Chapter 6
Submergible Tainter Gates

6-1. Design Analysis

The design of a submergible tainter gate is similar to that of a spillway tainter gate. Guidance in EM 1110-2-2702 should be followed. Navigation locks are wider and have lower forebay heads than spillway gates. Because of the greater lock widths, the gates main horizontal structural members will be trusses or plate girders. Secondary stresses in truss joints should be considered. Because of lock clearance requirements, trunnion anchorages are placed in lock wall recesses. Anchor bolts require special considerations in design. Eccentricity of hub alignment during construction introduces some additional stresses during gate operation. A typical navigation lock plate girder, submergible tainter gate is shown in Plates B-45 and B-46.

6-2. Seal and Gate Deicing

Devices for preventing the formation of ice, or to thaw ice adhering to the gates and seals, will be necessary for the lock to function during subfreezing weather. Lock operation in winter will be facilitated by the use of deicing (and trash clearing in all seasons) systems described.

a. Heaters. Two types of electric heating systems can be used for gate seals; one is by direct heating the seal by an electrical resistance element inserted below the seal face and the other by circulating electrically heated heat-transfer oil.

(1) Direct electrical heating. Replaceable heating elements can be installed in recesses in back of the seal surfaces to be kept thawed, the recesses being insulated so as to direct heat toward the surface to be heated. Because of the length of the sill seal and its inaccessibility, it is impractical to use this method across the bottom of the gate.

(2) Heating by circulating fluid. The usual method of seal heating is done by a design circulating heat-transfer oil through pipes built into the seal plates next to the surface to be thawed. Immersion-type electrical heating units, thermostatically controlled, heat the oil which is forced through the pipes by circulating pumps. The heating stations are located in the hoist machinery spaces at opposite ends of the gate.

b. Air deicing and trash clearing systems. Air nozzles at about 10-ft spacing and 4-ft^3 free air per minute per nozzle terminate both upstream and downstream of the gate face. The air discharging from these nozzles carries the warmer water to the surface (when water temperature is below 39 deg F) and melts any ice buildup at the surface. This air system is most useful in clearing floating debris from the path of a rising gate at all times of the year. The air to the upstream nozzle sets is controlled by two sets of reducing valves to prevent one set from "hogging" to the lower outlet pressure. The upstream and downstream air control valves are separately operated from the gate control stand to be used at the discretion of the lock operating personnel.

6-3. Operating Machinery

a. General description. The machinery used to operate lock-type tainter gates usually consists of two equal hoist units of contra-facsimile design arranged to lift each end of the gate. The hoist units are kept in synchronism by power selsyn motors. Each hoist unit consists of a rope drum, open gear set, speed reducer, magnetic brake, hoist motor, and power selsyn. The drum is mounted on a cantilevered shaft of a size to prevent excessive error in the mesh of the final drive pinion and gear due to shaft deflection. A general arrangement of an electric-motor-driven hoist for the lock-type tainter gate is shown in Plate B-60.

b. Design considerations and criteria. The design capacity of the hoist should be based on the maximum load at normal speed which is found to be at the nearly closed or raised position. The hoisting speed should be selected so as to raise the gate from full open to closed in 2 to 3 min, varying so as to allow the selection of a motor of standard horsepower and speed. General criteria applicable to the design and selection of various hoist components are presented in paragraph 1-11. Shock, impact, and wear factors are considered negligible and may be disregarded. Wire rope for these types of hoists should be stainless steel, lang lay, style G, flattened strand. Drum diameter should not be less than 30 times the rope diameter.

c. Determination of machinery loads. The maximum dynamic load on the hoist normally occurs near the end of the raising cycle. The maximum holding rope load occurs when the gate is fully raised and the lock water level is below the upper sill. No consideration should be given to rope loads created by the flow of water over a partially opened gate. The rope loads from these conditions are indeterminate and control features are provided to prevent their occurrence. The total load on the rope drum is the sum of the following:

(1) Deadweight of the gate as applied to a moment arm (W × CG) divided by the perpendicular distance of the rope to the gate trunnion center line.

(2) Side seal friction (total seal force × 0.05).

(3) Weight of the ropes can be neglected.

(4) Trunnion friction less than 200 lb can be neglected.

(5) The static load of the water head on the unbalanced area on the bottom seal when the lock level is down.

(6) Ice buildup and silt formation should be considered when severe freezing or silt-loaded water are factors. The air deicing and seal heating systems usually minimize these factors.

d. Operating machinery control.

(1) General. The electrical equipment for the operation of a power selsyn drive for the hoists for a tainter gate consists of two squirrel-cage induction-type motors, two wound rotor induction motors (synchronizing drive), two electrically operated brakes, two limit switches, and a control system that will provide operating features applicable to the particular installation. Equipment meeting the requirements of Guide Specification CW-14615 is considered to be the best suited for the service.

(2) Motors. The squirrel-cage induction motors should have high-torque high-slip (between 8 and 10 percent) speed torque characteristics with drip-proof frames as this equipment is usually located indoors. The drive motor should be continuous rated and sized to drive the gate machinery without overload during any portion of the operating cycle. No arbitrary limit should be placed on motor speed other than that which is practical and economical. The wound rotor motor for synchronizing shall be of the same horsepower rating as the drive motor, as it may be necessary, under some circumstances to provide the full torque of a drive motor. For the protection of the motor windings, means shall be taken to provide winding heaters or encapsulation. Motors should be specified in accordance with the applicable provisions of Guide Specification CW-14615.

(3) Brakes. The brakes should be of the shoe or split-band type, spring-set with direct current magnet-operated release, suitable for floor mounting and should be provided with NEMA 12 moisture-resisting, enclosing case. The brake mechanism should be of corrosion-resistant construction using nonferrous parts for bearings, pins, etc. The necessary direct current for operating the brake should be obtained from a rectifier mounted within the controller enclosing case. The torque rating of the brake should be of a value corresponding to approximately 150 percent of full load motor torque when referred to the shaft on which the brake wheel is mounted. A space heater should be provided within the brake enclosure as required in Guide Specification CW-14615.

(4) Control. The control equipment consists of a combination of magnetic controllers, limit switches, control stations, and remote gate position indication as shown in Plate B-74. The main control station (remote from the equipment) is located at the upstream control stand along with the other controls for the navigation lock. A local control station along with a local-remote transfer switch is located in one of the machinery rooms, and is provided for operation of the equipment during maintenance. The control equipment may be located where convenient but usually in one central location in a control center. The rotors of the two wound rotor motors are connected so that when the stators are energized from a common tie through a controller the rotors will rotate in a common direction, either raise or lower. When final adjustments are being made and the gate leveled, the rotors are synchronized with the couplings disconnected. The stators are energized first single-phase and then three-phase to pull the rotors into synchronism. Then the couplings are connected while the gate is in level condition supported on the ropes. During normal operation the drive motor, wound rotor motors, and brakes are all energized simultaneously and run until stopped by a limit switch in either the open or closed position or by the movement of a control switch to the stop position. During the stopping sequence, both the drive motors and brakes are de-energized but the wound rotor motors remain energized for a short time (5 sec) while the brakes are setting. This prevents skewing of the gate should the brakes set unevenly because of wear or misadjustment. A synchro system is used to show gate position at the control stand. A system of interlocks is used in the control circuit to prevent opening the gate at a time which might cause damage to the equipment or create hazardous conditions. Among these is a differential level circuit which will allow opening the gate only when the water surfaces on

either side of the gate are nearly at the same elevation. Control voltage is obtained from the control transformer whose primary is connected to the load side of the wound rotor motor supply which prevents gate operation unless synchronizing power is available. The controllers are of the combination air circuit breaker disconnect and reversing magnetic contactor type, with thermal overload protection. The limit switch should be of the heavy duty, high-accuracy type in order to ensure reliable operation of the control system.