19.0 GATES, OPERATORS, AND CONTROL SYSTEMS

19.1 Gates

19.1.1 General

Historically, the types of gates most frequently used on the Province's water control structures are as follows:

- Chute spillway: radial and vertical lift gates. More recently, radial gates are preferred as noted in Section 19.1.2.

- Low level outlet works: slide and vertical lift gates.

- Sluiceway: radial gates.

- Check structure: radial and overflow gates. Overflow gates are preferred for control of upstream water levels as noted in Section 19.1.4.

- Wasteways: radial gates.

- Turnouts and drain inlets: slide gates.

Typically, the gate system consists of either readily available manufactured products (catalogue items) that satisfy the installation and operating conditions or a special project specific design. In both cases, the complete gate system should be obtained from an established gate fabrication company.

For special project specific gates, the detailed design of the gate system can either be completed by the gate fabricator as part of a design, supply, and installation contract package using performance specifications, or by the design team. Historically, the former approach has been used; however, the latter approach has become more prevalent in recent years in order to develop design expertise and encourage fabrication by local companies.

It is preferred that the supply and installation of the gate system be included as part of the water control structure contract in order to minimize the potential for scheduling, workmanship, warranty and safety issues to occur. Depending on the size of the gates, available lead time, and design responsibility, this can be accomplished by either incorporating the gate system as part of the structure contract at the onset or as a separate gate contract which is subsequently assigned to the structure contract. In either case, a prequalification process should be considered to ensure that the gate is designed, if required, and manufactured by a qualified gate fabrication company.

As a minimum, the specifications should require that the gate manufacturer supply all of the gate components including the embedded parts and hoisting equipment. It should also make the gate

manufacturer responsible for providing highly experienced personnel to supervise the installation and commissioning of the gate and associated components.

19.1.2 Radial Gates

Currently, radial gates are being primarily used on spillways, sluiceways, and wasteways. Radial gates are seldom used in check structures because overflow gates can provide better upstream water level control.

The radial gate is preferred over the vertical lift gate because it generally offers a number of advantages as follows:

- Provides better discharge characteristics at partial gate openings;
- Requires a lower hoisting force;
- Bearings are located out of the water;
- Does not require gate slots, which can become plugged with ice or debris and can cause cavitation;
- Is more aesthetic since it does not require an overhead supporting structure (gate tower); and
- Is typically less expensive.

Disadvantages include:

- Requires longer piers;
- Results in high concentrated loads at the trunnions;
- Involves more complex fabrication; and
- Requires a more complicated dogging system to facilitate maintenance activities.

Further discussions on the advantages and disadvantages of radial gates versus vertical lift gates are available in USACE EM 1110-2-2702 (2000), and Lewin (1995).

Radial gates are generally designed to discharge water under the gate only (no provision for overflow except for an emergency). Typically, the gates consist of the following assemblies and systems:

- The gate leaf assembly, which includes the curved skin plate, cross bracing or struts, supporting beams and girders, and rubber seals.

- The arm assembly, which includes the arm columns, bracing, and hub.

- The trunnion assembly, which includes a pin, bushing, thrust washers, lubrication provisions, and yoke.

- The trunnion support assembly, which includes the trunnion beam or anchor block and the

anchorage system.

- A wire rope hoist system as discussed in Section 19.2.1.

A large radial gate arrangement is shown on Figure 19-1, and a smaller version is shown on Figure 19-2.

For a specific installation, special care is required in identifying all of the conditions and loading combinations that can occur. Some examples of conditions and loading combinations that may apply in the design of a typical radial gate are provided below. The load symbols are defined in Section 4.0, and load factors are discussed in Section 9.2.

Usual Condition

- D+Impact (during installation, dry testing or servicing)
- $D+H_{FSL}$+ wave load
- D+H (corresponding with the top of the gate)
- $D+H_{FSL}+I$
- $D+H_{SDF}$, gate(s) opened

Unusual Condition

- $D+H_{FSL}+Q$

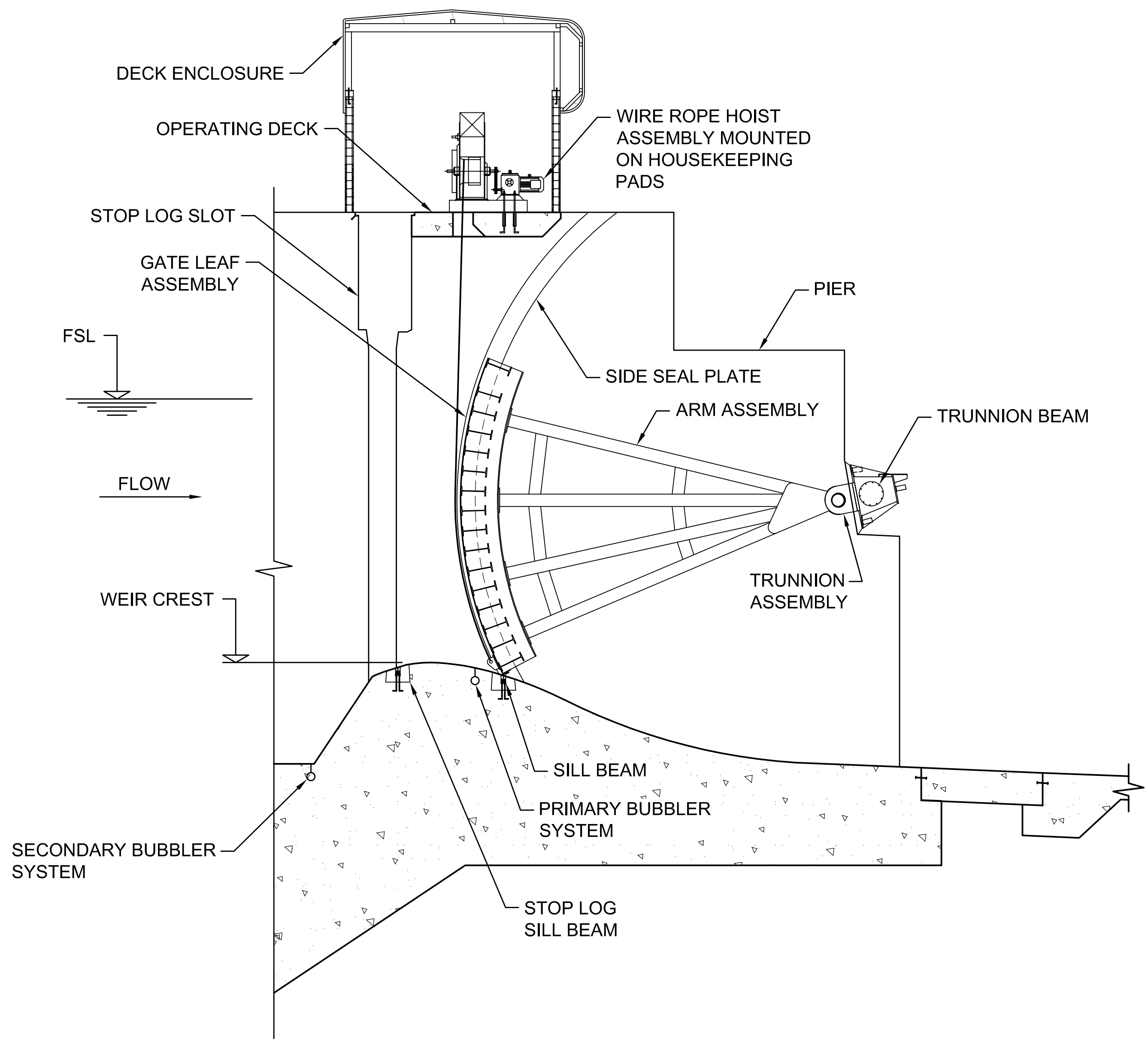
Extreme Condition

- $D+H_{IDF}$, gate(s) opened
- $D+H_{FSL}+Q_{MDE}$
- $D+H_{FSL}$+Gate Jammed (Maximum Hoist Load)
- $D+H_{FSL}$+Broken Hoist Cables (One Side of Gate)

Where appropriate, the design should consider the effects of the gate being opened or closed for various positions along its operating range, and the accompanying static or moving friction loads at the side seals, side rollers or guide shoes, and trunnion pins, and hydraulic downpull loads.

In the case where the gate is required to resist ice loading, the potential for the gate to be inadvertently opened by an induced moment caused by the ice loads should be examined. This is particularly important where ice loads can act on any point along the gate skin plate. Provisions for winter operation of gates are discussed in Section 19.1.9.

For loading conditions with the gate in operation, the induced loads due to friction at the trunnion assembly should be included in the design of the arms, trunnion, and trunnion support assemblies. Self-lubricating cylindrical or spherical bushings (bearings) may be used depending on the degree of alignment adjustment that is required. Current standards by the following agencies recommend



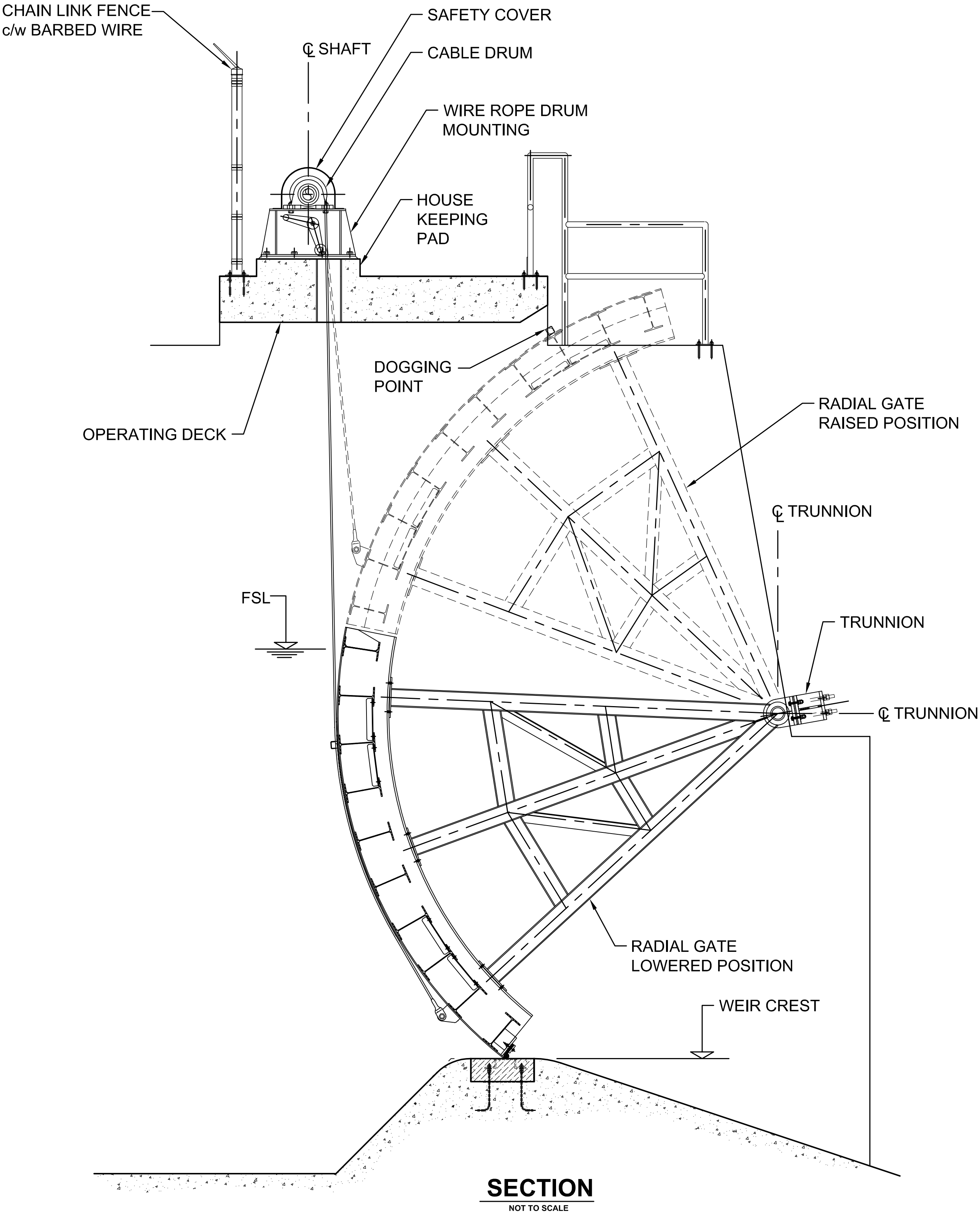
ALBERTA TRANSPORTATION
CIVIL PROJECTS BRANCH

ALBERTA ENVIRONMENT
WATER MANAGEMENT OPERATIONS

WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES

LARGE RADIAL GATE ARRANGEMENT

DATE: November 2004 | CAD FILE: 99008A19-1.dwg | FIGURE No.: 19-1



SECTION

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ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **SMALL RADIAL GATE ARRANGEMENT** DATE: November 2004 · CAD FILE: 99008A19-2.dwg · FIGURE No.: 19-2

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that the following design coefficient of friction be considered:

- USBR and USACE: A coefficient of 0.3 for steel pins on bronze bushings.

- USBR: A coefficient of between 0.1 and 0.2 for self-lubricating bearings.

Consideration should also be given to increasing the design coefficient of friction to include an allowance to account for detrimental factors, such as excessive wear, corrosion, or contamination, which may occur over its design life.

For the arm assemblies, adequate clearance between the arms and the structure walls (i.e. piers and end walls) to facilitate installation, adjustment, and replacement of the gate seals (i.e. by providing either angled arms or parallel arms that are sufficiently offset from the structure walls or other appropriate means) is required.

The effects of temperature variations should also be examined, particularly with respect to the setting and performance of the gate seals, and guide shoes or rollers.

Flow induced vibration can occur in radial gates especially at small gate openings and particularly for lightweight gates. It may be possible to reduce the vibration by increasing the weight of the gate (moment of inertia), avoiding operation of the gate at that particular opening, or limiting the eccentricity between the gate leaf assembly and the pivot point, as discussed by Ishii and Naudascher (1992).

For larger radial gates, the trunnion support assembly generally consists of a structural steel girder and post tensioned anchors, or a concrete anchor block and post tensioned anchors. With the steel girder, a single gate support or a double gate (girder supports the trunnion assembly of the two gates in adjacent bays) support system can be used at the piers. The single gate support system will require a larger girder and more anchors; however, it will also eliminate the possibility for progressive failure should one of the gates fail, and simplify the gate installation. Where a double gate support system is used, the installation of the trunnion assemblies can become extremely difficult, particularly where the girder is vertically inclined, the pier is tapered, and differential foundation movements can occur. In any case, jacking screws or other means should be incorporated in the concrete walls and trunnion girders to allow fine installation adjustments to be made.

For small radial gates, the trunnion support assembly typically consists of a side pivot weldment (steel pipe with bearing plates), which receives the trunnion pin, and threaded rebar. A blockout is provided in the concrete side walls or piers to permit access for installing and adjusting the pivot weldment. The blockout is subsequently filled with secondary concrete.

Typically, rubber J-seals with a Teflon coating have been used along the sides of the gate. For the rubber seals, shop fabricated fittings should be used, and only vulcanized butt joints should be permitted in the field.

At the bottom of the gate, rubber J-seals or compression seals have been used. The bottom J-seal simplifies the transition at the corner with the side J-seal; however, particular care should be taken to locate the bottom J-seal so that it is not exposed to the high velocity jet which can result in gate vibration and seal damage. In addition, the bar provided to clamp the J-seal to the gate should sit close to the bulb to prevent it from being folded over by the jet.

Typically, the bottom corners of the seal are very susceptible to leakage due to the difficulties associated with the change in direction and resulting increased stiffness. Consequently, particular care is required in designing and detailing the requirements at this location.

Embedded metalwork is typically used to provide the sealing surface between the J-seal and the structure. The sealing surface normally consists of a stainless steel plate whereas the embedded portion including adjustment anchors may be fabricated from carbon steel.

Appropriate tolerances for fabricating and installing the side and bottom seal plates are needed to ensure that intimate and continuous contact between the seal and the seal plate is attained with the gate in the closed position. The required tolerances for a particular installation will depend on numerous factors including the amount of leakage that can be tolerated, impacts of leakage on operations and maintenance, and the type, shape, and deflection capability of the seals being used. As indicated above, adequate clearance or other means to facilitate installation and future replacement of the seals should be provided.

For installations where some leakage can be tolerated (e.g. radial gates for a canal wasteway structure), typical tolerances required for the completed installation are provided below. These values are generally consistent with those typically required by the gate manufacturer. For portions of the side seal plates that extend above the top of the closed gate (i.e. above the design water level), the tolerances can be relaxed.

- Straight edge check: ± 0.5 mm in 2000 mm
- Bottom seal plate alignment ± 1.0 mm over its full length
- Side seal plates alignment ± 1.0 mm over its full length
- Horizontal distance between side seal plates (bay width) ± 3.0 mm

For installations where the objective is to achieve a completed gate installation that has no or very little leakage (e.g. spillway gates where leakage would result in excessive ice buildup that could affect operation and maintenance activities), the need to include more stringent tolerances for the completed installation (after secondary concrete placement) should be considered. Tolerances that have been used in the past for such cases are provided below; however, the current applicability and the need for employing these very stringent tolerances should be reviewed. The review should consider the type of seal, the seal arrangement, and seal adjustment capabilities.

- Straight edge check: ± 0.15 mm in 2000 mm
- Bottom seal plate alignment ± 0.5 mm over its full length
- Side seal plates alignment ± 0.5 mm over its full length
- Horizontal distance between side seal plates (bay width) ± 3.0 mm

Careful review of the need to specify such stringent tolerances, and the added costs to meet them should be undertaken. On past projects where these stringent tolerances have been specified, machining of the sealing surfaces on the stainless steel plates were required, therefore the initial plate thickness had to consider the loss in section due to machining. In addition, provisions for making fine adjustments to the position of the sealing plates were incorporated in the design, and requirements for more precise survey and other installation techniques were identified.

In conjunction with the installation tolerances, a compatible allowable leakage rate should be provided. Normally, the allowable leakage rate will include a unit leakage rate per metre of seal length at any point along the seal, and a total leakage rate for the entire gate.

19.1.3 Vertical Lift Gates

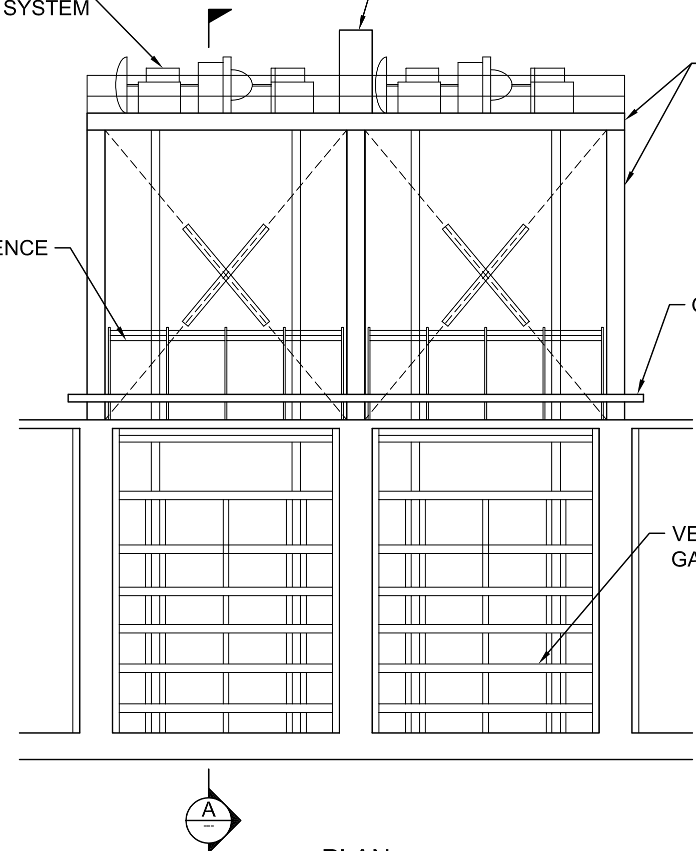
Vertical lift gates may be used for chute spillways and low level outlet structures.

Typically, a fixed wheel type gate is used, and it generally consists of the following assemblies:

- The gate leaf assembly, which includes the skin plate, supporting beams and girders, bracing, and rubber seals.
- The wheel assembly, which includes the main and side rollers, lubrication provisions, and mounting brackets.
- The embedded seal path assemblies, which include the side seal, bottom sill, and anchors.
- The hoist tower and bridge assembly for supporting the gate hoist system.
- A wire rope hoist system as discussed in Section 19.2.1. For smaller gates, the system may consist of a rising stem gate hoist system.

An example of a vertical lift gate arrangement with a traditional high tower and bridge assembly for supporting the gate hoist system is shown on Figure 19-3. The current preference for a site where aesthetics is important, is to provide a low profile arrangement where the vertical height of the hoist tower and bridge assembly is kept as low and as visually non-obtrusive as possible.

In general, a typical vertical lift gate and hoist would be designed for similar conditions, loads, and



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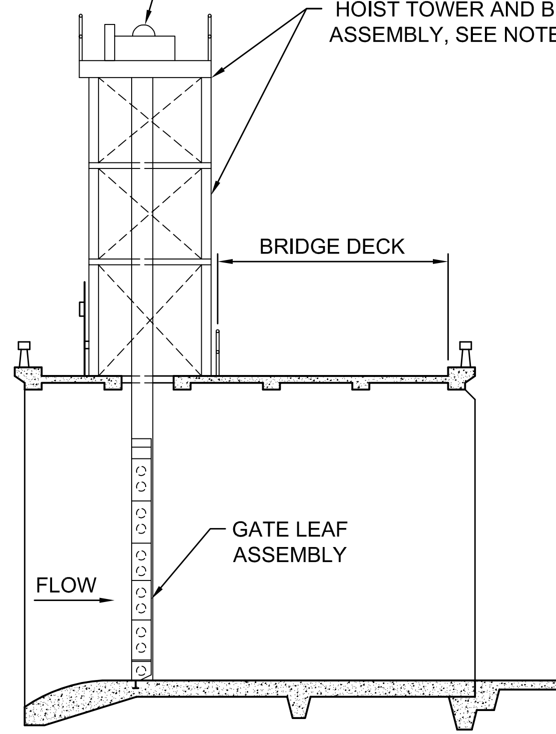

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NOTES:

1. TRADITIONAL HOIST TOWER AND BRIDGE ASSEMBLY IS SHOWN, HOWEVER THE PREFERENCE IS TO USE A LOW PROFILE ASSEMBLY THAT IS AS VISUALLY NON-OBSTRUSIVE AS POSSIBLE WHERE AESTHETICS IS IMPORTANT.

SOURCE: ALBERTA ENVIRONMENT 1980

ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **VERTICAL LIFT GATE ARRANGEMENT**	
DATE: November 2004	CAD FILE: 99008A19-3.dwg	FIGURE No.: 19-3

loading combinations as described for the radial gate, except that wheel friction would be used rather than trunnion pin friction. Tolerances for side and sill sealing plates will be similar to those for a radial gate; however, tolerances will also be required for the roller paths.

19.1.4 Overflow Gates

Overflow gates are typically used on main canal check structures to provide upstream level and flow control. They may consist of either a bottom-hinged leaf gate or a Langemann gate.

Since these gates operate as overflow gates, air vents are normally installed within the piers and sidewall to supply air to the underside of the gate to ensure that the nappe forms.

The bottom-hinged leaf gate generally consists of a bottom hinge that connects the gate to the structure, a gate leaf consisting of a skin plate and supporting beams, and wire ropes at the top corners of the leaf that are connected to the wire rope hoist system. The hoist system is discussed in Section 19.2.1. A typical bottom-hinged leaf gate arrangement is shown on Figure 19-4.

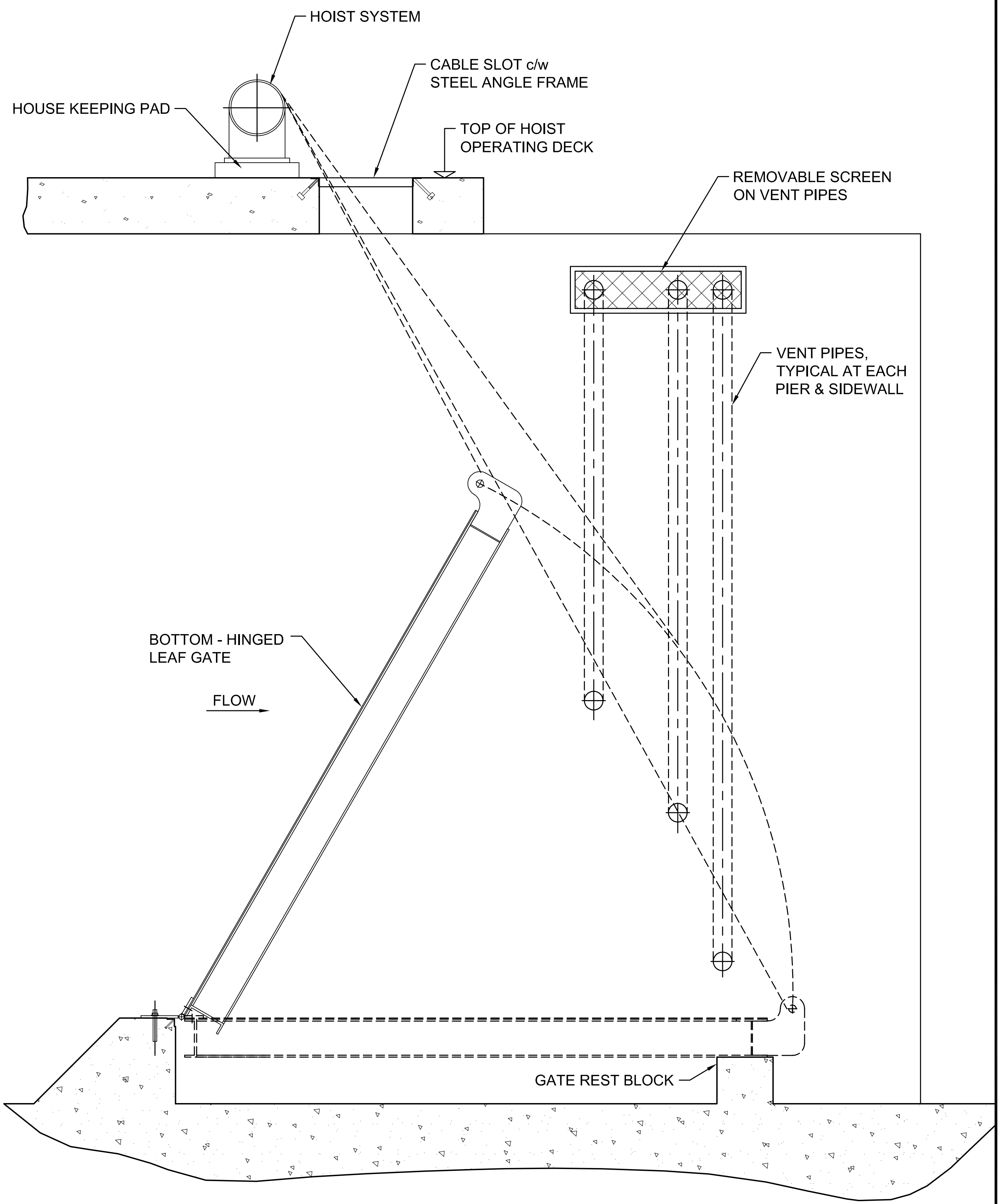
The Langemann gate was developed in 1994 and can be used on new and existing structures. However, it is better suited for retrofitting existing structures than the bottom-hinged leaf gate. The pre-assembled gate generally consists of top and bottom gate leaves connected together and to the gate frame by hinges, a rigid gate frame and side plates which connect to the structure, built in air vents, and roller chains that connect the top corners of the gate to the hoist system. The gate hoist system generally consists of an electric motor that can be powered using solar panels and batteries (12 or 24 VDC), gear reducer, and shafts mounted on the pier and end walls. The main advantages of the Langemann gate versus a bottom-hinged leaf gate are that it requires shorter length of structure, has a simpler hoisting system, and is easier to install. A typical Langemann gate is shown on Figure 19-5.

19.1.5 Slide Gates

Slide gates operate in a similar fashion to that of a vertical lift gate except that wheels or rollers are not provided. They are generally smaller in size and can be designed to operate under seating and unseating head conditions.

In general, cast-iron slide gates are designed and manufactured in accordance with AWWA C-560-00. Depending on the size, the gate can be designed for maximum seating heads of up to 61 m and unseating heads of up to 23 m. Various combinations of materials are available as required to suit the expected operating and exposure conditions. For a typical installation, the following materials are generally used: cast iron gate, frame, slide, wedge blocks and thimble; naval bronze seating face; stainless steel stem, studs, and anchor bolts; manganese bronze stem block; and zinc aluminium stop nut.

Typically, cast-iron slide gates installed in main canal structures (6.1 m seating and 3 m unseating heads) have employed naval bronze seating faces, cast iron or galvanized steel frames and guides;



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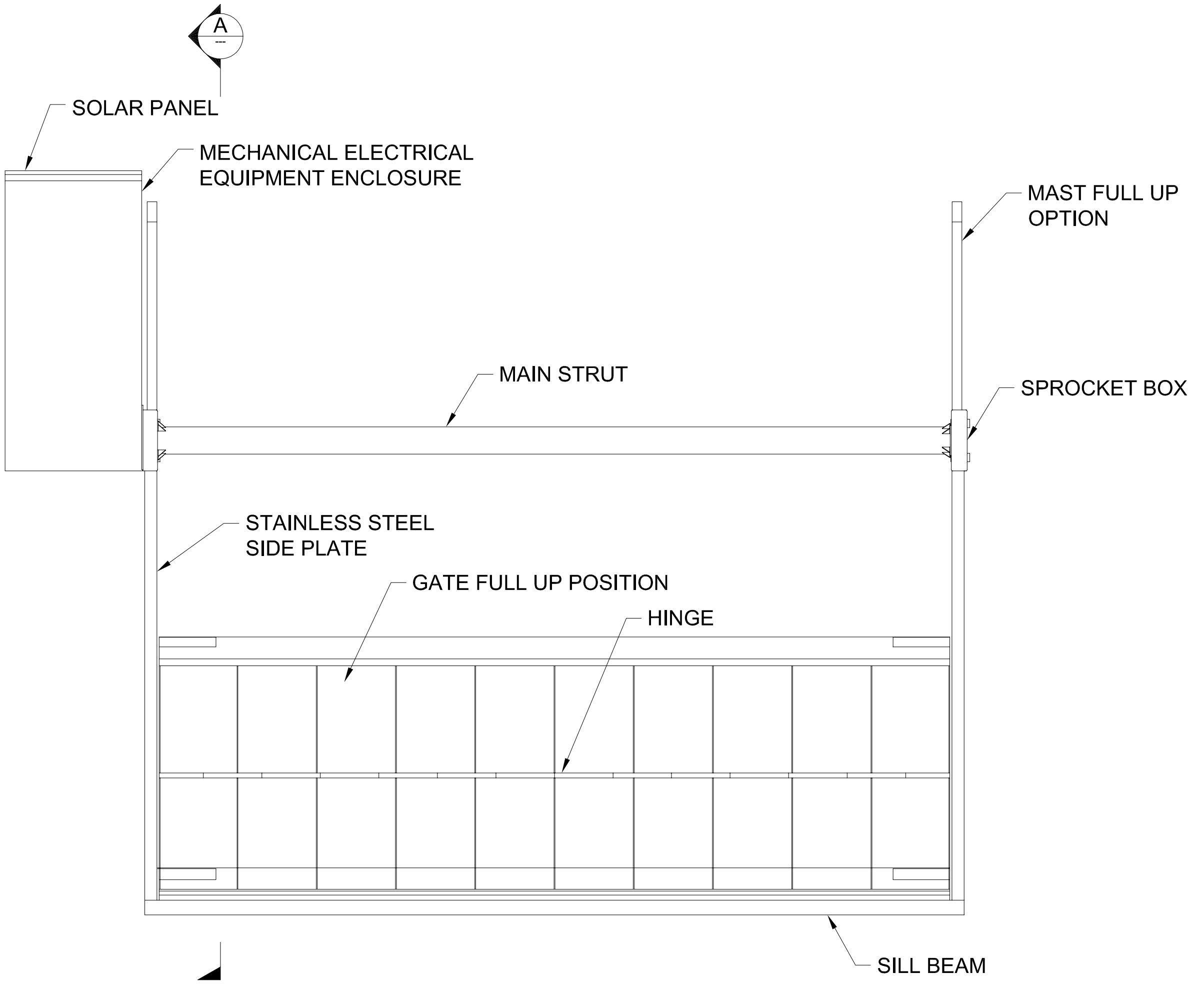
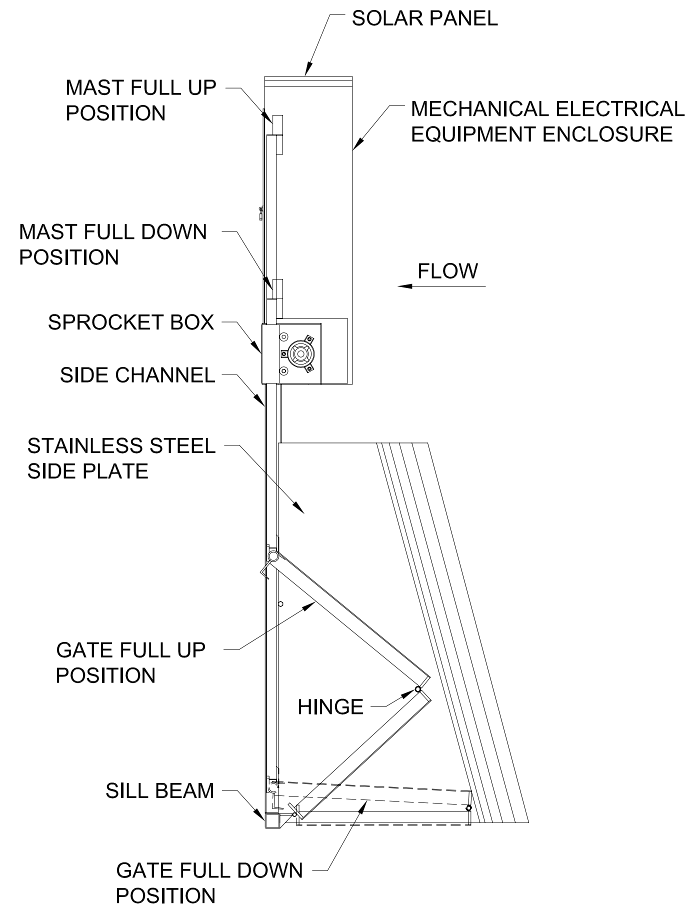
ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **BOTTOM - HINGED LEAF GATE ARRANGEMENT** DATE: November 2004 · CAD FILE: 99008A19-4.dwg · FIGURE No.: 19-4



DOWNSTREAM ELEVATION



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ALBERTA TRANSPORTATION
CIVIL PROJECTS BRANCH

ALBERTA ENVIRONMENT
WATER MANAGEMENT OPERATIONS

WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES

LANGEMANN GATE ARRANGEMENT

DATE:	CAD FILE:	FIGURE No.:
November 2004	99008A19-5.dwg	19-5

stainless steel stem, fasteners, and anchor bolts; manganese bronze or zinc aluminium lift nuts; and galvanized steel nuts.

The standard coating provided by the slide gate manufacturer for metallic components (except for stainless steel, aluminium or galvanized components) generally consists of an epoxy paint (i.e. not coal-tar epoxy) system.

Fabricated slide gates are generally manufactured using galvanized or stainless steel or aluminium and, depending on the size, are designed for maximum seating heads of 10 m and unseating heads of 6 m. Rubber seals or ultra high molecular weight polyethylene seats are usually provided, particularly where unseating conditions are expected. Metal slide gates are designed and manufactured in accordance with AWWA C-513-97, C561-04, or C562-04.

Hoisting requirements for the gates are discussed in Section 19.2.2.

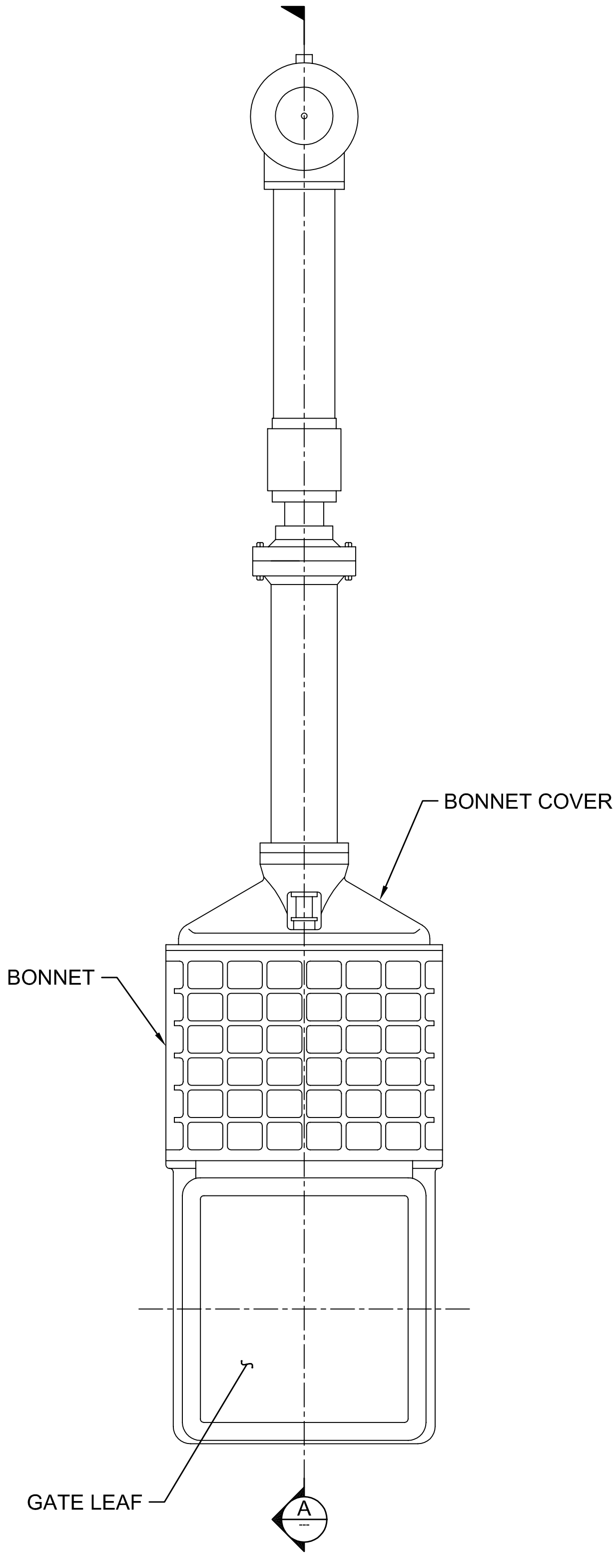
For high head slide gate installations (low level outlet structure), the potential for cavitation to occur, particularly at the bottom surfaces of the gate, at the side and sill seal locations, and immediately downstream of the gate, should be examined and appropriate mitigative measures provided as outlined in Section 12.8.

19.1.6 Bonnet Gates

Bonnet gates may be installed within the conduit of an outlet structure. These gates are ordinarily used for high head installations. Typically, two identical gates are provided in tandem with the upstream one serving as an emergency or guard gate. The bonnet gate generally consists of a gate leaf, a body consisting of upstream and downstream frames, the bonnet and cover, hoist system, and gate hanger system as shown on Figure 19-6. Sealing and sliding of the gate occurs at the mating surface between the gate leaf, body and bonnet. Provisions for lubricating the gate seats to reduce friction and wear, and to allow for making adjustments to the position of the hydraulic rod or gland should be considered.

Depending on the head, cavitation may occur particularly at bottom surfaces of the gate, at the side and sill seal locations of the body, and immediately downstream of the gate. Consequently, the cavitation potential should be examined and appropriate mitigative measures provided as outlined in Section 12.8. In addition, the provision of a 45° slope at the bottom of the gate leaf along the upstream side to produce positive pressures that will reduce the downpull force and ensure positive control at the spring point should be considered. An air vent must also be provided just downstream of the gate to aerate the conduit.

A gatewell, as discussed in Section 14.6 is generally provided to house and allow access to the gates.



ELEVATION
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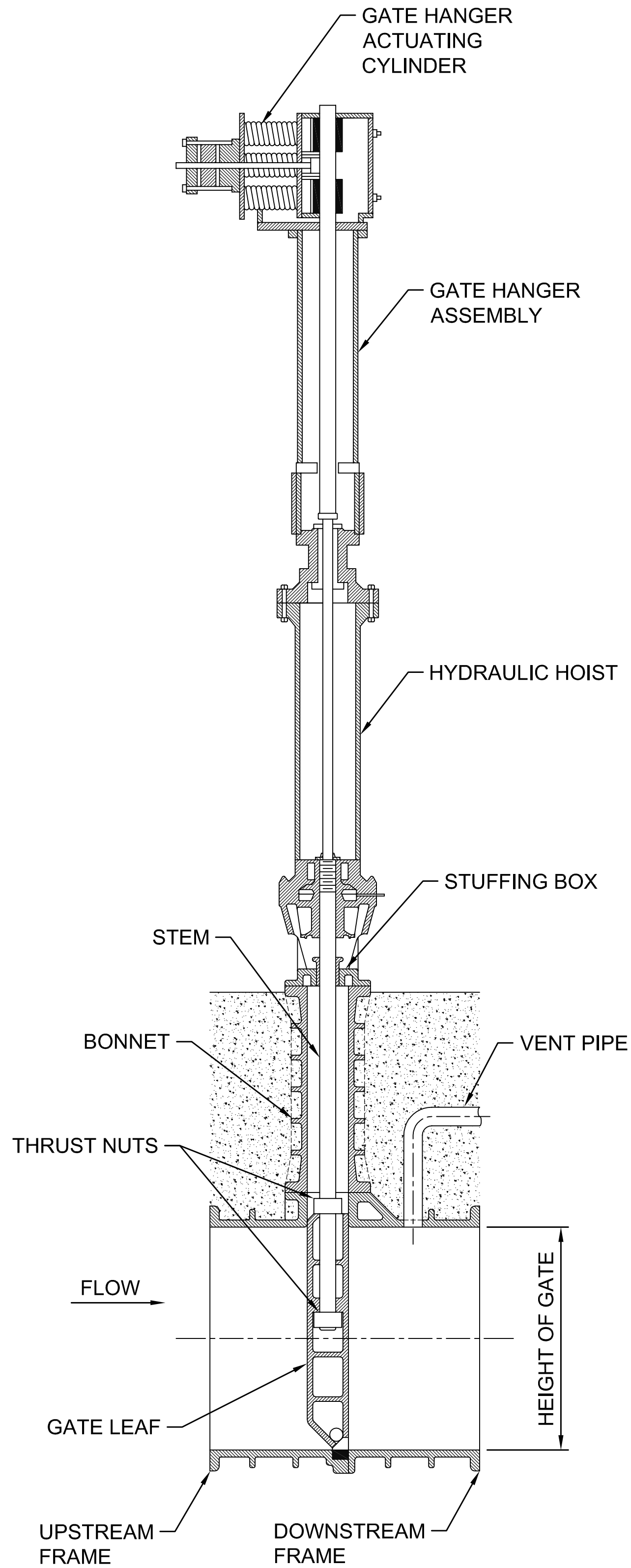

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ALBERTA TRANSPORTATION
CIVIL PROJECTS BRANCH

ALBERTA ENVIRONMENT
WATER MANAGEMENT OPERATIONS

WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES

BONNET GATE ARRANGEMENT

DATE:	CAD FILE:	FIGURE No.:
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19.1.7 Valves

In general, large discharge and shutoff valves can be designed for higher heads than gates. For high head and large discharge conditions, the typical installation may consist of a guard (e.g. butterfly valve) installed immediately upstream of the main regulating (e.g. fixed cone) valve. The design and manufacture of such valves are highly specialized and careful attention should be given to the effects of cavitation and vibration.

For smaller diameter pressure pipeline systems, gate valves are generally used since they are less prone to plugging than butterfly valves.

19.1.8 Stop Logs and Bulkheads

Stop logs and bulkheads may be used to facilitate inspection and maintenance of the structure, conduit or gate components that are generally submerged. Stop logs may also be used for controlling water levels (e.g. small check or lake stabilization structures).

In general, a set of stop logs is ordinarily used for low head, large span conditions where a higher leakage rate can be tolerated. One example is for a large spillway where stop logs are provided to facilitate gate maintenance. Inherently, the use of stop logs will result in a much longer sealing length, consequently higher leakage can be expected. Typically, the stop logs are designed for installation and removal under balanced head conditions. As a result, some means (other than through leakage) for filling the downstream side, in order to remove the stop logs, may be required.

A bulkhead is ordinarily used for short spans, high heads, and/or where excessive leakage is a concern. One example is as a guard gate to the primary control gate within the gatewell of a low level outlet structure in a dam. The bulkhead can be designed for installation and removal under unbalanced or balanced head conditions. In any event, some means for filling the area on the downstream side in order to remove the bulkhead should be considered.

For multi-bay structures, only one set of stop logs or a single bulkhead is normally provided since typically only one bay will be serviced at a time. Provisions (dogging system) are ordinarily included in the structure for storing these items out of the water when not in use.

Depending on the structure type and size, and its operational requirements, the stop logs or bulkhead and the hoisting system required to install and remove them may or may not be provided. Nevertheless, slots for accommodating the required stop logs or bulkhead should be designed and incorporated within the structure.

In addition to the installations discussed above, slots for installing stop logs are generally provided at inlet structures for conduits and check structures.

19.1.9 Winter Operation Provisions

Where winter operation of the gates may be required, incorporation of the following measures should be considered:

- Installing bubblers immediately upstream of the gates to prevent ice formation.
- Providing heaters along the seal paths to prevent the rubber gate seal from freezing to the seal plates.
- Installing insulation on the downstream face of the skin plate to prevent ice formation on the upstream face of the skin plate.

Gate heating systems installed within the gate leaf assembly have been employed on some large vertical lift gates to prevent ice formation against the gate leaf. These systems generally have high operating and maintenance costs, and are prone to problems associated with condensation and frozen lines. As a result, bubbler systems are normally the preferred option.

The design of the bubbler system generally includes both a primary and a secondary system that are relatively independent of one another. This approach provides an important degree of redundancy, particularly since the bubblers are typically the only means of preventing ice formation adjacent to the gates, and access for maintenance or repair of the system components such as the air nozzles may be difficult.

The primary system is typically designed to circulate the water located immediately upstream of the gate skin plate. As a result, the nozzles are located at the weir near the bottom sill of the gate. For the secondary system, the nozzles are typically located upstream of the stop logs to prevent ice formation in front of the gates during lower reservoir levels or in front of the stop logs if they are in place. Special considerations should be given to incorporating measures that will prevent condensation and freezing of the pneumatic lines of the bubbler systems.

For a new structure, the installation of piping for a bubbler system and ducts for seal path heater systems should be considered even where winter operation is not contemplated but could change in the future.

19.2 Operators

19.2.1 General

In general, gate operators have consisted of electrically powered motors connected to gear boxes. Wire rope hoist systems are normally provided for radial, vertical lift gates, and overshot gates, and rising stem hoists for slide gates.

Hydraulic gate operators have not been used because they are generally more costly to install and

maintain.

19.2.2 Wire Rope Hoist System

Wire rope hoist systems are normally employed for radial, vertical lift and overshot gate installations. Depending on the type and size of the gate, the hoist system may include the electrical motor and brake, shafts, couplings, gear reducer units, pillow blocks, cable drums, sheaves, wire ropes, and fan brake.

In general, the wire rope hoist system consists of wire ropes attached to each end of the gate and wound on overhead drums. The drums are interconnected with shafts to the gear reducer and motor (i.e. actuator). Depending on the function and type of gate, the electrical hoist system should generally be capable of lifting the gate at a speed of around 0.3 metres per minute. Normally, the gate operator is equipped with a shaft extension on the output shaft to permit operation of the gate using a portable electric drill during a power failure.

For a particular installation, special care is required in identifying all of the conditions and loading combinations that can occur. Some examples of conditions and loading combinations that may apply in determining the rated capacity of a typical hoist system are provided below. The load symbols are defined in Section 4.0.

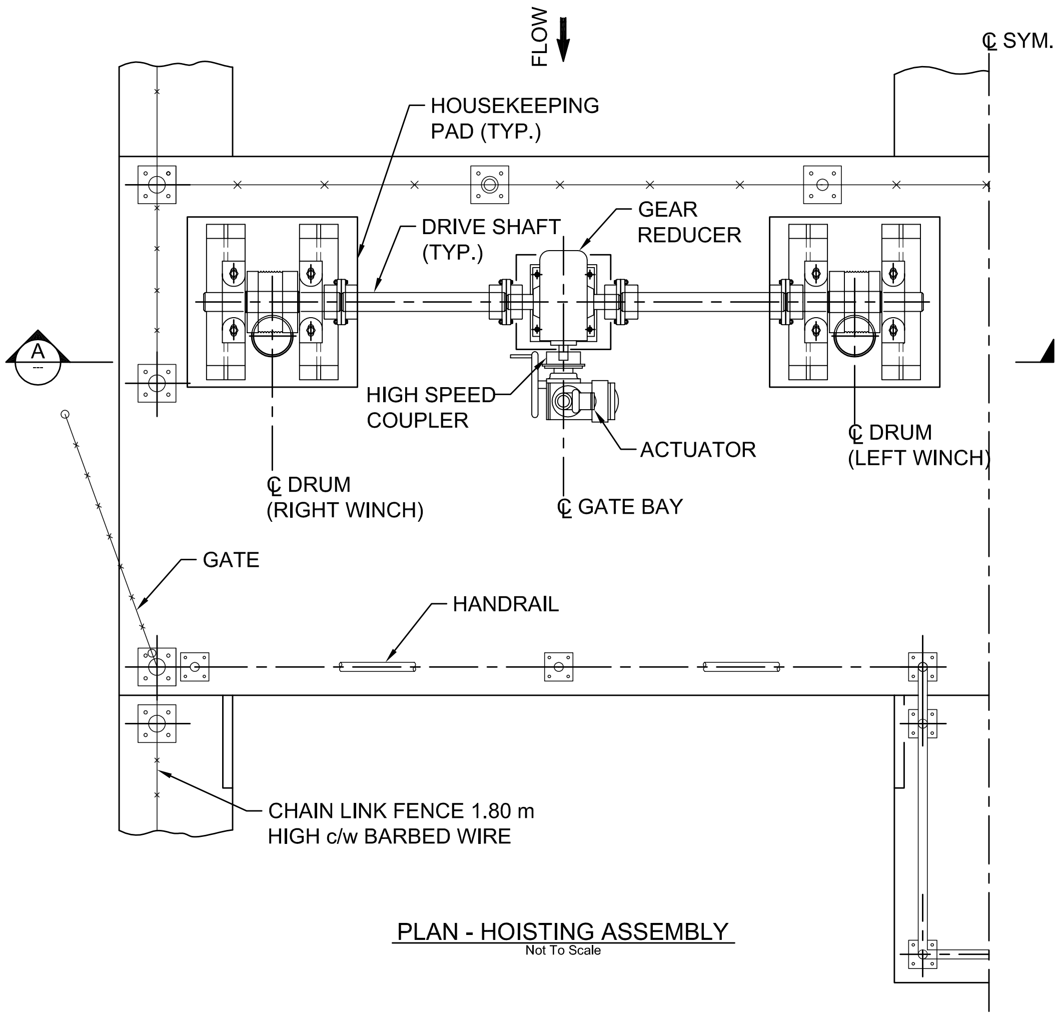
- D+Friction
- D+H_{FSL}+ wave load+friction
- D+H (corresponding with the top of the gate)
- D+H_{FSL}+I+ Friction
- D+H_{SDF}+Hydraulic downpull+Friction

As outlined in USACE EM 1110-2-3200 (1998), the factor of safety against breaking for a dynamically loaded wire rope should usually not be less than five. The dynamic load ordinarily consists of the static load plus the friction effects of any sheaves. For extreme conditions, a minimum factor of safety of two is normally provided. More detailed information respecting the selection of wire ropes for gate operating devices is available in USACE EM 1110-2-3200 (1998).

For radial gates, the cables are typically attached to lifting hitches located near the bottom of the upstream side of the gate. Ideally, the gate and hoist configuration is designed to have vertically pulled wire ropes that are in contact with the skin plate below FSL. This configuration minimizes the required hoisting force and prevents ice or debris from becoming lodged between the cable and the gate. For large radial gates, it is preferred that multiple wire rope arrangements be provided at each drum for redundancy. The typical arrangement of a wire rope hoist system for a smaller sized radial gate is shown on Figure 19-7.

19.2.3 Rising Stem Hoist System

A rising stem hoist system is normally used for slide gates. A stem cover, that includes a clear



PLAN - HOISTING ASSEMBLY
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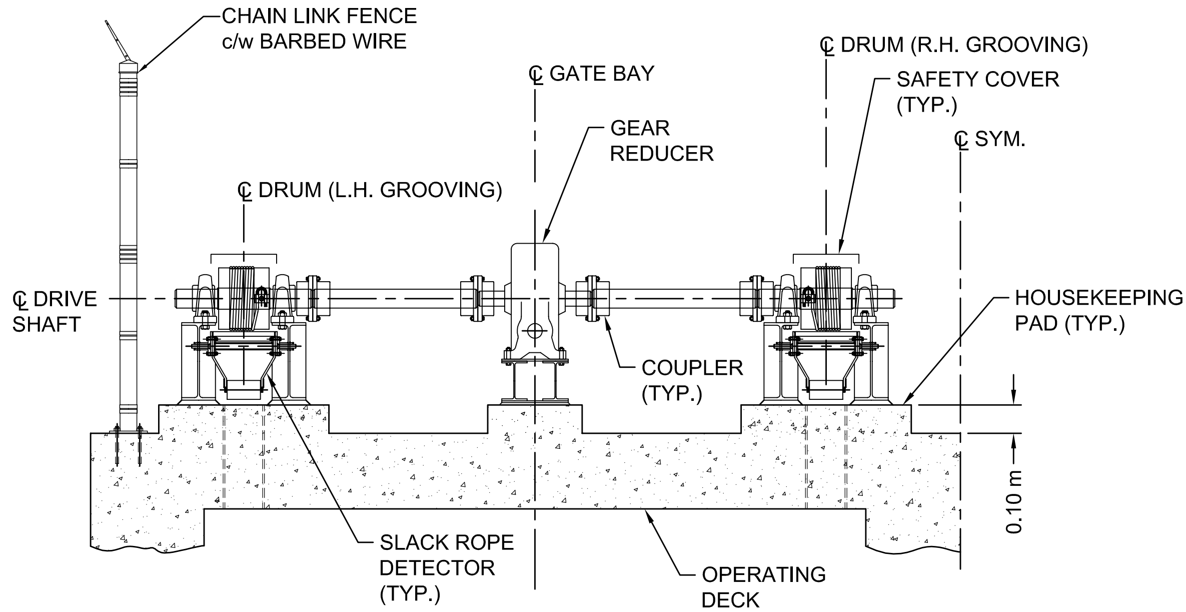

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ALBERTA TRANSPORTATION CIVIL PROJECTS BRANCH **ALBERTA ENVIRONMENT** WATER MANAGEMENT OPERATIONS	**WATER CONTROL STRUCTURES - SELECTED DESIGN GUIDELINES** **SMALL RADIAL GATE HOISTING ARRANGEMENT** DATE: November 2004 — CAD FILE: 99008A19-7.dwg — FIGURE No.: 19-7

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plastic window with a graduated scale for indicating the gate position, is provided to protect the stem and facilitate gate operation. In general, the use of electric hoists should be considered if the gates will be operated frequently, controls are automated, the pull exceeds 111 N, or the gear ratio is excessively high. For other cases, a manual (crank) hoist can be used.

Where an electric hoist is provided, an output shaft extension is usually provided to permit operation of the gate using a portable electric drill during a power failure.

19.3 Control Systems

19.3.1 General

Where required, the control system should ordinarily be designed to permit the facilities to be monitored and operated in accordance with the protocol established by the Province. Prior to starting the design, it is imperative that the designer review and confirm that the information contained in this section represents the latest requirements.

Hardware equipment and software incorporated into the control system must be compatible with the Province's systems, and have a proven track record for reliability and dependability.

A control system typically consists of the electro-mechanical, electrical and electronic components used to monitor a structure, and to initiate gate and valve movements. The control system should not be designed in isolation from the structural/mechanical components of a project. Typical components of a control system may include:

- Actuators for controlling the movements of gates and valves.
- Sensors, indicators and displays for monitoring water levels, gate and valve positions, flow rates, electrical power status, alarm conditions, and other structure related parameters.
- Programmable logic controllers (PLCs) connected to the actuators, sensors, indicators, and displays. The PLCs implement and enforce the operating rules for the gates and valves. The PLCs also collect and process information from sensors and indicators, and supply data to the display units.
- Communication hardware to connect the PLCs and display terminals, and for relaying information to AENV's central monitoring facilities.
- Human-Machine Interface (HMI) software to display information collected by the PLCs. The HMI is a graphical presentation of real time data, and allows an operator to control and monitor the structure remotely.
- Uninterruptible Power Supply (UPS) for providing backup power for the PLC.

19.3.2 Design Considerations

AENV requires that the control systems are compatible with existing systems, and are designed for reliability, fault tolerance, and stability.

Control systems must be serviceable. As a result, replacement components should be readily available from nearby suppliers without necessitating that spare parts be stocked by AENV.

As part of the initial design process, it is important that a process and identification diagram (P&ID) be prepared and submitted to the Province for review prior to proceeding with the detailed design. Requirements for the major components of a control system are described in Sections 19.3.3 to 19.3.7.

The design must also include appropriate lightning and surge protection measures.

19.3.3 Gate Operator Selection and Controls

In general, gate operators employed on water control structures have included the following:

- Basic gate operator which consists of a motor without any electronic controls and a gearbox.

- Non-intelligent gate operator which includes a non-intelligent actuator with has some built-in electronic controls. For a larger gate or gate operating under high heads, a gearbox is usually required to provide further gear reduction.

- Intelligent gate operator which includes an intelligent actuator with sophisticated built-in electronic controls, communications, and data storage capabilities. For a larger gate or gate operating under high heads, a gearbox is usually required to provide further gear reduction.

More recently, gate operators comprised of manufactured non-intelligent and intelligent actuators have been used since they are suited for most applications and are readily available.

The Province has experienced a number of operational problems and maintenance issues with the recent use of intelligent actuators. In particular, a number of operational problems have occurred in cases where 3-phase intelligent actuators are supplied with 3-phase power converted from a 1-phase utility service. In comparison, the Province has used 3-phase non-intelligent actuators supplied with 3-phase power that has been converted from a 1-phase utility service with very few problems. Also servicing of intelligent actuators, other than for routine maintenance, normally requires using the manufacturer’s service personnel and equipment (i.e. specialized tools) that are typically not readily available locally, and are costly.

Therefore, selection of an appropriate gate operator system for a particular installation should consider the following:

- Preferably be a rugged, reliable system that is simplistic in design relative to its operational requirements, and that will require minimal ongoing preventative maintenance and relatively inexpensive repair costs.

- Operating requirements, life cycle cost analysis, past performance of similar installations where applicable, and availability of spare parts. Where the gate operator will incorporate an actuator, a non-intelligent actuator should be used.

- Mechanical considerations that take into account the torque/speed/power requirements of the gates/valves. Where the supply and installation of the actuator is being handled using performance specifications, care is needed to adequately size the actuators and select suitable gear ratios to avoid having undersized equipment (i.e. equipment selection should not be left solely to the supplier).

- Electrical/electronic considerations that take into account the availability and suitability of 3-phase/1-phase power, operating voltages, and available control system interface devices. As noted above, operational problems have been experienced primarily where 3-phase intelligent actuators with converted 1-phase power have been used. Therefore, the following approach should be implemented when selecting actuators depending on the utility service that will be provided:

    - Where actuator power requirements can be met with 1-phase actuators and 1-phase utility service is available, use 1-phase non-intelligent actuators.

    - Where actuator power requirements cannot be met with 1-phase actuators, use 3-phase non-intelligent actuators. Provide 3-phase power as discussed in Section 20.1.1.

For each gate operator, separate control inputs and outputs for the PLC interface should be provided to suit the gate operator and site requirements. These inputs and outputs may include:

Inputs:
- Gate operator position via an encoder on the gate shaft as noted in 19.3.4.
- Torque limits, open and close, on the gate operator or gate shaft.
- Travel limits, open and close, on the gate operator or gate shaft.
- Gate operator operating in opening direction.
- Gate operator operating in closing direction.
- Gate operator overload trip.

Outputs:
- Open, close, and maintain.

The gate operator controls should also include PLC inputs for identifying a power supply failure and providing the status of the UPS.

Actuators should usually have three operating modes, “remote”, “local”, and “off”. In “remote” mode, local control is disallowed. In “local” mode, remote control is disallowed. In “off” mode all control is disallowed.

Standard overhead hoist arrangements should normally be hard wired to a hoist local I/O drop that is fitted with a remote communication module.

19.3.4 Sensors, Indicators, and Displays

Typical components for sensors, indicators and displays include the following:

- Water level sensors are normally submersible 4-20 mA transmitters with an appropriate operating range.

- Gate position transmitters are ordinarily provided except where intelligent actuators are used and the gate position can be reported electronically through a built-in communication module. Gate position transmitters normally consist of multi-turn absolute optical encoders with an appropriate range (number of revolutions) and accuracy (number of steps). Encoder parameters (zero, span, direction of rotation) should usually be programmable to avoid remounting/rezeroing the transmitters by mechanical means.

- Operator displays (operator terminals) should usually be industrial terminals. Examples of industrial terminals include Nematron, PanelMate, Greyline, PanelView, etc. PC based or PC terminals are not allowed.

19.3.5 Programmable Logic Controllers

For hardware, the Province normally uses Modicon and Allen-Bradley PLCs.

For software, the Province uses Proworx/Proworx NxT, and Concept for programming the Modicon series of controllers, and RSLogix 500, and Topdoc for PLC-5 for the Allen-Bradley series of controllers. Ladder Logic and/or IEC are also acceptable program structures.

19.3.6 Communication Hardware

PLC connected communication equipment/protocol handlers should normally be hardware based.

19.3.7 HMI Considerations

The Province uses Wonderware Intouch for HMI integration.

19.3.8 Certification, Testing, and Documentation

Electrical installations must comply with the Canadian Electrical Code including any provincial amendments. Electrical installations should be inspected and certified by a qualified inspector.

The operation of the control system should be verified by the Province, and formal documentation for the complete control system installation is required. The documentation will normally include:

- Complete set of project “Record Drawings” in both hardcopy (mylar) and electronic format (AutoCAD drawing format and pdf).
- Operation and installation manuals for the equipment.
- Operations manual describing the operator interfaces, and the operation and maintenance procedures for the control system.
- Printed listings of all PLC logic, and any operator interface programs.
- PLC logic and display/HMI programs.
- Software programs used to set-up and program the PLCs, displays and HMI terminals.