Chapter 11
Direct-Current System

11-1. General

A direct-current system is used for the basic controls, relaying, SCADA equipment, inverter, communication equipment, generator exciter field flashing, alarm functions, and emergency lights. The system consists of a storage battery with its associated eliminator-type chargers, providing the stored energy system required to ensure adequate and uninterruptible power for critical power plant equipment. The battery and battery circuits should be properly designed, safeguarded and maintained, and the emergency requirements should be carefully estimated to ensure adequate battery performance during emergencies. IEEE 946 and EPRI EL-5036, Volume 9, provide guidance about factors to consider and evaluate in planning and designing direct current systems. IEEE 450 provides guidelines and procedures for testing the capacity of the battery system.

11-2. Batteries

a. Type. The battery or batteries should be of the lead-acid type in vented cells or a sealed cell.

b. Battery room and mounting. A separate room or an area enclosed with a chain link fence with lockable doors provides adequate protection against accidental contact or malicious tampering. The room or area should be ventilated in such a manner that exhaust air from the room does not enter any other room in the plant. If necessary, heat should be provided to obtain full rated performance out of the cells. The cells should be mounted in rows on racks permitting viewing the edges of plates and the bottom of the cells from one side of the battery. The tops of all cells should preferably be of the same height above the floor. The height should be convenient for adding water to the cells. Tiered arrangements of cells should be avoided. Aisles should be provided permitting removal of a cell from its row onto a truck without reaching over any other cells. The lighting fixtures in the room should be of the vapor-proof type, with the local control switch mounted outside by the entrance to the room. Battery charging equipment and controls should not be located in the battery room. Thermostats for heater control should be of the sealed type, and no contactors or other arc-producing devices should be located in the battery room. A fountain eyewash-safety shower and drain should be provided in the battery room.

c. Number and sizes. The number and sizes of batteries depend upon the physical sizes of the initial and ultimate stages of plant construction and the loads to be carried by the battery system. A 58/60-cell battery (129-V) is adequate for a plant with four to six main units. Where a large plant has a considerable amount of emergency lighting, long circuits, and a high number of solenoid loads, a 116/120-cell battery may be warranted.

d. One- or two-battery systems. If the ultimate plant will have a large number of generating units, studies should be made to determine whether one control battery for the ultimate plant will be more desirable and economically justifiable instead of two or more smaller batteries installed as the plant grows. Selection of a one- or two-battery system will depend not only on comparative costs of different battery sizes and combinations, including circuits and charging facilities, but consideration of maximum dependability, performance, and flexibility during periods of plant expansion.

e. DC load. The recommended procedure for determining the proper battery rating is outlined in IEEE 485. The standard classifies the total DC system load into the following categories:

(1) Momentary loads. Momentary loads consist of switchgear operations, generator exciter field flashing, voltage regulators, and similar devices. Momentary loads are assumed to be applied for 1 min or less.

(2) Noncontinuous loads. Noncontinuous loads consist of emergency pump motors, fire protection systems, and similar systems. Noncontinuous loads are those only energized for a portion of the duty cycle.

(3) Continuous loads. Continuous loads consist of indicating lamps, inverters, contactor coils, and other continuously energized devices. Continuous loads are assumed to be applied throughout the duty cycle.

f. Emergency loads. In cases where emergency lighting is excessive, the emergency load should be broken down into two separate loads:

(1) Thirty-minute emergency load. The 30-min emergency load consists of emergency lights that can be conveniently disconnected from the DC system when the location of the trouble has been determined.

(2) Three-hour emergency load. The 3-hr emergency load consists of the emergency lights required after the trouble area has been determined.

g. Battery capacity. Using the above load classes and durations and battery data obtained from manufacturer's literature, a station battery duty cycle is determined (see IEEE 485). The battery capacity required is determined as the sum of the requirements for each class and duration of load comprising the duty cycle.

h. Battery and accessory purchase. The batteries, with their accessories, indicating cell connectors, hydrometers, cell number, etc., are normally purchased through the GSA Schedule. Standard battery racks for the battery installation may also be obtained through GSA Schedules.

i. Safety considerations. Standard rack performance criteria should be evaluated to ensure compliance with plant requirements. Seismic considerations and other factors may dictate the need for special racks and special anchoring needs. The racks, anchors, and installation practices, including seismic considerations, are discussed in IEEE 484 and IEEE 344. Electrical safety considerations for battery installations are covered in Article 480 of the National Electrical Code (NFPA 70).

11-3. Battery-Charging Equipment

Static charger sets are preferred for battery-charging service. Two sets should be provided so one will always be available. The charger capacity should be sufficient for supplying the continuous DC load normally carried while recharging the station battery at a normal rate. The chargers should be of the "battery eliminator" type (additional filtering) allowing them to carry station DC loads while the battery is disconnected for service. The battery-charger systems should be located near the battery room, usually in a special room with the battery switchboard and the inverter sets. Standard commercial features and options available with station and communication battery chargers are outlined in NEMA PE5 and PE7.

11-4. Inverter Sets

One inverter set should be provided in all plants where it is necessary to maintain a continuous source of 120-V AC. A separate supply bus for selected 120-V AC single-phase feeder circuits should be provided for SCADA, recording instrument motors, selsyn circuits, and communication equipment. A transfer switch should be provided to automatically transfer the load from the inverter output to the station service AC system feeder in case of inverter failure. Standard commercial features and options available with inverters used in uninterruptible power supplies are outlined in NEMA PE1.

11-5. Battery Switchboard

Battery breaker, DC feeder breakers, ammeters, and ground and undervoltage relays should be grouped and mounted in a battery switchboard.