Chapter 7
Gates, Valves, and Bulkheads

7-1. General

This chapter provides a discussion of the various types of lock gates, valves, and bulkheads. The discussion includes advantages and disadvantages, geometry, and recommendations for application of different types.

7-2. Lock Gates

The primary function of lock service gates is to form a damming surface across the lock chamber. Depending on the specific type gate and the conditions at a particular project, lock gates can be used to fill and empty the lock chamber and to pass ice and debris. These gates can also be used to unwater the lock chamber and to provide access from one lock wall to the other by means of walkways or bridgeways installed on top of the gates. For further descriptions and details on lock gates, including cathodic protection and painting requirements, see EM 1110-2-2703. Seven different types of gate structures have been used in the past for lock service gates. These structures include the following: miter gates, submergible vertical lift gates, overhead vertical lift gates, submergible tainter gate, vertical axis sector gates, rolling gates, and tumbler gates. The horizontally framed miter gate has proven to be the best type lock gate based on operational efficiency and lower maintenance requirements. However, use of the submergible vertical lift gate, the overhead vertical lift gate, the submergible tainter gate, or the sector gate may be advisable because of specific project conditions and requirements. Because of recent technological advances, the rolling gate and the tumbler gate will probably not be used on future locks.

a. Miter gates. A miter gate has two leaves that provide a closure at one end of the lock. The miter gate derives its name from the fact that the two leaves meet at an angle pointing upstream to resemble a miter joint. Horizontally framed miter gates have many advantages over other gate types and have been used on more locks than any other type gate. Miter gates are rugged and do not involve complicated construction problems. Miter gates are also easily serviced and fast operating. The only drawbacks arise from the inability of the gates to operate under head and to withstand reverse head. Plate 6 illustrates a miter gate installation.

b. Lift gates.

(1) Submergible vertical lift gates. Submergible vertical lift gates can be used at the upstream end of a lock. If the lift is high enough, a single-leaf gate can be designed so that when it is lowered, it drops down along the downstream face of the sill block. If the lift is not as great as the upstream sill depth, the gate may have separate sections side-by-side that are raised and lowered individually. However, it is not recommended to use a submergible vertical lift gate in a situation where the leaf or leaves would have to rest on the bottom of the lock chamber or in a bottom recess when the gate is lowered. Debris and silt would cause operation problems and lead to high maintenance costs. A vertical lift gate can be designed to operate under either direct head or reverse head. The disadvantages of the vertical lift gate are high maintenance and operation costs and difficulty in controlling skew and misalignment. Plate 37 depicts a single-leaf vertical lift gate, and Plate 35 shows a submergible double-leaf vertical lift gate.

(2) Overhead vertical lift gates. The overhead vertical lift gate has been used as the downstream gate at several locks where the lift is great enough to provide sufficient overhead clearance when the gate is in the raised position. For example, this type gate has been used at the downstream end of the John Day, Ice Harbor, and Lower Monumental Locks. Overhead lift gates at these locks are rugged and heavy. They have the same general advantages as the submergible lift gates but require a much longer operation time--approximately 3 to 5 min. This type of vertical lift gate requires counterweight. Operation and maintenance problems are not as great with overhead lift gates as with submergible gates. Plate 37 shows an overhead vertical lift gate.

c. Submergible tainter gates. Submergible tainter gates have the same advantages as submergible lift gates, but they are subject to the same limitations with regard to their use in a low- or medium-lift situation. The lift must be great enough to allow the gate to submerge to below the sill without resting directly on the lock floor. Submergible tainter gates also have fewer operating and maintenance problems than vertical lift gates. However, if traffic is heavy, the longer operating time required for the tainter gate type closure can be a disadvantage. A submergible lock tainter gate is shown on Plates 7 and 36.

d. Vertical axis sector gates. A vertical axis sector gate, similar to a miter gate, requires two sections for closure of a lock chamber. Plates 13 and 14 show a sector gate installation. The two sector gate sections are used in pairs and are designed to rotate around a vertical axis and meet at the center line of the lock chamber. Since the hydrostatic pressure is toward the gate axis, there is very little unbalanced hydraulic force opposing opening or closing of the gate under any condition of head. Since sector gates can be opened or closed under a head, they can be used for filling and emptying locks with very low lifts. Sector gates can be designed to withstand head from either direction and are very useful at a tidal lock or at any situation where reversal of head occurs. The two principal disadvantages of sector gates are their cost and the amount of horizontal space they require.

7-3. Culvert Valves

Lock filling and emptying systems that have culverts in the lock walls require mechanically operated valves to control the flow of water into and out of the lock chamber. These valves are located in the culverts near the upstream and downstream ends of the lock chamber and are usually of the same height and width as the culvert. Two valves are required in each longitudinal culvert. One valve is located between the intake and lock chamber to admit the water in the filling operation, and the other between the chamber and the discharge diffuser to empty the lock chamber. A typical valve layout in a lock wall is shown in Plate 6. Further information on lock culvert valves can be found in EM 1110-2-1604 and EM 1110-2-1610.

a. Types of lock culvert valves. The different types of valves used in the past for controlling the flow of water into and out of the lock chamber include the following: reverse tainter valve, true tainter valve, stoney valve (vertical slide valve), butterfly valve, wagon valve (wheeled vertical lift valve), spool valve, and cylindrical valve.

b. Background. Currently, all medium- to high-lift major locks under construction use the reverse tainter valve. When the true tainter orientation was first used in the 1930's, the skin plate was located upstream with the supporting arms in compression. But this arrangement allowed large amounts of air to be drawn into the culverts from the valve shaft, and the air became trapped into the flowing water which hindered the water flow. When enough pressure developed, the water would enter the lock chamber and cause extreme disturbances in the downstream valve shaft and to small craft and moored vessels in the chamber. However, subsequent model tests of the reverse tainter valve with the skin plate downstream and the valve arms in tension showed that this arrangement prevented air from entering the culvert at the valve shaft, and thereby the entrapped air problem was solved. However, it was several years before the best results were obtained with a single skin plate vertically framed body. Many shapes of the valve body, such as double skin plates with both plates convex, double skin plates with concentric skin plates, using both covered support arms and arms with no special treatment, were model tested and built before the single skin plate vertically framed layout was finally adopted as the best arrangement.

c. Guidance. Structural stainless steel side seal guides must be furnished above the top level of the culvert, so that the valve is laterally supported and thus maintains its stability throughout its entire range of travel from the culvert floor to the fully open position. Selecting the proper type of rubber side seals and the top seal for culvert valves is important. The rubber seal should have teflon coating. The coating greatly reduces contact friction on the rubbing plates during valve movement. A "J" seal properly oriented, positioned, and adjusted has been found to be the most suitable choice for use as side seals. The top seal may be either a block type or a "J" seal.

d. Maintenance bulkheads for culvert valves. Culvert bulkhead recesses, which extend from the top of the lock wall to the floor of the culvert are provided immediately upstream and downstream of each culvert valve shaft. This arrangement allows bulkheads to be lowered to the floor of the culvert for unwatering of the individual valve shaft for culvert valve inspection and repair without the necessity of shutting down the entire lock. In this case, the lock chamber can be filled and emptied through the other culvert at a reduced rate of speed. Also, during lock unwatering, the two extreme upstream and downstream bulkheads are put in place so that all four valves may be inspected and serviced. Usually, the culvert bulkheads are stored on hangers at the top of the recesses for easy access in case of valve failure. At least four bulkheads must be provided so that the entire lock chamber can be unwatered. Bulkheads may be constructed of structural steel, high-strength low alloy steel, or aluminum, and may be one piece or sectional. Sectional bulkheads are especially adaptable when a mobile crane with limited lifting capacity is provided at the lock. The bulkheads should be designed for the hydrostatic head from the maximum anticipated upper pool level to the culvert floor. These bulkheads are designed neither to be lowered to the culvert floor in flowing water nor to be removed when an unbalanced head exists. Therefore, some means must be provided for bypassing the bulkheads and filling the valve shaft so that the bulkheads may be removed under balanced head. Recesses downstream from the filling valves are often equipped with horizontal sealing diaphragms just above normal lower pool to prevent air from being sucked into the culvert during the lock-filling operations. The diaphragms must be removable for placement of the bulkhead when needed.

7-4. Lock Chamber Bulkhead Closures

In addition to the normal operating (service) gates, all locks should have temporary closures for unwatering the lock chamber during maintenance activities. These closure structures can be stored either at the site or at a central location if used for several locks. Installation can involve the use of cranes, stiffleg derricks, derrick boats, and divers. Maintenance closure structure types include sectional bulkheads, poiree dams, needle dams, and floating caissons which are installed in a static (balanced) pool. Some locks need to have upstream emergency closures bulkheads which can be used to stop the flow of water through a lock chamber. These bulkheads are used in cases in which flow through the lock is allowed during open-river conditions or the service gates should fail to operate properly or be damaged by traffic so they will not close. Emergency closure structure types include stacked sectional bulkheads and vertical lift gates (overhead or submerged) which can be installed in flowing water. Figure 5-2 shows a typical installation of bulkheads that can be used for either maintenance or emergency procedures.