Western Michigan University
Campus Facilities

Design Guidelines for Construction:

DESIGN GUIDELINE DG16-4 Primary Voltage Electrical Distribution System

GUIDELINE CONTENTS

1. SYSTEM DESCRIPTION & GENERAL DESIGN REQUIREMENTS

For guidelines and requirements applicable to all of Division 16 sections, see DG16-0.

This Section describes the requirements for the primary electrical distribution system for the Western Michigan University Campus. Primary distribution on campus is a 13.8 kV looped system consisting of a network of switches, underground duct banks and vaults. Buildings are powered through unit substations located within the buildings. Each unit substation includes primary switch section consisting of a pair of loop switches and a fused transformer switch. Loops can be fed from two physically remote methods. The switch lineups are in turn powered from one of two busses at the WMU Power Plant.

2. MEDIUM VOLTAGE SUBSTATIONS

Unit Substations shall consist of an incoming line section, a transformer section, a secondary distribution section and accessories as identified and described herein. Unit substations shall comply with NEC and UL requirements for service entrance equipment and shall be labeled as such. All equipment shall have a UL listing. Phasing shall be marked at each terminating location of cable in the substation.

The incoming Line section shall consist of two loop switches and a fused load switch to the transformer. Switches shall be, front and rear accessible. Kirk Key Interlocks are not required and should not be provided between the primary loop switches.

The University has standardized on the following unit substation manufacturers, subject to compliance with specification requirements:

Square D
Siemens Energy & Automation, Inc.

2.1 Submittals Required:

Submittals shall be required and include shop drawings and manuals for each substation including the following:

- Dimensioned plans and elevations showing major components and features.
- One-line diagram.
- Materials list.
- Nameplate legends.
- Size and number of bus bars and current rating for each bus including mains and branches of phase, neutral, and ground buses.
- Short-time and short-circuit current ratings of substations and components.
- Ratings of individual protective devices.
- Metering provisions.
- One line of the communications within the substation.
- Time-current characteristic curves for over current protective devices.
- Manufacturer's certification, signed by the manufacturer, certifying that the company complies with the specified requirements.
- Product certification, signed by manufacturer of equipment, certifying that products comply with the specified requirements.
- Operating and maintenance data for substations and component devices.

2.2 Manufacturer's Field Services:

Provide the services of a factory-authorized service representative to supervise the assembling and connecting of components, pre-testing of substation, and adjusting of substation components.

2.3 Spare Parts Required:

Each project shall provide extra materials matching products installed as described below; packaged with protective covering for storage, and identified with labels clearly describing contents and shall be delivered to the University.

- One set of spare fuses for each type and rating of fuse and fusible devices used. Including but not limited to spares for primary disconnect, potential transformer, and control-power. Spare primary fuses shall be located in a spare cabinet external from the switch.

- Touch-Up-Paint: Three half-pint containers of paint matching enclosure exterior finish.

Accessory tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation shall be provided. Include fuse-handling tool as recommended by switchgear manufacturer.

2.4 Identification

A Mimic Bus shall be provided on the front of the substation. The mimic bus which indicates bussing, connections, and devices in single line form on the front panels of the switchgear using black colored plastic strips, 1/2 in wide, fastened flat against the panel face and utilizing the same symbology as used on the contract documents. One line diagrams of the substation are not acceptable to meet this requirement.

2.5 Testing/Commissioning Requirements:

The Engineer is to ensure the removal of temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from substation units and components.
Engineer shall submit all breaker trip settings to the University for review 2 weeks prior to any tests being performed.

Schedule tests and provide notification to the University at least one week in advance of test commencement. All corrections and re-testing necessary and identified by testing shall be the responsibility of the contractor.

Test substation buses and perform such other tests and examinations as needed to achieve specified objectives. Correct deficiencies and arrange for retesting until objectives are achieved without extra cost to the University.

For most projects an independent testing firm will be used and for others the main electrical contractor will provide these tests. The Engineer will consult with the University to determine what will apply to each project and how extensive the testing will be.

Make the following preparations for tests:

- Test insulation resistance of switchgear buses; components; and connecting supply, feeder, and control circuits.
- Test continuity of circuits.
- Provide set of Contract Documents to test organization.
- Provide Manufacturer's installation and testing instructions to test organization.
- Verify all documentation for breaker set points and substation certified documents are in the University's possession prior to testing.

Testing shall include but not be limited to:

- Test continuity of circuits.
- Phase and rotation.
- Quality Control Testing Procedure: Assure substation installation is operational within industry tolerances, installed in accordance with the specified requirements, and suitable for energizing.
- High Potential Tests: Test substation buses and perform such other tests and examinations as needed to achieve specified objectives.
- Real power (watts) readings for all three phases is positive.
- Use an infrared scanning device to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
- Perform a follow-up infrared scan at 11 months after Substantial Completion.
- Adjust/set all breaker trip settings.

2.6 Acceptance Criteria:

Provide signed documentation of all tests performed to the University. Contractor shall be required to provide a written report of observations and tests with in one week of the tests. Report defective materials and workmanship and corrective action.

Verify following meter values for all metered devices such as, transformer bus and main, branch, and tie breakers:

- Real power (watts) readings for all three phases is positive.
- Total real power (watts) reading is positive.
- Voltage meters are on correct phase as indicated by meter (ABC).
- Potential transformers (PT) and current transformers (CT) are each on appropriate phase.
- Verify negative or lagging power factor, note any poor readings
- Verify readings at gear and at software for gear (i.e. WinPM).
- Document readings for each metered device and provide in report.

Upon satisfactory completion of tests, apply a label to tested components indicating the test results, the person responsible, and the date.

Voltage Monitoring and Adjusting: After Substantial Completion, when requested by the Owner, but not more than 6 months after Final Acceptance, perform the following voltage monitoring:

- During a period of normal load cycles as evaluated by the Owner, perform one week of 3-phase voltage recording at the outgoing section of each unit substation. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance between phases greater than 1 percent or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period is unacceptable.
- During normal building load, use an appropriate meter to measure and record voltage and current harmonics.
- If test results are unacceptable, perform corrective action.
- Repeat monitoring after corrective action has been performed until satisfactory results are obtained.

Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may effect test results. Describe measures taken to improve test results.

Prepare a certified report of the infrared scan, identifying equipment checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and rescanning observations after remedial action.

3. SUBSTATION VAULTS & ROOMS

The arrangement of the primary switches, unit substations, and all other equipment in the transformer vault shall be such as to provide ample maintenance room and such that any piece of equipment can be removed without removing other pieces of equipment.

All substation vaults/rooms shall be provided with two exits and an area way or door/hallway to the outside of the building so as to be able to remove/replace the largest single piece of equipment as shipped from the factory without disassembly.

All primary switch units and unit substations shall be mounted on 4” concrete house keeping pads. Extend housekeeping pad at secondary end as far as possible to accommodate future sections. Installation of unit substations shall include the bolting of the substation components to channel-iron sills provided in the 4” house keeping pad.

Provide a solid copper ground bus continuously around the perimeter walls of the substation, mount at 24 inches above finished floor. Keep continuous by routing above and around obstacles.

Ground equipment to main electrical ground bus indicated. Provide minimum 5-ohm ground resistance at substation location.

4. TRANSFORMERS

Transformers shall be dry-type 80 degree C rise, VPI, 96 KVBil, fan cooled two-winding type, designed for operation with high-voltage windings connected to a 3-phase, 3-wire,

60-Hz, grounded neutral distribution system. Windings shall be copper only, NO ALUMINUM. Fan cooling equipment shall consist of cooling fans, temperature-sensing devices, and controls complete with housing, mounting devices, conduit, and wiring. Cooling Fan Operation shall be automatically and sequentially controlled by temperature-sensing devices. Temperature indicating devices shall be wired out to the substation computer monitoring equipment (WinPM). Connections to the buses of the high and low voltage sections shall be rigid bolted copper bus with silver plated joints.

4.1 Voltage Adjustment

Two 2 - 1/2% taps above and two 2 - 1/2% taps below nominal rated voltage tap shall be provided in the high voltage Windings. All shall be rated KVA taps. The taps shall be brought out to tap connections on each phase coil for manual operation. They shall be accessible by removable covers. The tap connections shall be brazed.

4.2 Temperature Indication

A control module shall be provided to include a hot spot temperature indicator or indicators (one required for each phase). The indicator shall be equipped with two normally open electrically separate contacts set to close on temperature rise at 100 deg. C for the fans on, and 135 deg. C for Alarm. This

4.3 Identification

The transformer shall be equipped with an identifying nameplate of stainless steel or anodized aluminum suitably inscribed to include: Serial No., Shop Order No., Class of transformer, number of phases, frequency, KVA rating of all windings, voltage ratings, tap voltages, temperature rise, vector diagram, percent impedance between each pair of windings, core and coil weight, case and fittings weight, total weight, connection diagram, impulse level, and manufacturer's name.

5. SUBSTATION METERING

Electronic meters shall be provided and connected to the University's electronic meter reading software via an Ethernet connection provided to the substation meter section. The main meter shall be Siemens model 9650-DC-100-ONZZZ-A, or PML/ION 7550-BO-O-B-6-EO-E-OA.

6. SECONDARY DISTRIBUTION SECTIONS

Secondary voltage may be 120/208 volts, or 277/480 volts or both, depending on the nature of the building loads and design.

Secondary sections shall be rear accessible with extensions and hinged doors. All secondary devices to be draw-out type breakers. Bussing shall be silver plated copper, 65 KA symmetrical bus rating. Provide a fiber barrier between cable and bussing. The secondary sections shall be top fed unless approved by the University.

6.1 Breakers

Main breakers shall be electrically operated xxxx. Branch breakers shall be manually operated xxxx. The main breaker section shall contain, at the top, the 9610 meter with Ethernet connection with an internal fan control transformer. The middle compartment shall house the main breaker, and the bottom compartment shall be empty for spare parts storage. No molded case breakers shall be used.

Provide (1) spare branch breaker, 800A frame with 600A C-Ts. Make provisions in unused branch breaker compartments for future breakers. Horizontal bussing shall be extended internally to accommodate future breaker sections that may be added. Extend 100% rated neutral into all compartments including future. The maximum bus size shall be 4000 Amp unless approved in writing by the University.

6.2 Accessories

Provide a permanently attached traveling hoist mounted on top of secondary gear for handling draw-out breakers.

Access to controls by means of a hinged door.

Controls located in a low voltage compartment completely isolated from high voltage circuits and operation mechanism located outside 15 kV switch enclosure.

7. SUBSTATION PRIMARY LINEUP

The metal clad primary switch unit shall consist of two 15 KV load break air switches and one 15 KV fused transformer load break air switch as provided by Siemens Energy Corporation. Switches shall be rated for a 40 KA fault. Each unit shall be free standing, consisting of cubicles bolted together. The switch unit shall be front and rear accessible with bottom cable feed. Each switch shall have two cable conduits fed to it from the nearest manhole. The spare conduit shall be temporarily capped and water sealed with a pull string in the conduit.

Primary load break switches shall be suitable for application on 3-phase, 60-Hz, grounded-neutral system of 13.8 kV nominal; 15 kV maximum voltage, with a 600 ampere main bus rating of tin plated copper. Switches shall be 40 KA fault rated. A full size ground bus of copper, shall be installed the full length of switchgear. The ground bus shall be connected to the room grounding system.

The primary switches are to be hard bussed and shall be non-insulated flat copper bar, mounted on track resistant bus supports. The contact surface for each bus connection shall be silver plated and tightly bolted to insure maximum conductivity.

Switches shall be provided with connections and connecting materials to transformer primary and sufficient space for termination of cables and stress cones. Lightning arrestors are to be installed on each loop switch.

Switches shall have mechanically interlocked doors to prevent access to switches or fuses when the switch is closed, and is to have an inspection window to verify switch status.

Transformer primary switches shall each be provided with three 15 KV fuses sized to properly protect the unit substation transformer. Fuses shall be power type with condensers and minimum interrupting rating of 570 MVA.

Primary switches are to be identified with 4" by 6" black on white lamacoid tags attached to doors with stainless steel screws. Each tag shall identify its respective unique switch number, voltage, feeder name. Fuse size and type, if applicable, shall also be identified as well.

8. PRIMARY FEEDER DISTRIBUTION SWITCHES

9. FUSES & PROTECTIVE DEVICES

Specifications shall include the providing of an extra set of fuses of each type matching the products installed. Fuses shall be packaged with protective covering for storage, and identified with labels clearly describing contents. Fuses to be provided include primary disconnect fuses, potential transformer fuses, and control-power fuses.

Primary fuses shall be S&C expulsion type SM5 sized at 133% of transformer primary FLC as per Siemens Current Limiting Fuse Selection table 6.3. A spare set shall be furnished and located in a cabinet on the wall adjacent to the switches (not inside the switch door). Fuses shall be positively held in position with provision for easy removal and replacement from the front without special tools.

Fuses shall be in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption controlled and silenced by chambers designed for that purpose. Interrupting Ratings of Fuses shall be at Rated System Voltage and capable of interrupting 32,000 asymmetrical amperes at 15KV with an XIR ratio equal to 15.

10. POWER DISTRIBUTION

10.1 Duct-banks:

Duct-banks shall be located a minimum of 30" below grade to top of duct-bank. All ducts shall be schedule 40 PVC and a minimum of 4" trade side. Ducts are to be encased in a minimum of 3" concrete with ducts spaced minimum of 2" side to side. Use nylon or plastic duct spacers to keep proper spacing. Concrete pours are to be free of voids.

Install a bare #2/0 copper ground cable in duct-bank and connect to manhole ground ring. A minimum duct-bank arrangement is 2. There are to be at least (1) spare duct for each full duct in each duct bank. All spare ducts are to have polypropylene pull ropes

run from manhole to manhole or from manhole to switch cabinet. Spare ducts are to be sealed shut at both ends with tapered rubber end plugs. Plugs are to be sealed to prevent rodents and water from entering ducts.

All ducts are to free of internal blockages. A mandrel shall be passed through each duct prior to cable pulling. A representative of the University shall be present during the mandrel pull.

All ducts which must change direction or elevation are to use factory bent sweeps. If factory bent sweeps are not practical or available, field bent sweeps can be made. Field bent sweeps are to made using a “hot box” only and inside diameter must not be smaller than straight run diameters. A mandrel must also pass through each field bend.

A maximum manhole spacing of 400’ shall not be exceeded without University persmission.

10.2 Manholes:

Manholes shall be reinforced concrete, poured in place or pre-cast, with H20 loading, minimum size of 8’ by 8’ by 8’ deep. Manholes are to have (2) hatches located on opposite corners. An aluminum access ladder is to be located at one of the hatch entrances. Manholes are to have a concrete floor with a sump located directly under the hatch which does not have the access ladder. Manhole covers shall be inscribed in 3” high letters “ELECTRIC”. Provide and install cast iron soil pipe drains with grates if water table is low.

Corrosion resistant pulling eyes are to be installed solidly in the walls of the manhole opposite any ductbank entrances. Manholes are to have a #2/0 copper ground cable installed around the inside perimeter of the manhole run to a minimum of three ¾” x 10’ ground rods outside each manhole. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below the concrete. Seal floor opening with waterproof nonshrink grout.

Each wall of the manhole is to have (2) 3’ long pieces of corrosion resistant unistrut inset vertically at 2’ from corners and 4’ apart located 3’ to center above floor of manhole for cable support.

All duct terminals shall be formed with and poured as an integral part of the manhole, and shall be recessed.

Connect exposed metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole to the ground rod or ground conductor. Make connections with minimum No. 4 AWG stranded hard-drawn copper wire. Train conductors plumb or level around corners and fasten to manhole walls. Connect to cable armor and cable shields by means of tinned terminals soldered to the armor or shield or as recommended by the manufacturer of splicing and termination kits.

10.3 Medium Voltage Cables:

All medium voltage cables used on main campus shall be rated over 600V and shall be a minimum of 250 Kcmil, 133% EPR insulation. All primary and secondary cables shall be installed in ducts with manholes at each change in direction or connection.

All cable located inside manhole are to be fire wrapped with a U.L. approved fire wrap material. Cable splices are to be done in accordance with approved practices using properly sized hydraulic compression fittings only. Insulation of splices is to be done with 3M cold shrink product.

Cables in manholes and switches are to identified with 2” by 5” white letters on black background engraved lamacoid tags. Each tag is to identify in 3/8” high lettering the following information: Feeder Name, Conductor Size and Insulation, Date of Installation, Manhole or Switch Number where feeder is spliced or terminated.

All three phases of each feeder are to be run within the same duct. All ducts which have cables installed are to be sealed at both ends with pliable, non-shrinking, non-drying duct seal. Duct is to be sealed well enough to prevent rodents and water from entering ducts.

Cable installed in manholes should have a minimum of 8’ of slack. In running cable through manholes or connecting into manholes, rack the cable the longest way around the hole to provide extra cable for future changes or for resplicing after a failure.

Ground fault indicators are to be installed on each set of feeders. Ground fault indicators are to mounted to front of loop switches and shall be as manufactured by Cooper Industries.

END OF SECTION