Chapter 2
General Requirements

2-1. Location of Powerhouse

a. Determining location. The location of the powerhouse is determined by the overall project development. The factors affecting the location include:

(1) Location of the spillway (when powerhouse is located adjacent to the dam).

(2) Location of navigation locks (on navigation projects).

(3) Foundation conditions.

(4) Valley width.

(5) River channel conditions below dam.

(6) Accessibility.

(7) Location of switchyard and transmission lines.

b. Local conditions. At projects where the powerhouse is located at the dam adjacent to the spillway, local condition such as width of flood plain, accessibility, and depth of foundations will usually govern the location. On projects which will include a navigation lock, the powerhouse is preferably located at the opposite end of the spillway from the lock. Where the river channel below the dam has an appreciable fall, economic studies should be made to determine whether a remote powerhouse location downstream from the dam is justifiable.

c. Sub-structures. At low-head projects, the substructure of the powerhouse may be wholly or partially incorporated into the design of the intake structure. At medium-head plants, the substructures of the generating units and the upstream generator room wall should be separated from the toe of a concrete dam, and any part of the powerhouse supported thereon, by a formed joint. See paragraph 4.7 for additional joint details. The amount of separation between the powerhouse substructure and the toe of the dam at, or below, the elevation of the generator room floor may be dependent upon the foundation conditions, but the separation is frequently as much as 10 feet or more to provide adequate space to install service facilities.

2-2. Location of Switchyard

The availability of suitable space will, in a great many cases, determine the location of the switchyard. Consideration should be given to the number and direction of outgoing transmission lines. The elevation of the switchyard should be established above design high tailwater. The most desirable and economical location is usually adjacent to or near the powerhouse.

2-3. Highway and Railroad Access

In planning the development of the site, both highway and railroad access to the powerhouse, switchyard, and other structures should be considered. Highway access to the plant should usually be provided. At plants where large generating units are to be installed, an access railroad should be considered if feasible and economically justified, consideration being given to utilizing the railroad connection which will usually be required for construction of the dam. Trucking costs from the nearest rail point, together with all handling costs should be compared with the cost of constructing and maintaining a railroad to the plant. The location of the highway or railroad access into the powerhouse will be determined by the approach conditions in the valley and the arrangement of the powerhouse. The access facilities should, where possible, be located so that their use will not be impaired by design high water. It is not essential that the railroad entrance be located above high water, especially where the flooding period would be of short duration; however, provision for bulkheading of the railroad entrance should be provided, and an access protected from design high-water conditions should be provided for personnel.

2-4. Other Site Features

Area should be provided for both public and employee parking. Sidewalks, guard rails, fences, locked gates, parapets, and other safety features should be included in the general plan. Adequate drainage, a water supply, and lighting should be provided in the areas near the powerhouse. Landscaping should also be considered in the studies of the site development.

2-5. Types of Powerhouse Structures

Three types of powerhouses classified as to method of housing the main generating units are described:

a. Indoor type. The generator room is fully enclosed and of sufficient height to permit transfer of equipment by means of an indoor crane.

b. Semi-outdoor type. The generator room is fully enclosed but the main hoisting and transfer equipment is a gantry located on the roof of the plant and equipment is handled through hatches.

c. Outdoor type. In this type there is no generator room and the generators are housed in individual cubicles or enclosures on, or recessed in, the deck.

2-6. Selection of Type of Powerhouse

This determination will be made on the basis of an economic analysis which takes into consideration, not only first cost, but operation and maintenance costs. While there is some structural economy inherent in outdoor and semi-outdoor plants, it does not necessarily offset increased equipment costs. An outdoor type of plant may be competitive with an indoor type at a site having low maximum tailwater and where the number of generating units to be provided is sufficient to minimize increased crane costs. The structural economy of a semi-outdoor plant is marginal since the only saving is in wall height, while the roof, which is actually the working deck, must generally sustain higher live loads. It is emphasized, however, that selection of type, for any given site, can only be made after a thorough study.

2-7. General Arrangement of Powerhouse

In general, a powerhouse may be divided into three areas: the main powerhouse structure, housing the generating units and having either separate or combined generator and turbine room, erection bay, and service areas.

a. Main powerhouse structure. The generator room is the main feature of the powerhouse about which other areas are grouped. It is divided into bays or blocks with one generating unit normally located in each block. The width (upstream-downstream dimensions) of the generator room for the indoor type should provide for a passageway or aisle with a minimum width of 10 feet between the generators and one powerhouse wall. The height of the generator room is governed by the maximum clearance height required for dismantling and/or moving major items of equipment, such as parts of generators and turbines; location of the crane rails due to erection bay requirements; the crane clearance requirements; and the type of roof framing. All clearances should be adequate to provide convenient working space but should not be excessive. The elevation of the turbine room floor should be established so as to provide a minimum requirement of 3 feet of concrete over a steel spiral case, or a minimum roof thickness of 4 feet for a semi-spiral concrete case. In establishing the distance between the generator and turbine room floors, if they are not combined, the size of equipment to be handled in the turbine room, the head room between platforms in the turbine pit, and the generator room floor construction should be considered.

b. Erection bay. In general, the erection bay should be located at the end of the generator room, preferably at the same floor elevation and with a length equal to at least one generator bay. The above length should be increased sufficiently to provide adequate working room if railroad access is provided into the erection bay at right angles to the axis of the powerhouse; however, no additional space should be required if the access railroad enters from the end of the powerhouse. In cases where the elevation of the crane rail would be dependent on the requirement that a transformer with bushings in place be brought under the crane girder, consideration should be given to the possible advantages of revising the layout to permit bringing the transformer in at the end of the structure, at the end of the generator room, if the generator room is at a lower elevation than the erection bay, or removing bushings before moving transformer into powerhouse. If the height required for untanking a transformer appears to be the controlling dimension, a study should be made of the economy of installing a hatchway and pit in the erection bay floor to provide the required height.

c. Service area. Service areas include offices, control and testing rooms, storage rooms, maintenance shop, auxiliary equipment rooms, and other rooms for special uses. For plants located at the toes of gravity dams, the space available between the generator room and the face of the dam is a logical location for most of the features enumerated above. However, in all cases an economic study, which should include the cost of any added length of penstock required, should be made before deciding to increase the space between the dam and powerhouse to accommodate these features. The offices are frequently located on upper floors, and the control room and other service rooms on lower floors. The most advantageous location for the maintenance shop is usually at the generator room floor level.

d. Space allocations. Space should be provided for some or all of the following features and uses, as required:

(1) Public areas: main public entrance, reception area, public rest rooms, exhibits, and elevator.

(2) Employee areas: employee entrance, equipment entrance, offices, office storage, rest rooms for office use, control room, rest rooms for control room operators, kitchen for control room operators, repair and test room for instruments, main generator rooms, main turbine rooms, station service or fish water units area, erection and/or service areas.

(3) Shops: machine, electrical, electronic, pipe, welding, sheet metal, carpenter, and paint with spray booth.

(4) Storage and miscellaneous areas: storage battery and battery charger rooms, cable galleries, cable spreading room under control room, telephone and carrier current equipment room, oil storage tank room, oil purification room, storage for paints and miscellaneous lubricants, storage rooms, locker rooms with showers and toilet facilities, first aid room, lunch room with kitchen facilities, elevator, heating, ventilation, and air conditioning equipment rooms, and auxiliary equipment rooms.

2-8. Location of Main Power Transformers

The choice of location of the main power transformers is inter-related with the selection of the type and rating of the transformers. The selection of single-phase or 3-phase type of transformers, the method of cooling, and the kVA rating are also directly related to the basic switching provisions selected for the plant, the number and rating of generators associated with each transformer or transformer bank, and the location of the transformers. In order to determine the most suitable and economical installation, including the type, rating, and location of the main power transformers, adequate studies, including comparative estimates of total installed first cost and total annual cost for each scheme studied, should be made during the preliminary design stage along with studies to determine the basic switching arrangement and general arrangement of the powerplant. Locations at which the main power transformers may be placed are: between the powerhouse and dam, on the draft tube deck, in the switchyard, and near the powerhouse but not in the switchyard. From the viewpoint of electrical efficiency, the power connections between the generators and transformers should be as short as practicable. This consideration favors the location of the transformers at or near the powerhouse. In deciding between the upstream or downstream location at the powerhouse, consideration should be given to the location of the switchyard and the nature of the high-voltage connections between it and the transformers. In some cases the location of the transformers on the draft tube deck may increase the cost of the powerhouse structure. However, if such a location makes possible a direct overhead connection to the switchyard, this feature may more than balance any increased cost of the structure. At small plants and, where the switchyard can be located close to the powerhouse, a transformer location in the switchyard may be economical. Where transformers are located between the powerhouse and dam, special high-voltage cable connections to the switchyard may be required. In selecting the location for the transformers, as well as in planning the general plant arrangement, consideration should be given to the requirements for transporting and untanking the transformers.

2-9. Powerhouse and Switchyard Equipment

The connection between items of equipment in the powerhouse and switchyard will require special study in each individual case. The connections fall into three classes described below:

a. Main power connections. In general, when the main power transformers are located in the switchyard, the main power connections between the powerhouse and switchyard should be carried in an underground tunnel or duct bank. When the transformers are at the powerhouse, consideration should be given to the economy and advantages of overhead connections.

b. Control cables and power supply to switchyard. The number and types of these connections require that they be run underground. For best protection from dampness and for ease of inspection and replacement, a cable tunnel is usually justifiable in major plants. In small plants, the cables are sometimes run in conduits or duct banks from the powerhouse to a distributing point in the switchyard.

c. Oil piping. It is desirable to concentrate oil purification operations and oil storage in the powerhouse. This concentration requires connections between the switchyard and powerhouse for both clean and dirty insulating oil. If a tunnel is required for electrical connections, these pipes can be run in the same tunnel; otherwise, they must be buried underground. If the switchyard is some distance from the powerhouse, a separate oil purification and storage system may be more economical. Oil piping or tanks buried underground must meet local, state, and Federal regulations for environmental protection.

d. Drains. Any drains that may handle a mixture of oil and water should be connected to an oil/water separator.

2-10. Powerhouse Auxiliary Equipment

In planning the general arrangement of the powerhouse, space must be assigned in all of the auxiliary electrical and mechanical equipment that will be required. The location of the auxiliary equipment must also be considered with respect to the location of the main equipment with which it is associated. The following is a list of auxiliary equipment and systems usually required for powerplants. It is not expected that all items listed will be incorporated in all plants. The size, service, and general requirements of the plant will usually determine which items are necessary: water supply systems for raw, treated, and cooling water, unwatering systems, insulating and lubricating oil transfer, storage and purifications systems, compressed air systems, turbine governing equipment, fire protection, detection and annunciation, heating, ventilating, and air conditioning systems, turbine flow meters, water level transmitters and recorders, elevators, main generator excitation equipment, station service power generating units, station service transformers and switchgear, main unit control boards, station service control boards, storage battery and chargers, inverter, electronic equipment (carrier current microwave), telephone and code call system, maintenance shop equipment, sewage disposal equipment, auxiliary equipment for oil-filled or gas-filled cables, emergency engine-driven generator, incinerator, station drainage system, generator voltage switchgear, metal-enclosed buses, and surge protection equipment, air receivers for draft tube water depressing system, heating, ventilation and air conditioning switchgear, lighting transformers and switchgear, unit auxiliary power centers, electrical shop, transformer oil pumps and heat exchangers (when located remote from the transformers), and generator neutral grounding equipment and switchgear.