



DESIGN GUIDELINE 5.7

UNIT SUB-STATION ROOMS

General

This guideline applies to rooms that contain medium voltage unit substations, and as appropriate, to rooms with large transformers, large power panels, emergency power distribution equipment or central UPS systems.

Related Sections

Design Guidelines:

[6.0 DG260500 Common Work Results for Electrical](#)

[6.0 DG260533 Electrical Materials and Methods](#)

[6.0 DG260543 Underground Services for Electrical Systems](#)

[6.0 DG260526 Grounding and Bonding for Electrical](#)

[6.0 DG265100 Interior Lighting](#)

[6.0 DG283100 Fire Detection and Alarm](#)

[6.0 DG260800 Electrical Acceptance Tests](#)

U-M Master Specifications:

[7.0 MS261100 Unit Substations](#)

[7.0 MS261102 Installation of Pre-Purchased Unit Substations](#)

References

International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines
NESC, "National Electrical Safety Code"

Architectural Design Requirements

Separate the substation room from occupied areas or provide sound-proofing so the 60 Hz hum cannot be heard in occupied areas.

Separate the room and large secondary feeder circuits leaving the room from occupied areas and from areas containing computers, computer servers, telecom equipment, electronic instruments and other electronic equipment which could be affected by electromagnetic fields (EMF).

- The most stringent human EMF exposure limit is published by the ICNIRP. Their published maximum limit is 833 mG. University studies have shown that EMF greater than 833 mG is possible on the face of the transformer enclosure, but that five feet away EMF has not been measured greater than 228 mG.
- University studies have shown that substation transformers and secondary feeder circuits 400 amps and larger can produce EMF of sufficient strength to impact nearby electronic equipment. Route large secondary feeders away from electronic equipment.

Extend the walls from the floor to the deck above. CMU block walls are recommended for noise mitigation and safety. Obtain permission through the Design Manager before providing gypsum board walls. Chain link fence or expanded metal walls and gates are not acceptable.

Provide a minimum of 5 feet clear above the substation primary switches and secondary switchgear. Obtain approval of primary and secondary conduit and cable tray routes and installation details before providing less clear space above this equipment.

Where required by code, provide fire-resistance rated walls and doors.

Provide the NEC-required working spaces on all sides of each piece of equipment. Provide the NEC-required dedicated equipment space above each piece of equipment. These spaces shall be free of obstructions and grounded surfaces including columns, ductwork, piping, electrical panels, lighting, ground bus bars, floor drains and water leak detectors.

Exit doors shall swing outward from the room. Provide a minimum of two exit doors on opposite ends of the room if the room contains electrical equipment rated 1200 amps or more.

- Exit doors shall be equipped with panic bars, gaskets and bottom edge door sweeps. Double doors require only a single panic bar. Door locks shall be keyed with Arrow "L Series" cores.
- One door shall be large enough for the passage of the largest shipping section of the substation. Typically, this means a minimum 8 foot tall by 7 foot wide double door.
- Where two or more doors are provided, the others may be single doors. These doors should be a minimum 36 inches wide.

Slope the floor toward the floor drain. The floor drain shall be the low point of the floor.

Provide a 4 inch minimum housekeeping pad under each piece of floor-mounted equipment.

- Pads shall conform to the footprint of the equipment and shall be the full width and depth of the equipment, but shall not extend beyond the equipment by more than 4 inches. Pad edges shall be chamfered.
- Pads shall be smooth and level within 1/8 inch overall, or shall include embedded steel leveling channels that are level to within 1/8 inch overall. Leveling channels shall have a 1/8 inch reveal above the top of the concrete and shall be located directly under the equipment support points. Pads that fail to meet these criteria shall be corrected before installation of the equipment.

Provide 2 coats of water-borne epoxy paint over a compatible primer on the concrete floor.

Provide paint or a concrete sealer on the walls and ceiling.

Provide a 10 pound Type ABC fire extinguisher at each exit door.

Provide an unobstructed route to the building exterior to permit replacement of the largest shipping section of the substation. Design the floor of the entire route for the weight of the largest transformer.

Mechanical Design Requirements

The NEC limits substation room access to Plant Operations High Voltage Electricians, making it difficult for others to perform maintenance inside the room. Avoid locating mechanical equipment including fans and fan coil units inside the room.

Ductwork, piping, clean-outs, and other mechanical system components are not permitted in the room unless they serve the room. When there is no alternative to installing foreign ductwork or piping in the room, provide an architectural barrier to segregate the foreign ductwork and piping from the room.

- Provide a minimum of a gypsum board barrier to segregate foreign ductwork.
- Provide a minimum of a waterproofed light weight concrete barrier to segregate foreign piping. Gypsum board barriers or drip pans are not acceptable to segregate foreign piping.

Provide wet sprinklers if the building will be sprinkled.

- Locate the sprinkler heads and route the piping over aisles, not over the electrical equipment.
- Provide wire guards on the sprinkler heads.

In below-grade substation rooms, provide a floor drain at the low point of the room floor. Locate the floor drain in front or behind the middle of the substation and tight to the front or rear wall. Provide a backwater check valve for the floor drain. The backwater check valve shall be located outside of the room.

When a floor drain is provided, provide a water leak detector adjacent to the floor drain and tight to the wall so it isn't a trip hazard. The leak detector shall be outside of the working space of the substation. Connect its alarm contact to the nearest Building Automation System DDC panel.

Provide ventilation to remove equipment heat and maintain equipment within their ambient temperature ratings under all weather and electrical load conditions. Typically, provide supply and exhaust fans with variable speed control to maintain the setpoint temperature. Avoid discharging unheated outside air directly into the room, which can freeze sprinkler lines. Mix return air with outside air so that tempered air above freezing is discharged into the room.

- Design for a summer design space temperature of 10 degrees F over outside ambient.
- Design for a year-around setpoint temperature of 70 degrees F (knowing the summer space temperature will rise to a maximum of 10 degrees F over outside ambient).
- Base cooling load calculations on actual equipment heat rejection data and on the projected peak diversified load for the next 10 years.
- Design the supply and exhaust to produce a slightly positive room.
- Filter the supply air to the room. Minimum filter efficiency shall be 65 percent.
- Air condition the room only if the room cannot be ventilated with outside air. If building chilled water is used, verify the chilled water system operates all year long.

Electrical Design Requirements

Avoid locating electrical equipment requiring maintenance by others in the room, including general lighting and receptacle panels, central UPS systems, Building Automation System DDC panels, fire alarm control panels, security panels, or MOSCAD panels.

Avoid locating emergency or standby power system equipment including transfer switches and panels in the room. This equipment may be required by code to be in a separate room with not less than 1-hour fire-resistance-rated fire barriers and ventilation to and from the exterior.

Provide a 1/4 inch x 2 inch solid copper ground bus bar on the wall behind each substation. Extend it the full length of the substation and mount it 18 inches AFF. Connect multiple ground bus bars together using #4/0 AWG copper ground cables. Do not wrap ground bus bars around the room doors.

- Connect both ends of each substation internal ground bus bar to its room ground bus bar using #4/0 AWG copper ground cables embedded in the housekeeping pad and floor. Connect the internal ground bus bars of other equipment to the room ground bus bar in the same manner.
- For renovation projects only where the floor is not being cut, connect the substation ground bus bar to the room ground bus bar by routing the ground cables overhead.
- Connect the room ground bus bar with #4/0 AWG copper ground cables to all available grounds including the ground grid, concrete-encased foundation rebar, building steel, incoming water services, duct bank ground conductors, lightning protection ground rods, and the ground bus bars in other electrical rooms in the building.

Terminate the incoming primary duct bank with end bells that are embedded in and flush with the inside of the room wall, and as high off of the floor as possible. Slope the duct bank away from the room. If a duct bank must enter the room from below floor level, stub it up along the inside of the wall. Obtain permission through the Design Manager before stubbing ducts up into the bottoms of the primary loop switches.

Provide 24 inch wide aluminum ladder-type cable trays with 24 inch minimum radius fittings to route the primary cables up the wall and across the ceiling of the room. Locate the trays 3 feet minimum above the primary switches, but low enough to permit cable pulling. Provide cable tray roll-outs where the cables drop down into the primary loop switches.

Provide O-Z Gedney No. R4001BO strain relief fittings where the primary cables enter the tops of the primary loop switches. Specify that the Contractor coordinate with the Utilities and Plant Engineering High Voltage Engineer (734 615-4468) or the Plant High Voltage Shop (734 615-5279) before installing the cable trays.

Provide fluorescent lighting in front of and behind each substation, and in front of other electrical equipment. Connect this lighting to emergency power. Provide a battery-backed lighting fixture or an emergency lighting battery pack in front and behind each substation. If emergency power is not available, provide battery-backed lighting fixtures or battery packs throughout the room.

Provide exit signs above the exit doors.

Label the outsides of exit doors "DANGER - HIGH VOLTAGE - KEEP OUT".

Provide duplex receptacles and connect them to emergency power.

Provide one hard-wired IT data connection to each substation watt-hour meter.

To facilitate Building Automation System monitoring of electrical power system status, connect the following devices to a DDC panel.

- Status contacts of main and tie circuit breakers in double-ended unit substations.
- Integral power metering units of the limited number of circuit breakers being monitored by BAS.
- "On generator power" status contacts of automatic transfer switches.

Provide fire alarm system rate-of-rise heat detectors and one combination audible/visual appliance in accordance with Design Guideline 16720.

Provide framed copies of the building's One Line Diagrams and Riser Diagrams on the wall in front of the unit substation.