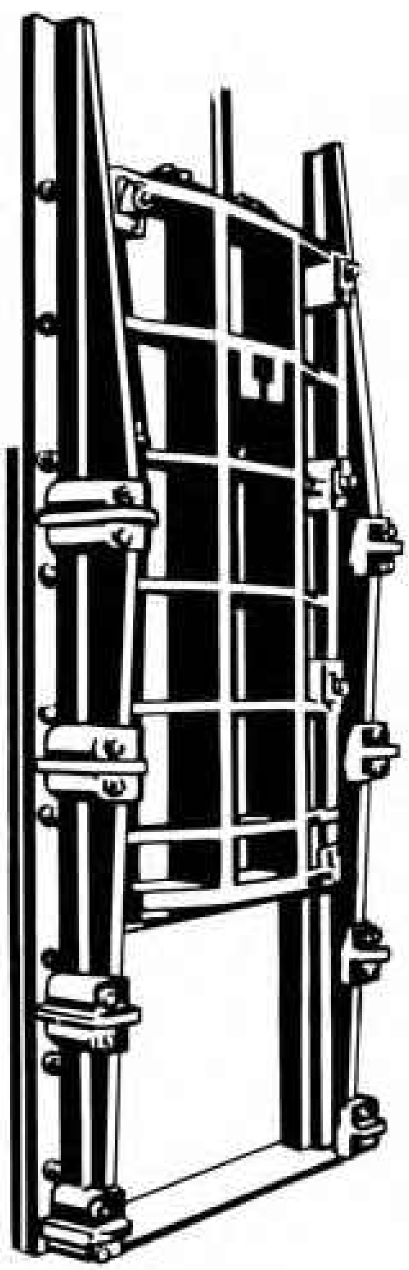
RODNEY HUNT®

Seminar Report:

Anatomy of a Sluice Gate

An In-depth Review of Sluice Gates and Related Systems



INTRODUCTION

This information was abstracted from Seminars given to consulting engineers and reflects the most often raised questions at these Seminars. Sluice gates, in essentially their present form, have been used to control water for many years but they are not in as common use as gate valves, butterfly valves and other in-line valve equipment. Because of this, we at Rodney Hunt, are continually asked to assist in the selection of sluice gates and to answer questions concerning their application. Answering these questions is an essential part of our service to this market. It is hoped that by presenting answers to the more common questions, further interest in sluice gates will be stimulated and there will be more widespread knowledge of their characteristics, limitations and application.

What is a sluice gate?
A sluice gate is a cast iron, vertically sliding valve having bronze seating surfaces and adjustable bronze wedges. It is used at the end of a pipe line or to cover an opening in a wall and is not an in-line valve. Sluice gates are raised and lowered by means of a stem or rod using a manually operated screw stem hoist, an electrically driven screw stem hoist or a hydraulic cylinder. Sluice gates are mounted to a pipe flange, to a wall casting or thimble embedded in the concrete or directly to the conc rete wall with anchor bolts.

What are the variations in types of gates?
There are a large number of variations of sluice gates.
Sluice gates can be furnished with flange or flat frames, which are the mounting surfaces of the sluice gate.
They can be furnished with conventional closure with bronze seats completely around the periphery or with a resilient seal across the bottom of the gate for flush-bottom closure.
In the normal gate, the operating thrust is taken on the floor or a separate support above the gate. All sluice gates can be furnished as self-contained gates in which the operating device is mounted on the yoke of the gate which is, in turn, attached to the top of the guides. On these gates the operating thrust is taken by the gate itself.
Most sluice gate applications use a rising stem in which the threads are at the operator and the stem moves up and down with the gate. It is possible, however, to provide sluice gates with non-rising stems. On these installations the threaded section of the stem is at the gate and the disc climbs the stem as the stem is turned.

What is the practical size limitation of sluice gates?
The largest gate we've made measures 16 ft. x 16 ft., which is about the largest practical size for a sluice gate. On the other side of the scale, it is possible to make a gate as small as 4 or 6 inches, but, we recommend other types of valves for openings smaller than 12 inches.

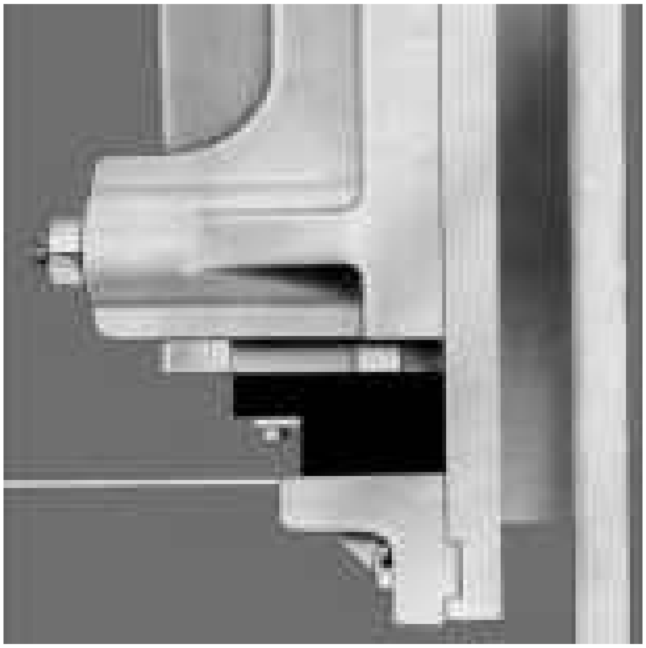
What is the head limitation on sluice gates?
The maximum head under which a sluice gate can be used depends primarily on the type of application and the size. Sluice gates can be designed to withstand seating heads of 200 ft. and unseating heads of 100 ft., but for heads greater than 80 ft. seating and 50 ft. unseating, the sluice gate manufacturer should be consulted. If the sluice gate is an extremely large gate or if it is to be used under unusual conditions, such as throttling or modulating service, perhaps some modification will be required to make the gate suitable for that service.
Normally, a further limitation on the amount of head under which a gate can be used is the operating thrust necessary to open and close the gate. This thrust is usually limited to approximately 150,000 lbs., which is equivalent to a 10 foot gate under a head of approximately 60 ft.

What is the difference between flange and flat frames?
The flange frame consists of two flanges. The back flange is used to mount the gate to the pipe flange, wall thimble or wall. The front flange provides a mounting surface for the seat facings and guides. On the flat frame gate both of these flanges are combined into a single flange.
The primary difference between these types of frames is the installation clearance requirements. Because it is necessary to reach around the front flange for access to the mounting bolts on the flange frame gate, a clearance of approximately 8 inches on each side of the gate is recommended. With the flat frame, the mounting bolts extend through the frame and guides and are accessible from the front of the gate. An installation clearance of only 1 inch is required.
The size of the gate, the head under which it is to be used, the leakage specifications and the type of gate is not a consideration in the choice of a flange or flat frame. Either the flange or flat frame can be used on almost all sluice gate installations. The major exception is when the gate is to mount on a circular pipe flange. There, a flange frame gate must be used.

What makes a well designed guide? Because high loads exerted by the side wedge system must be resisted by the guides, their design is of critical importance. On gates over 24 inches, Rodney Hunt uses a reinforcing rib extending from the flange of the guide over the top of the wedge seat. The guides are bolted and doweled to the frame. Once in position they cannot be moved. This rib helps to make the entire wedge seat system extremely strong and rigid.

Why are wedges used on gates?
Wedges are used to insure tight contact between bronze seat facings. Wedges are cast bronze, machined on their contact surfaces and once adjusted, are positively held in place with a locking nut on the silicon bronze adjusting bolt.
Three types of wedges are used on sluice gates. Top and bottom wedges, specified for gates designed for unseating heads, are hook-type configurations which seat onto machined bronze loops attached to the frame. As the gate moves into a closed position, the wedges pull the top and bottom seats into contact.

The side wedge system, used on all gates, is the most critical. It must resist the vertical loads placed on the gate when closing and assumes most of the unseating head loads. Because it is virtually impossible to spread these forces equally on all wedges, the loads assumed by the side wedge system can be high.



What is a Rodney Hunt flush-bottom closure sluice gate?

This is a gate that uses a wide resilient seal on the bottom edge of its disc. The seal takes the place of a bronze seat. Seal materials, normally a chemical and oil resistant neoprene elastomer with low water absorption properties, is attached to the disc with a stainless steel plate and attaching screws. Because of its position on the disc it is not exposed to sunlight and does not deteriorate. It is compressed against a machined cast iron stop-bar which, in turn, is bolted and keyed to the frame.

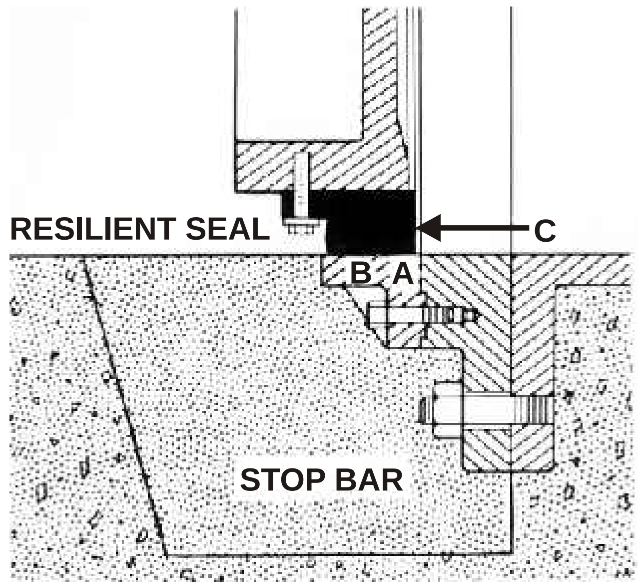
Rodney Hunt introduced the flush-bottom closure gate in 1952. It makes use of a Hy-Q seal that has withstood thousands of closings and openings without permanent deformation. Since its introduction, we have not replaced a Hy-Q® seal because of deterioration or damage.

When should a flush-bottom sluice gate be used?

Primarily, when you want to avoid a cut-out in the floor or a wall beneath the gate where debris can collect. When you want a completely flush draining of the chambers. And when you want maximum head and increased coefficient of discharge.

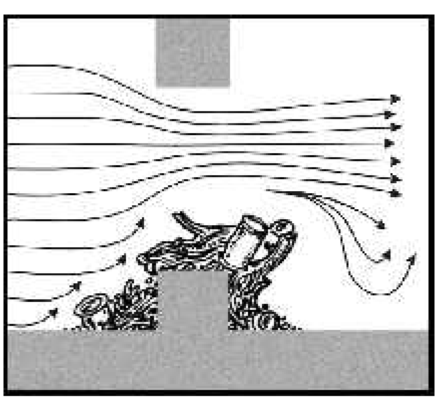
Can flush-bottom closure gates be made to seal at the corners?

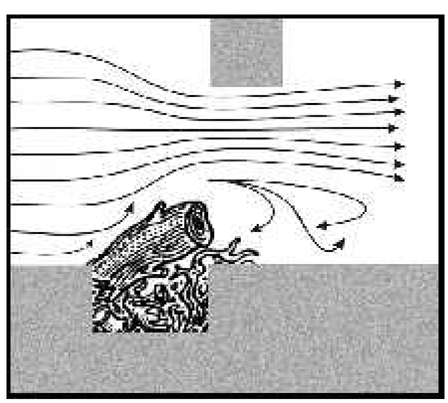
Yes. Although making a tight corner seal has traditionally been a most difficult problem in the design of flush-bottom closure gates, we have found a very workable solution. Specifically, we use a special, wide-seal shape which keeps its vertical face in direct contact with the bronze side seat facings while its bottom surface is compressed against a cast iron stop-bar.

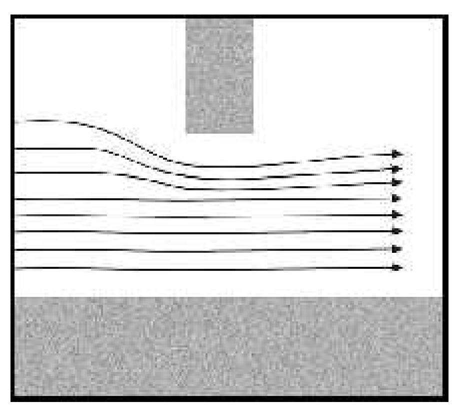


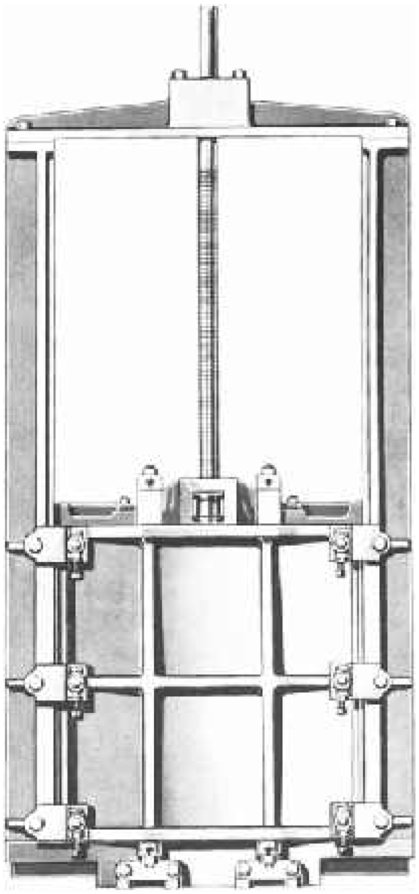
What are the limitations on the use of a flush-bottom gate?

The flush-bottom closure gate has no limitations that do not exist for the conventional sluice gate. They can be used in any application where conventional gates are









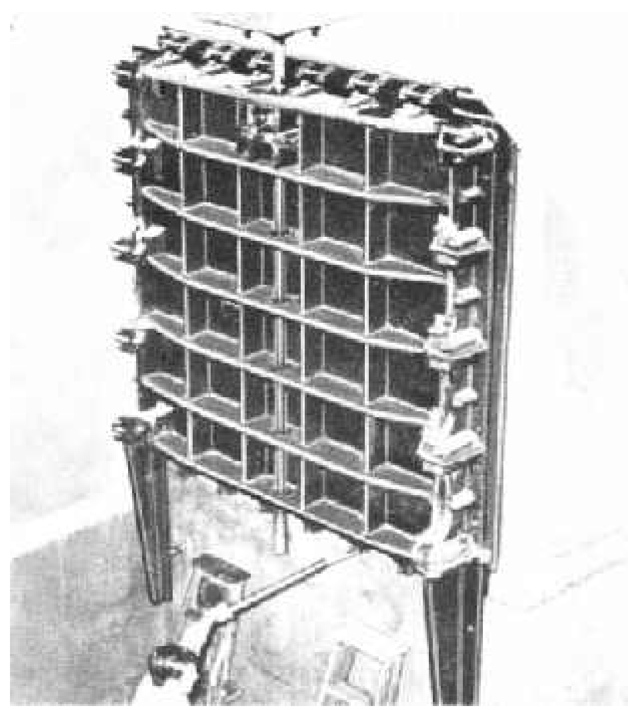
What is a self-contained sluice gate? The self-contained gate differs from the conventional gate in that it absorbs the operating load created during opening and closing. This is accomplished through the use of a yoke or supporting member mounted on the top of extended guides. The force required to operate the gate is transmitted by the yoke and guides directly back to the gate.

Self-contained gates are available with both rising and non-rising stems. The non-rising stem is the most common on gates with dimensions of 24 inches or under. Because operating forces on small gates are low, nonrising stems can be successfully operated with a T-handle wrench acting on an operating nut attached to the stem.

Where are self-contained gates recommended?
The self-contained gate is ideal where there is no concrete floor above the gate or where it is impractical to build a structure to take the load. By mounting the floorstand or benchstand directly on the yoke, the operating thrust is taken by the gate. There are no limitations for the self-contained gate that do not exist for conventional gates. They are available in the same sizes and for the same heads as conventional gates.

Why should non-rising stems be avoided?
Whenever possible, the use of non-rising stems should be avoided. Because the threaded part of the stem is normally submerged, it is impossible to lubricate it. Any debris and rubbish jamming into the thread creates wear and makes the gate very difficult to operate.

What is an inverted gate?
An inverted gate is a conventional gate designed to lower to open. Its best application is where there is no adequate clearance between the opening and the floor above the gate to allow the disc to raise to open. It can also be useful for decanting from a reservoir or tank, although flow along the bottom and side may prevent precise level control.



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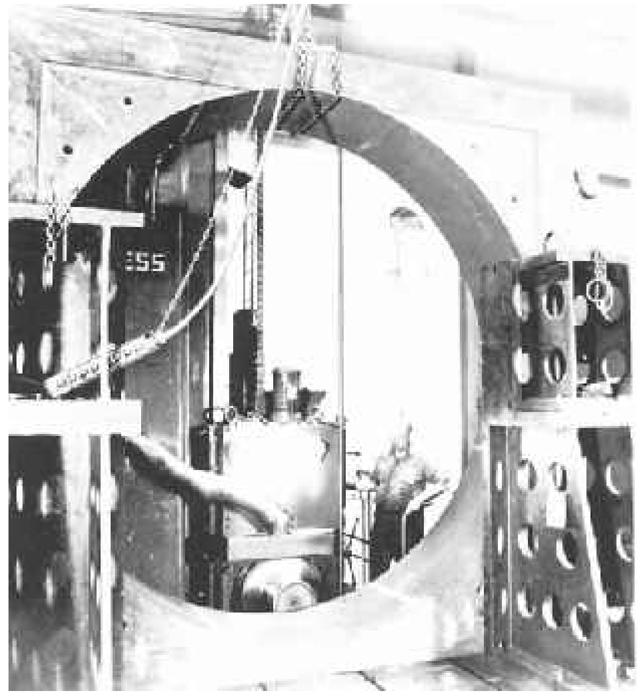


What construction materials are used in the manufacture of sluice gates?

The materials suitable for most sluice gate applications are: Cast iron in the frame, disc and guides, ASTM A-126, Class B. Bronze castings, for wedges thrust nut, lift nut and couplings, ASTM - B147, Alloy 8A, (Copper Alloy No. 865). Bronze seat facings in frame and disc ASTM B-21, Alloy B, extruded (Copper Alloy No. 482). Bronze for stems, ASTM 8-138, Alloy A (Copper Alloy No. 675). Stainless steel for stems and fasteners, ASTM A-276, Type 304 or ASTM A-582, Type 303. Bronze for adjusting screws and mounting and attaching bolts, ASTM B-98, (Alloy A, Copper Alloy No. 655). Stainless steel for mounting and attaching bolts, ASTM A-276, Type 304.

When is the use of special materials justified?

Bronze having less than 2% aluminum and 5% zinc should be used where dezincification of bronze can occur. AWWA specifications are quite clear on the types of water producing dezincification. If faced with this problem, we recommend seat facings of phosphor bronze or silicon bronze and castings of silicon bronze, both of which have no zinc or aluminum.

In some industrial wastes, it may be necessary to use stainless steel seat facings, but this should be avoided whenever possible. Stainless steel has a tendency to gall when rubbed in contact with itself. The same is true of wedges and wedge seats which are also in sliding contact.

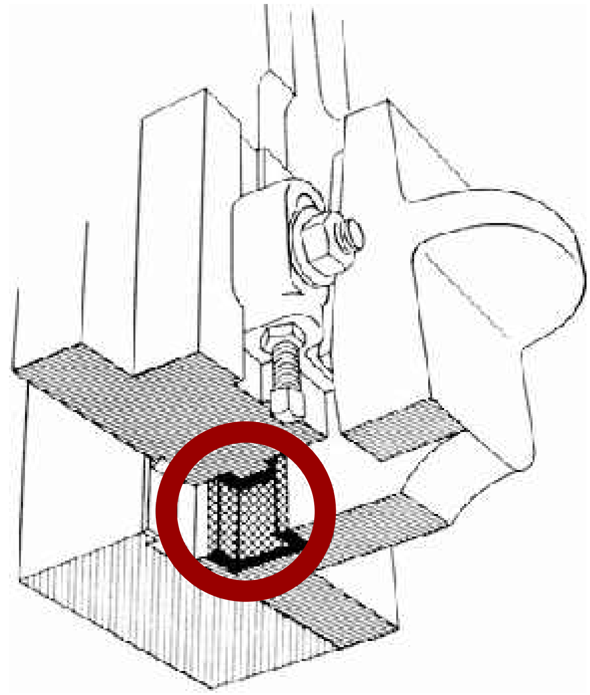
What are some of the factors affecting drop tight gate guarantees?

There isn't a sluice gate manufacturer who will guarantee a drop tight gate. A gate can be designed and manufactured and tested in the shop to produce a very low leakage rate but installation factors are beyond the control of the manufacturer. And they can seriously affect leakage characteristics. How was the gate stored? Was it installed on a flat surface? Have the bolts been tightened evenly? Have the seats been damaged by concrete spillage? All of these factors make guarantees impractical.

What should the leakage specification require?

AWWA specifications maintain that leakage under seating head should not exceed 0.1 gpm per ft. of perimeter. Under unseating heads up to 20 ft., leakage should not exceed 0.2 gpm per ft. of perimeter. To figure permissible leakage beyond that point use the square of the head over the square of 20 and multiply by 0.2 gpm per ft.

This is not a sufficiently tight specification. It is our opinion that leakage limits of 0.1 gpm per ft. of perimeter can be maintained for normal sluice gate applications required to withstand all seating heads and unseating heads up to 50 ft.



What's the best way to control the operation of a modulating gate?
We generally recommend the use of hydraulic cylinders. Hydraulic cylinders are made to oscillate and do not present the problem of stem nut wear. Fail-safe closure can be easily provided, something that is not easily achieved with electric floorstands. If electric operators are used, we recommend that the size of the hoist unit and the motor be one size larger than normally required.

How do you specify sluice gates for throttling heads?
Designing gates for throttling heads requires knowledge of the severity of the head and the extent to which the gate will be left in a partially open position. Sluice gates can be used for throttling heads up to 40 ft. without difficulty. However, for heads over 40 ft. excessive vibration may occur. This vibration can be damaging to the gates and can cause loosening of the stem guides, reducing the support for the operating stem. Long periods of operation with the gates slightly open should be avoided.
If a gate is specified for throttling heads, bronze liners should be placed on the tongues of the disc and in the grooves of the guides to reduce clearance. This will reduce the amplitude of any vibration that may occur.

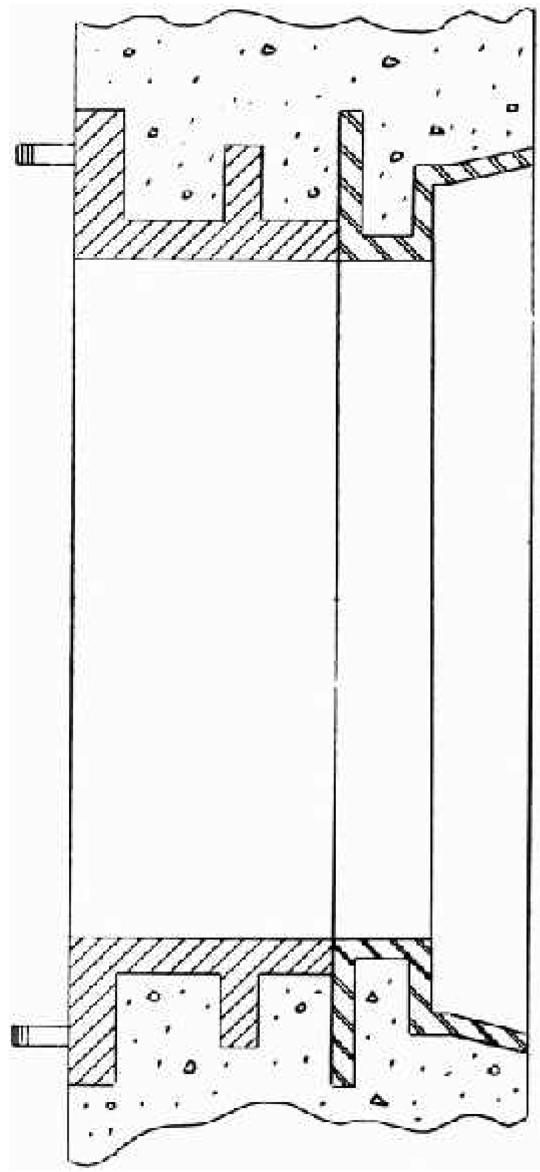
What factors limit the use of conventional sluice gates for modulating service?
Modulating sluice gates can cause excessive wear on tongues that protrude from either side of the disc into the grooves of the guide. Cast iron is not suitable for the task. To withstand this wear we make use of a bronze liner in the groove and on the tongue so that all contact surfaces are bronze to bronze.

How can you control stem and nut wear on modulating gates?
Rapid nut wear comes about where screw stem hoists are used to operate gates in modulating service. Stem wear is not a problem because any part of the stem is in contact with the nut only at a specific gate opening. An excellent solution, arrived at after much experience, is the use of a cast nylon operating nut and a polished stainless steel stem. This combination has extended the life of the operating nut from a matter of a few months to years.

What are the advantages of mounting a sluice gate on a wall thimble?
A wall thimble is a heavy cast iron fitting with a machined front face which has been drilled and tapped. It is cast into the concrete when the concrete is poured and provides a smooth, flat mounting surface for the sluice gate, eliminating most of the causes of distortion of the gate. An additional advantage, although not often realized, is the ease with which a gate is removed from the wall and reinstalled, if this becomes necessary. A wall thimble is an additional initial expense, but it eliminates the requirement for the contractor to form the opening so that the total additional cost is minimal.

Can a sluice gate be mounted to a cast iron pipe flange?
Yes. A cast iron flange is flat and rigid and is not likely to distort. The flange should be drilled and tapped if the front surface of the flange is going to be positioned flush with a concrete wall.

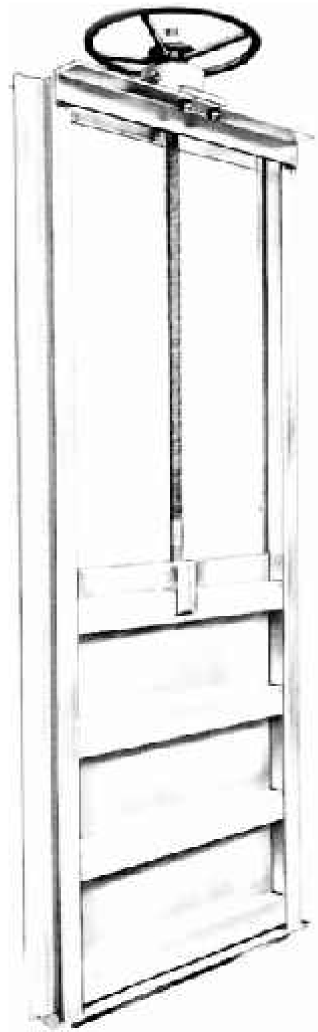
What's the best way to mount a gate to concrete pipe?
Mounting a gate on a steel flange or flange and bell adapter for concrete pipe is almost a guarantee of problems. The flange invariably becomes distorted during the welding process. This installation is only workable when a heavy, shop-welded front flange is used - assuming that it has been stress relieved and machined. A good solution to this problem is to provide a short F or E section cast iron wall thimble that can be butted to the standard flange and bell adapter used for concrete pipe. If an E section wall thimble



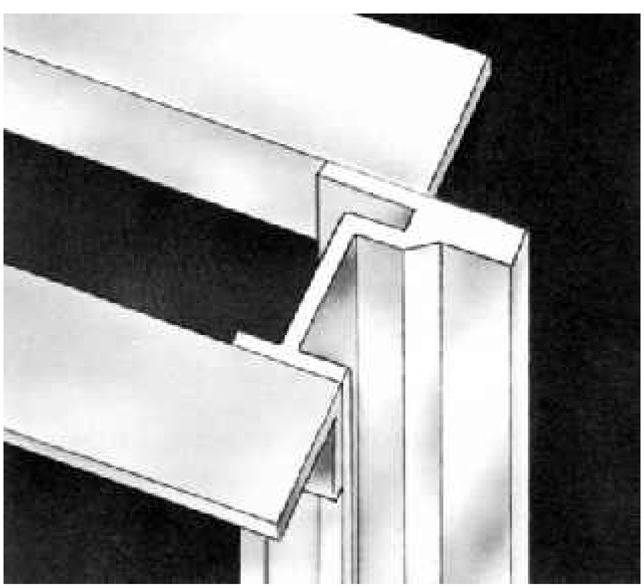
is used, the two flanges can be bolted or clamped together. If the concrete pipe manufacturer can furnish a spigot suitable for a cast iron pipe bell, Rodney Hunt can furnish a flange and bell wall thimble.

What is an appropriate bolt spacing for sluice gates?
On gates with circular back flanges, the most common arrangement is 25# standard drilling. 125# standard drilling is not justified by the load and its use will result in unnecessarily higher costs. With rectangular sluice gates, we recommend bolt spacing not greater than 12 to 14 inches.

What kind of gate is recommended for open channel flow?
Because a cast iron gate is designed to mount on the face of a wall, it is not suitable for installation in a channel. In this situation, a fabricated gate is ideal because the guides can be designed for embedment in the concrete side walls of the channel. And it can be used for either seating or unseating heads because the disc will take a position to seat in either direction. The slide gate can also be mounted on the face of the wall to cover an opening. Under these conditions it is not suitable for an unseating head because there are no wedges to hold the disc to the frame.



What are the distinctive features of Rodney Hunt aluminum slide gates?
The Rodney Hunt aluminum slide gate makes use of a unique dual-slot extruded guide offering greater rigidity and strength than conventional slide gates. The narrow slot in the extrusion has been designed to accommodate the disc while the wide slot accommodates the reinforcing rib. The overlap of the reinforcing rib into the guide offers an excellent transfer of stresses. The box design of the reinforcing rib on the disc places the strength away from the disc where it does the most good. The gate has a cast aluminum, threaded and pinned , stem connection, welded, not only to the disc, but to the top reinforcing rib as well. This gate is normally supplied with a resilient seal attached to the bottom of the disc for flush-bottom closure. The design of the guides and yoke allows removal of disc and stem without disassembling the yoke.



Can the fabricated aluminum gate be used in a weir application?
Yes. An excellent weir can be made by designing the fabricated aluminum slide gate to lower to open. It is ideal for aeration tanks where flow travels over the top of the gate. Where the gate is used under unseating head conditions, a J-seal can be attached to the frame to provide a positive seal at all positions of the disc.

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How are hoist sizes determined?

The selection of a hoist size is determined by the operating thrust required to open the gate under full operating head. The operating thrust consists of water load thrust, the weight of the gate and stem and the force necessary to pull the gate from the wedges. Specifically, thrust due to water load is determined by the head and the coefficient of friction. For bronze seat facings, we recommend a coefficient of 0.35. The weight of the disc and stem must be included because both are lifted and the force necessary to pull the gate from the wedges is assumed to be one half the weight of the disc (a close approximation determined from experience).

Once the operating thrust is determined, the hoist is selected from the manufacturer's catalog. For example, a Rodney Hunt S-5012 floorstand has an output range varying from 28,900 pounds using a 2 inch diameter stem to 18,200 pounds with a 31/4 inch diameter stem. If the operating thrust is more than 9,000 pounds but below 28,000 pounds, the S-5012 floorstand is recommended. This insures that the gate can be opened with less than a 40 pound effort on the crank.

How are stem sizes determined?

Stem size is determined by the output of the floorstand and the unsupported length of the stem. The operating thrust of the gate does not directly control the size of the stem.

It is possible to place more than the normal 40 pound effort on the crank. If, for example, a gate hits an obstruction while being closed, or the stop collar on the stem is not adjusted properly, a force of 80 to 100 pounds could be exerted on the crank. This would result in a thrust equal to 2 to 2 1/2 times the rated output of the floorstand.

From the catalog, the rated output of an S5012 hoist with a 2 1/2 inch diameter stem is approximately 24,000 lbs. With a 100 lb. effort on the crank the output of this hoist would be nearly 60,000 lbs. This is why specifications should require stems to withstand, in compression, 2 ½ times the rated output of the floorstand with a 40 pound effort on the crank. The sluice gate manufacturer should produce these calculations when requested.

From what materials should stems and components be made?

Stainless steel is the most common material for stems. It is corrosion resistant and has higher strength than bronze. Operating stems can also be bronze or cold rolled steel. Thrust nuts and couplings should be cast maganese bronze.

What are critical considerations in the design of geared floorstands?

Geared floorstands are normally subject to operating loads ranging from 5,000 to as much as 100,000 pounds. They are exposed to weather and are expected to operate easily after long periods of inactivity. Consequently, we recommend the use of cast maganese bronze operating nuts mounted on anti-friction roller bearings. Roller bearings are better able to withstand side thrust exerted by the stems during operation than are ball bearings. Also, roller bearings should be used to support the pinion shafts because they are better able to withstand the axial thrust which occurs because of the bevel or worm gear arrangement in the hoist. They operate more easily after a period of inactivity, and, are better able to wit h s tan d higher operating speeds present when a portable operator is used.

What is the advantage of mechanical seals?

Even though the highest quality grease is used to lubricate bearings and gears, its contamination by moisture will cause bearing corrosion and pitting. Mechanical seals prevent grease from leaking out and moisture from getting into the hoisting mechanism. Seals should be placed around the top and bottom of the operating nut and around the pinion shaft.

What do you recommend for pipe covers and position indicators?

Rodney Hunt has successfully used a clear, butyrate-plastic pipe cover that does not discolor with age and is difficult to fracture. Available in lengths up to 20 ft., this is a strong, durable material that gives excellent protection to the stem and ample visibility to determine the position of the gate. If necessary to lubricate a stem, this cover can be easily removed. Position indication is achieved with Mylar markings on the cover. A counter type indicator is sometimes used for position indication. It can be read directly (when a 48 inch gate is fully open, the counter reads 480) and is the best solution for non-rising stems.

Unless the galvanized steel pipe cover is hot-dipped after fabrication, rust particles will form on its inside wall contaminating the grease on the stem. Open indication slots, sometimes used on these covers, allow blown dust to contaminate the grease on the stem.

How much of a differential head is required to open a flap valve?
A flap valve will begin to open with approximately 0.2 ft. of differential head on the cover. In most calculations the head loss through the flap valve can be neglected. The maximum head loss will not exceed 0.4 ft.

What are the limitations of flap valves?
The major limitation of a flap valve is that the only force available to close the valve is the weight of the cover. If a log or other debris lodges in the opening the valve will remain open.

How can a flap valve be made suitable for pump discharge application?
Flap valves are often used on the end of a pump discharge line. Under these conditions, the forces on the flap valve at the time of pump start and stop can be considerable. The Rodney Hunt pump discharge flap valve is designed to withstand these forces. A heavy resilient seat is placed in the frame to absorb the forces resulting from pump shutoff. The hinge arms are cast maganese bronze of heavy cross section for strength. An anti-locking bar limits the rotation about the lower hinge posts. The cover is often made of cast ductile iron for maximum strength with minimum weight so that the sensitivity of the valve is not affected. This flap valve has been successfully used in many applications throughout the country.

How much maintenance is required on a sluice gate?
The maintenance on the gate is minimal but what there is, is important. The threads on the stem must be cleaned and lubricated periodically. Dirty grease or a lack of grease will increase the operating force necessary to open or close the gate and will accelerate the wear in the stem nut. Stem covers should be removed at least twice a year to inspect, clean and regrease the stems.
There are grease fittings on the manual and electric screw stem hoists and these should be lubricated at least every six months. No other regular maintenance is required.

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