

## SCOPE

- I 1.1 This practice covers substation layout.
- I 1.2 Outdoor switchyards and switch racks are covered only with respect to spacing from other equipment, and not in regard to the layout of the switchyard or switchrack itself.
- I 1.3 **An asterisk (\*)** indicates that additional information is required. If a job is contracted, this additional information is furnished in the Job Specification.

## SUMMARY OF ADDITIONAL REQUIREMENTS

- I \* 2.1 **IP 4-3-1, Plant Buildings for Operation and Storage**, shall be used as amended by this practice.
- I \* 2.2 **IP 4-3-2, Blast Resistant Buildings**, shall be used to the extent specified.

## DOCUMENTATION

- M 3.1 **Substation equipment layout drawings** of all indoor and main outdoor substations shall be prepared and shall show building doors, the position of all equipment, the extent of breakers when in withdrawn position with equipment doors open, and shall be dimensioned to show clearances and aisles.

## DEFINITIONS

- I \* 4.1 **Acceptable and Preferred Practices.** Where this practice lists more than one type of equipment or method as acceptable or preferred, the contractor shall make the selection based on optimum cost benefits. Optimum cost benefits may be achieved by reducing maintenance and operating expense through initial added investment. Economic basis for calculating optimum cost benefits will be specified in the design documents.
- I 4.2 **A substation** is defined as an assembly of switchgear or control center equipment supplied directly by feeders or by adjacent transformers.
- I 4.3 **An indoor substation** is defined as a substation within a field-constructed or prefabricated building.
- I 4.4 **An outdoor substation** is defined by construction type as one of the following:
  - a. **Standard outdoor construction** is metal-clad equipment protected by a weatherproof enclosure.
  - b. **Protected-aisle outdoor construction** is metal-clad equipment within a factory-assembled building-like enclosure.
- I 4.5 **A main substation** is defined as a substation or switchyard which supplies all or a major part of the power to the individual substations supplying the onsite and offsite facilities of a complete plant.
- I 4.6 **A substation at grade** is defined as having the finished floor level 8 in. (200 mm) **above the adjoining grade**.
- I 4.7 **A substation building with floor above grade to meet area classification** is defined as being at least 2 ft (600 mm) above surrounding grade.
- I 4.8 **A substation building elevated to accommodate underground cable entry** is defined as being at least 5 ft (1.5 m) above grade.
- I \* 4.9 **A critical facility** is defined as a facility which represents or is needed for 20% or more of plant production or throughput. The facilities can be process units, loading or unloading facilities, utilities, and similar major elements of a plant. Facilities not meeting the 20% rule may also be designated as critical for safety, environmental or commercial reasons.
- I 4.10 **Independent Facility.** One facility is defined as independent of another facility if the first mentioned facility can operate without the other facility.
- I 4.11 **A captive transformer** is defined as a transformer which supplies a single utilization device, usually a large motor. The transformer may be located either at a substation or close to the device it supplies.

## LOCATION AND PROTECTION

- S 5.1 **Minimum safety spacings for switchgear and motor controllers**, from sources of flammable release, as shown on the area classification drawings, are as follows:
  - a. **Spacing for main substations:** 150 ft (45 m).
  - \* Spacings less than 150 ft shall be approved by the Owner's Engineer.
  - b. **Spacings for other than main substations** are given in **Table 1** for the indicated **TYPE OF EQUIPMENT, FLAMMABLE RELEASE SOURCE LOCATION, and operation**.

**TABLE 1**  
**MINIMUM SPACINGS FOR SWITCHGEAR AND MOTOR CONTROLLERS OTHER THAN MAIN SUBSTATIONS**

| TYPE OF SWITCHGEAR OR MOTOR CONTROLLER                                          | DOES THE EQUIPMENT FEED ANY CRITICAL FACILITIES AND IS THAT CRITICAL FACILITY INDEPENDENT FROM THE RELEASE SOURCE FACILITY? |    | MINIMUM EQUIPMENT SPACING FROM RELEASE SOURCE, FEET |               |
|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|----|-----------------------------------------------------|---------------|
|                                                                                 | Yes                                                                                                                         | No | Flash < 100°F or (1)                                | Flash ≥ 100°F |
| Outdoor, open bus, as in switchyards                                            | X                                                                                                                           |    | 150                                                 | 50            |
|                                                                                 |                                                                                                                             | X  | 50                                                  | 50            |
| Outdoor, enclosed bus as in switchracks                                         | X                                                                                                                           |    | 150                                                 | 50            |
|                                                                                 |                                                                                                                             | X  | 50(2)                                               | 50(2)         |
| Outdoor, metal-clad switchgear and/or control centers in outdoor enclosures     | X                                                                                                                           |    | 150                                                 | 50            |
|                                                                                 |                                                                                                                             | X  | 50                                                  | 50            |
| Indoor, metal-clad switchgear and/or control centers in a conventional building | X                                                                                                                           |    | 150(3)                                              | 50            |
|                                                                                 |                                                                                                                             | X  | 50                                                  | 50            |

**Notes for Table 1:**

- (1) Where liquids are being handled at temperatures above or within 15°F (8°C) of their flash point.
- (2) May be decreased to 15 ft (25 ft from furnaces) for radially fed switchracks containing only motor controllers (no associated power transformer or power distribution switchgear). Explosion-proof enclosures would be required if hazardous gas is heavier than air.
- (3) May be decreased to 50 ft if substation building is blast resistant.

**Acceptable Metric Equivalents**

|    |     |     |    |     |        |
|----|-----|-----|----|-----|--------|
| ft | 15  | 25  | 50 | 150 | 100°F  |
| m  | 4.5 | 7.5 | 15 | 45  | 37.8°C |

- S **5.2 Elevation of Floor Level.** Indoor and protected-aisle outdoor substations, located in a 2 ft (600 mm) high Division 2 area 50 to 100 ft (15 to 30 m) from a heavier-than-air release source, shall have their floor levels 2 ft or more above surrounding grade. Ventilation shall **not** be used to make the substation unclassified. When a substation is elevated 2 ft (600 mm), the space under elevated indoor substations or protected-aisle outdoor substation shall be enclosed on all four sides and solidly filled from grade to floor.

**INDOOR AND PROTECTED-AISLE DESIGN**

- O,C 6.1 **Common operating aisle** is preferred for switchgear, control centers, and turnaround power center. Where this layout is used, the operating sides of the different equipment on each side of the operating aisle shall preferably be aligned. Front and back clearances may be increased where necessary to permit this arrangement.
- C 6.2 **Manufacturers' standard** of equipment is acceptable for protected-aisle outdoor substations.
- R,M 6.3 **Finished floors, ceilings and walls of concrete** shall be sealed to prevent dusting of the concrete; normally painted. Sealing method shall be approved by the Owner's Engineer.

**ELEVATION**

- I \* 6.4 **Substations** will be specified to be either **at grade** or elevated above grade, depending on the area classification and on the wiring system used for the circuits entering and leaving the substation.
- S **6.5 Substations at grade, or elevated 2 ft (600 mm) to meet area classification limits** shall be used when all power circuits enter or leave the substation in underground conduit systems or above ground wiring systems, or both.

- S ♦ **6.6** **Elevated substations to allow underground cable entry, with at least three sides open (between grade and floor)**, shall be used when power circuits enter or leave the substation in buried cable systems. In such substations, elevation shall provide at least 5 ft (1.5 m) clearance from finished grade to the lowest part of the underside of the building floor or support structure. The grade shall slope away from the substation to prevent any liquid hydrocarbon spill from flowing under the substation.

- \* When specified, chain link fencing, mesh size 2 in. (50 mm open area) shall be installed across each open side. Two access gates or removable panels shall be provided on opposite sides. Such accessways shall be provided with provisions for padlocking.

#### HEATING

- R ♦ \* **6.7** **Supplemental heating** for indoor and protected-aisle substations shall be provided when minimum site design temperature is below 41°F (5°C), or when specified. **Electric heaters** capable of maintaining indoor temperatures above 45°F (7°C) shall be used.

#### STEAM AND WATER

- S **6.8** **Steam and water piping** or equipment using steam or pressurized water shall not be located within substation buildings or enclosures.

#### COOLING

- R ♦ \* **6.9** **Air Conditioned cooling design** shall be used as follows, unless the design requirements of **Par. 6.10** are specified:

- a. Design shall include moisture-proofing and thermal insulation to prevent corrosion and to aid in limiting indoor temperature extremes. However, no means of ventilation such as louvers or roof ventilators shall be provided, except that small localized exhaust type natural draft roof ventilators may be used with Owner's Engineer approval, over switchgear control battery installations.
- b. Mechanical refrigeration shall be provided to limit indoor temperature if indoor temperatures would otherwise exceed 90°F (32°C). Automatic temperature control shall be provided such that cooling is turned on when indoor temperature reaches 85°F (29°C), and turned off when it drops to 80°F (27°C). Cooling capacity shall be based on limiting indoor temperature to 80°F (27°C). In substation building spaces where batteries are installed, the design cooling capacity shall be based on limiting indoor temperatures to a value consistent with the battery manufacturer's normal design life temperature rating; typically 77°F (25°C).
- c. Commercial wall-mounted units are preferred. However, for substations of blast-resistant design, an outdoor compressor/condenser unit and separate evaporator/fan unit will be required if wall mounted units cannot satisfy the blast-resistant criteria.
- d. Heat losses of all electrical equipment located indoors shall be considered in calculating needed amounts of artificial heating and cooling.
- \* e. When specified, disposable or reusable filters shall be provided in the return air system to the cooling unit, capable of removing contaminants such as dust, dirt, or H<sub>2</sub>S. Contaminant levels shall be specified by the Owner.

- C \* **6.10** **Alternate substation cooling design.** When specified, the substation cooling design shall be as follows:
- a. Design shall include natural ventilation, moisture-proofing, and thermal insulation to prevent corrosion and to limit indoor ambient temperatures to equipment manufacturers' ratings; typically 90°F (32°C) for switchgear and 77°F (25°C) for batteries.
  - b. Heat losses of all electrical equipment located indoors shall be considered in the ventilation design.

#### SMOKE DETECTORS

- S **6.11** **Ionization type smoke detectors** shall be furnished and installed per the following:
- \* a. **Location.** A smoke detector shall be located in **each room** within a substation building, and within enclosures of outdoor substations of protected-aisle construction. The final number and location of smoke detectors shall be reviewed with the Owner's Engineer.
  - b. **Installation.** A common alarm for each building's smoke detectors **shall individually annunciate in the main control house (or room)**. Each alarm shall be identified with the location of the smoke detector. Alarms shall be both visible and audible.