (with regulator)

8. Transient voltage dip and response

9. Voltage and current balance

F. The procedure for the shop test of the engine shall cover the engine manufacturer's standard practice and shall also include at least, but not be limited, to the following:

1. Prior to all starts during initial tests and all starts after new running parts have been installed, the engine shall be connected to a separately driven lubricating oil pump and filtered oil circulated through all of the engine channels. The engine shall be thoroughly inspected for oil leaks prior to shipment, paying particular attention to leaks around the shims of bearing shells in engines where shims are used.

2. The engine shall be pre-lubricated for a sufficient period of time to ensure adequate lubrication. Caution shall be taken to avoid the accumulation of oil in the combustion chambers.

3. Engine and generator alignment shall be checked and generator air gap measured prior to the test.

G. Provision shall be made for bypass filtering and full-flow straining of the lubricating oil during the test. The strainer shall be so constructed that it will not pass particles over 0.003-in.

1. The engine shall be tested with the governor intended for permanent use on the engine. New, clean lubricating oil shall be used in the governor.

2. An air filter or cleaner shall be used for the supply of combustion air during all testing.

3. All starting airlines shall be fitted with water traps and lubricators.

4. The engine shall be given a suitable wearing-in run before the witnessed shop test as recommended by the manufacturer. Before recording any readings, all operating temperatures and pressures shall have become stabilized.

5. All alarm, shutdown and control functions shall be demonstrated. Transient response shall be measured to indicate compliance with the performance

76.15 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Sound attenuating: Where required provide sound attenuating enclosure to meet local noise limits.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

76.16 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene.

2. Durometer Rating: 30.

3. Number of Layers: Four.

76.17 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

76.18 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

PART 77 EXECUTION

77.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

77.02 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1-inch on 4-inch high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section 260548, "Vibration and Seismic Controls for Electrical Systems."

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

77.03 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Division 23 Section "Facility Fuel-Oil Piping."

D. Ground equipment according to Division 26 Section 26 05 26, "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

77.04 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section 26 05 53, "Identification for Electrical Systems."

77.05 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection[for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

c. Verify acceptance of charge for each element of the battery after discharge.

d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-in. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Exhaust Emissions Test: Comply with applicable government test criteria.

8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

10. 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 on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

77.06 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."

77.07 INSTALLATION

A. The generator manufacturer shall provide services of a qualified field representative to supervise the installation of the generator unit to ensure a proper installation as listed in Paragraph 1.05. The Contractor will assist the generator manufacturer and coordinate with the Owner for any commissioning and testing requirements.

B. The complete generator unit shall be mounted on a welded steel sub base of sufficient rigidity and strength to maintain alignment of the unit. The base shall be suitable for and there shall be included, spring type vibration isolators for mounting the unit on a level surface of a concrete pad. The spring type vibration isolators shall be supplied by the generator unit manufacturer. The Contractor shall rig into place, install, and anchor the generators as recommended by the generator manufacturer.

77.08 EQUIPMENT START-UP

A. The generator manufacturer shall operate unit to demonstrate ability to operate continuously without vibration, jamming, leakage, or overheating and to perform specified functions, after installation and after manufacturer's representative check of installed equipment.

B. The Contractor shall follow all recommended installation procedures and coordinate with the service representative for the proper equipment installation.

C. The generator manufacturer and the Contractor shall promptly correct improper installation of equipment.

D. The Contractor shall cooperate with equipment supplier at the time of start-up and in making of all final adjustments necessary to place equipment in satisfactory working

order. Start-up shall not commence without the presence of the manufacturer's representative.

77.09 FIELD TEST

A. Upon completion of the installation and as soon as conditions permit, the emergency power supply system including the engine driven generator, electrical circuits, controls, transfer switch controls and other devices shall be tested in the presence of the Engineer by the installation Vendor and the service representative for the manufacturer of the engine driven generator unit to assure that the system functions as specified.

1. The Contractor shall, prior to scheduling the test, notify the Engineer in writing that all requirements and provisions of the Contract Documents have been fulfilled, that all apparatus are clean, properly adjusted and ready for operation and that the Instruction Manuals, parts lists and record drawings described in Paragraph 1.03 above, have been submitted.

2. The Contractor and generator manufacturers' representatives shall make such changes in wiring or connections and such adjustments, repairs or replacements necessary to make the circuit, device or control system function as specified and otherwise comply with the Contract Documents.

B. Engine Generator Load Tests:

1. Resistive Load Bank Test:

a. The test shall consist of 2 hours of continuous operation of the unit at full rated load using a portable resistive load bank. The Contractor is responsible for providing the resistive load bank for this test.

2. Live Load Test:

a. In addition to the resistive load bank test, a live load test shall be included and will consist of a 2 hours of continuous plant load operation.

3. During the tests, the same readings as outlined under Shop Test Paragraph 2.10C above, shall be taken and recorded at 30 minute intervals.

C. As part of the field tests, each of the automatic shutdown devices shall be tested and the respective values recorded at which the devices will stop the engine. Any adjustments required shall be made in the devices to make the operating values correspond to those recommended by the engine manufacturer and as recorded during the stop test.

D. After the two hour test has been completed, additional testing shall be performed to demonstrate the emergency power supply system's ability to meet the automatic starting, load transfer and motor starting requirements as specified under Paragraph 1.12 C&D above.

E. The Contractor shall provide a person qualified to conduct sound level testing to take and record octave band sound pressure level readings with the portable resistive load

shut off and operating the engine driven generators using the station load available at the time the field tests are conducted. These readings shall be recorded and submitted to the Engineer with the record documents.

F. Piping shall be tested in strict accordance with the manufacturers testing requirements. For each double wall fuel oil line entering the building, provide a pressure test port with threaded plug in the double wall piping termination fitting. Piping shall be subjected to an air test of 10 psig maximum.

G. If the emergency power supply system fails to fulfill the performance requirements of this specification, corrective action shall be taken and the system retested to assure full compliance. All additional expenses associated with the field tests due to the Contractor, including any corrective action, shall be borne to the Contractor. Additional expenses associated with the equipment provided shall be borne by the Generator manufacturer.

H. The Contractor shall coordinate with the Owner to refill the diesel fuel tanks after the field tests have been successfully completed and accepted by the Owner.

End of Section 26 32 12

Note: The blue note text will not appear when you print the document. Delete these tags and narration before issuing the specification

APPENDIX A

Passage of the Clean Air Act in 1970 established standards of Air Quality throughout our country, to achieve or maintain the National Ambient Air Quality Standards (NAAQS) for CO, NOx, HC, Ozone, SO2 and particulates. Responsibility for complying with these standards rests with the user (or his/her consulting engineer), not the engine manufacturer.

Since these standards apply to the total of all emissions from a site, the permissible emissions level from an individual engine can be varied as required. Most engine manufacturers set the air fuel ratio at the factory to provide a good balance between fuel economy and power output without regard to exhaust emission levels. However, there are certain modifications such as retarded ignition timing that can reduce NOx emissions with only a moderate increase (6 to 10 percent) in fuel consumption. Catalytic Reduction Converters can also be supplied under certain conditions.

In any event, you should first supply your local in house Air Quality Service Group with the following preliminary exhaust emission performance data for the selected diesel engine with pre set standard factory timing.

Output Load	Exhaust Emissions (grams/BHP hr)			
BHP	NOx	HC	CO	*SO2
Full	___	___	___	___

3/4	___	___	___	___
1/2	___	___	___	___
1/4	___	___	___	___

*Note: SO2 is proportional to a sulfur content of 0.20 percent by weight of the fuel.

APPENDIX B

EQUIPMENT MANUFACTURER'S CERTIFICATE OF INSTALLATION TESTING AND INSTRUCTION

Owner: Seattle Public Utilities

Project:

Contract No. _____

EQUIPMENT SPECIFICATION SECTION – 26 32 12 Diesel Engine Driven Generators

EQUIPMENT DESCRIPTION -

I_____ , Authorized representative of
(Print Name)

_____
(Print Manufacturer's Name)

hereby CERTIFY
that_____
(Print equipment name and model with serial No.)

installed for the subject project have been installed in a satisfactory manner, have been satisfactorily tested, are ready for operation, and that Owner assigned operating personnel have been suitably instructed in the operation, lubrication, and care of the units on Date: _____ Time: _____.

CERTIFIED BY: _____DATE: _____
(Signature of Manufacturer's Representative)

OWNER'S ACKNOWLEDGMENT OF MANUFACTURER'S INSTRUCTION

We the undersigned, authorized representatives of the Seattle Public Utilities_and/or Plant Operating Personnel have received classroom and hands on instruction on the operation of the subject equipment and are prepared to assume normal operational responsibility for the equipment:

_____DATE: _____

_____DATE:_____

_____DATE:_____