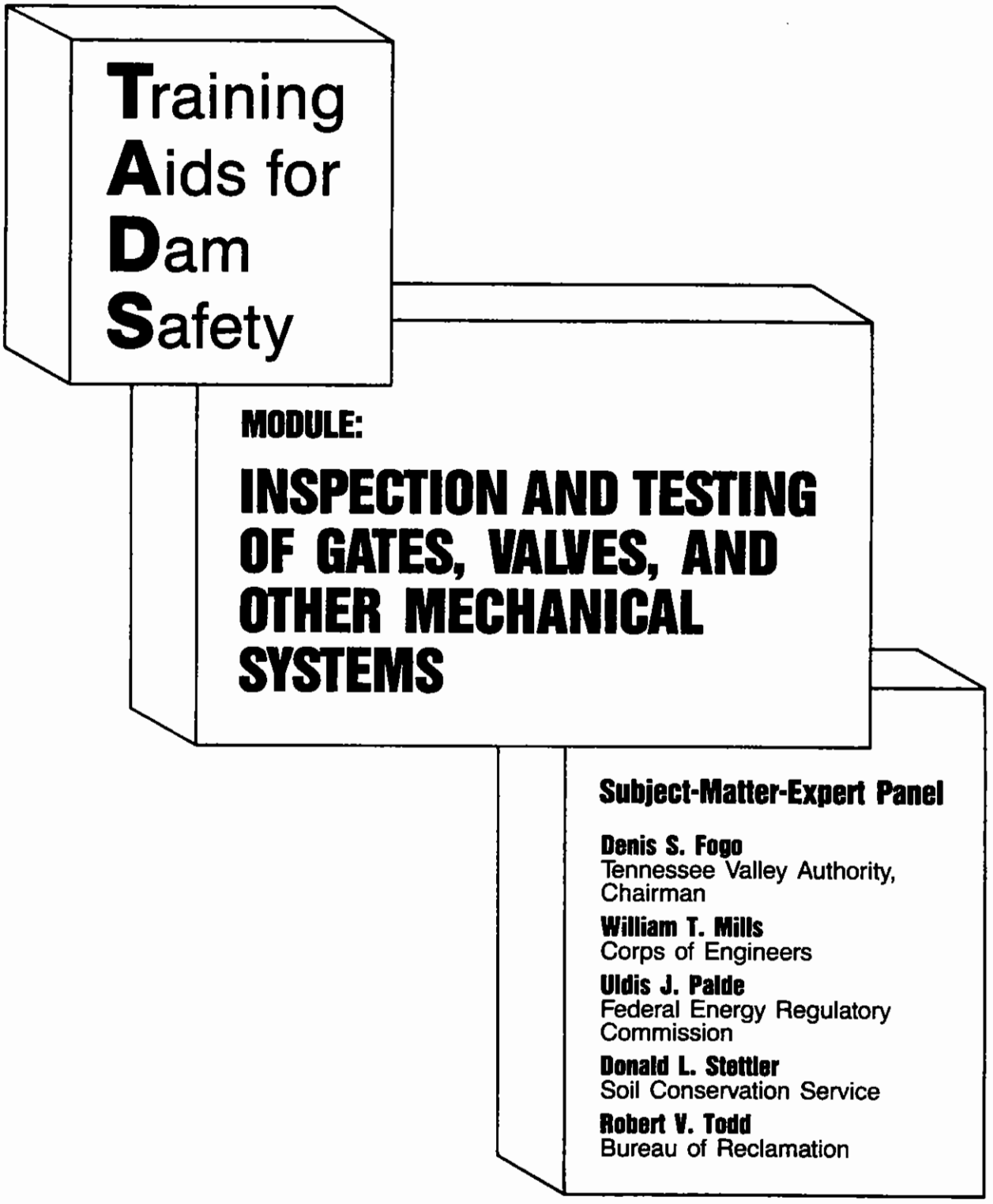
Training Aids for Dam Safety

MODULE:

INSPECTION AND TESTING OF GATES, VALVES, AND OTHER MECHANICAL SYSTEMS

A video presentation accompanies this workbook.


Training
Aids for
Dam
Safety
MODULE:
INSPECTION AND TESTING OF GATES, VALVES, AND OTHER MECHANICAL SYSTEMS
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PREFACE

There are presently more than 80,000 dams in use across the United States. Like any engineering works, these dams require continual care and maintenance, first to ensure that they remain operational and capable of performing all intended purposes, and then to preclude endangering people and property downstream.

The safety of all dams in the United States is of considerable national, state, and local concern. Given that, the principal purpose of the TADS (Training Aids for Dam Safety) program is to enhance dam safety on a national scale. Federal agencies have responsibility for the safe operation, maintenance, and regulation of dams under their ownership or jurisdiction. The states, other public jurisdictions, and private owners have responsibility for the safety of non-Federal dams. The safety and proper custodial care of dams can be achieved only through an awareness and acceptance of owner and operator responsibility, and through the availability of competent, well-trained engineers, geologists, technicians, and operators. Such awareness and expertise are best attained and maintained through effective training in dam safety technology.

Accordingly, an ad hoc Interagency Steering Committee was established to address ways to overcome the paucity of good dam safety training materials. The committee proposed a program of self-instructional study embodying video and printed materials and having the advantages of wide availability/marketability, low per-student cost, limited or no professional trainer involvement, and a common approach to dam safety practices.

The 14 Federal agencies represented on the National Interagency Committee on Dam Safety fully endorsed the proposed TADS program and have underwritten the cost of development. They have also made available technical specialists in a variety of disciplines to help in preparing the instructional materials. The states, through the Association of State Dam Safety Officials, also resolved to support TADS development by providing technical expertise.

The dam safety instruction provided by TADS is applicable to dams of all sizes and types, and is useful to all agencies and dam owners. The guidance in dam safety practice provided by TADS is generally applicable to all situations. However, it is recognized that the degree to which the methods and principles are adopted will rest with the individual agency, dam owner, or user. The sponsoring agencies of TADS assume no responsibility for the manner in which these instructional materials are used or interpreted, or the results derived therefrom.

ACKNOWLEDGMENTS

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TADS SUPPORTING ORGANIZATIONS

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MODULE INTRODUCTION

INSPECTION AND TESTING OF GATES, VALVES, AND OTHER MECHANICAL SYSTEMS

MODULE INTRODUCTION

OVERVIEW OF THE MODULE

In this module, you will learn the recommended methods for inspecting and testing gates, valves, and other mechanical systems associated with dams, and for detecting deficiencies in these systems. Specific types of mechanical systems will be described, including their basic operating principles and problem areas you should check. You will also learn how mechanical systems relate to the other major components of a dam.

OBJECTIVES

At the completion of this module, you will be able to:

- Discuss how mechanical systems are related to the other components of a dam.
- Explain the importance of periodic inspection and maintenance of dam mechanical systems.
- Describe the various types of mechanical systems used in dams, and their functions and operating principles.
- List problems commonly found in specific types of mechanical systems, and ways for the inspector to detect them.
- Carry out inspection and testing of mechanical systems efficiently and thoroughly, and properly document the results of your inspection.

HOW TO USE THIS MODULE

This module is designed to be used in conjunction with other Training Aids for Dam Safety (TADS) modules. The TADS Learner's Guide lists all of the TADS modules and presents a recommended sequence for completing the modules. You may want to review the Learner's Guide before completing this module.

The Inspection And Testing Of Gates, Valves, And Other Mechanical Systems module is an introductory module. Therefore, it is not necessary to complete any other modules before beginning this module. However, you may want to read the following modules before completing this module:

- Preparing To Conduct A Dam Safety Inspection
- Documenting And Reporting Findings From A Dam Safety Inspection
- Inspection Of Spillways And Outlet Works

MODULE INTRODUCTION

CONTENTS OF THIS MODULE

This module is divided into three units, followed by two appendixes:

- **Unit I. Mechanical Systems:** Provides an overview of mechanical systems, including their role in dam operation and safety.
- **Unit II. General Inspection Guidelines:** Presents some general information on conducting equipment inspections and tests.
- **Unit III. Specific Inspection Guidelines:** Contains detailed descriptions of the mechanical systems to be inspected, including the function of each type of equipment, and problems commonly associated with each type. Specific inspection tasks and recording techniques also will be included in this unit.
- **Appendix A. Glossary:** Defines a number of technical terms used in the module.
- **Appendix B. References:** Lists recommended references that can be used to supplement this module.

DESIGN OF THIS MODULE

This module is a self-paced instructional package. You may move through it as slowly or as rapidly as is comfortable for you. You may stop and review the material at any time. Since the module is designed for independent study, you may take breaks whenever you wish.

There are several components of this module that are designed to help you master the material being presented. These components include:

- Text Instruction
- Unit Exercises
- Video Presentation
- Final Review Exercise

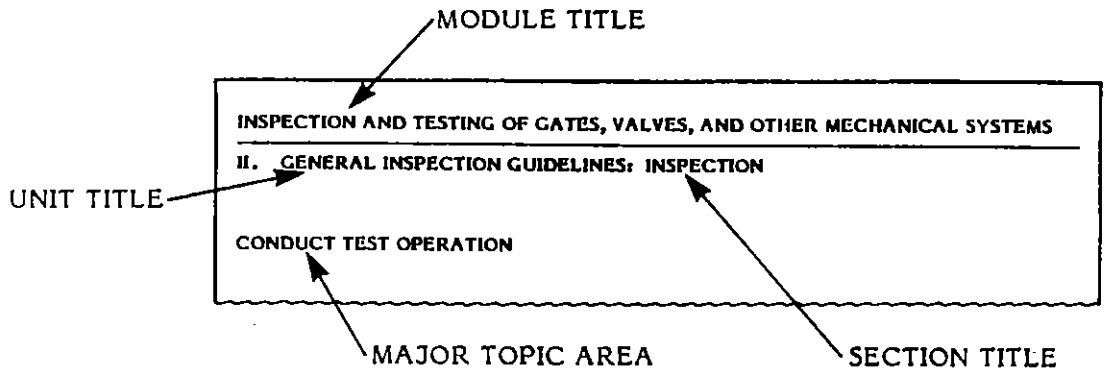
We will now look at how you will use each component individually.

MODULE INTRODUCTION

Text Instruction

The text instruction is presented in this workbook. Always begin by reading the text instruction, since it explains how to proceed through a given block of instruction.

As you read the text instruction, you will notice that every page has a header. The header is designed to let you know where you are in the module. Let's look at how information is presented in the header.



Unit Exercises

Most units include exercises to help you determine how well you are mastering the information presented. These exercises are **not** tests and will not be used to grade you or to rate your performance. Rather, the exercises are tools to help you assess your own learning.

Instructions for completing the exercises appear at the beginning of every exercise. Answers to the exercises are presented immediately following each exercise.

Video Presentation

One video presentation is included in this module. The text will tell you when to watch the video. After viewing the video, return to the text. You may watch the video presentation as many times as you find helpful.

Final Review Exercise

After reading the text instruction and watching the video presentation, you will complete a final review exercise. The final review exercise is designed to help you determine how much you have learned from the module. The final review exercise will not be used to grade you or to judge your performance.

Continued . . .

MODULE INTRODUCTION

Final Review Exercise (Continued)

Instructions for completing the final review exercise are presented at the beginning of the exercise. After completing the final review exercise, check your answers against those presented in the answer key. The answer key is located immediately after the final review exercise.

If you miss several of the questions, you may want to review the page numbers referenced in the answer key. If you get most of the questions correct, you are ready to begin another module.

REQUIRED MATERIALS

To complete this module, you will need the following materials:

- This workbook and a pencil or pen
- The accompanying videocassette and a videotape player

You may want to find a quiet place to work while you study these materials.

UNIT I

MECHANICAL SYSTEMS

INSPECTION AND TESTING OF GATES, VALVES, AND OTHER MECHANICAL SYSTEMS

I. MECHANICAL SYSTEMS: OVERVIEW

INTRODUCTION

The first unit of this module will introduce you to . . .

- **Fundamentals:** Gives a brief overview of the role of mechanical systems in dam operation.
- **Types Of Mechanical Systems:** Lists the various systems you will find on a typical dam.
- **Importance Of Inspecting Mechanical Systems:** Emphasizes the need for thorough and regular inspection and testing of mechanical systems.

UNIT OBJECTIVES

After completing this unit, you will be able to . . .

- Explain the functions of mechanical systems, and their role in the operation of a dam.
- List the various categories of mechanical systems used in dams.
- Discuss the need for periodic inspection, testing, and maintenance of gates, valves, and other mechanical equipment.

I. MECHANICAL SYSTEMS: FUNDAMENTALS

INTRODUCTION

In this section, we will examine mechanical systems in the context of the overall structure of a dam, so that you can understand the role that mechanical components serve in the operation of a typical dam.

FEATURES OF A DAM

A **dam** is a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water. A **reservoir** is the body of water impounded by a dam. The appurtenant works of a dam are described below, and illustrated in Figures I-1 and I-2 on the following pages.

- The **spillway** is a structure over or through which flood or excess flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway; if the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway.

- An **outlet works** is a structure through which normal reservoir releases are made. Since the outlet works also is used to drain the reservoir, it usually draws water through the dam at or near the bottom of the reservoir.

- **Control equipment** is a general term for the mechanical systems of gates and valves with which flows through the outlet works and spillway are regulated.

The appurtenant works of a dam serve three **main** purposes:

- Flood control (i.e., controlled release of flood-level flows)

- Normal release (for irrigation, reservoir level regulation, municipal or industrial use, hydroelectric power generation, minimum stream flow, etc.)

- Emergency reservoir drawdown

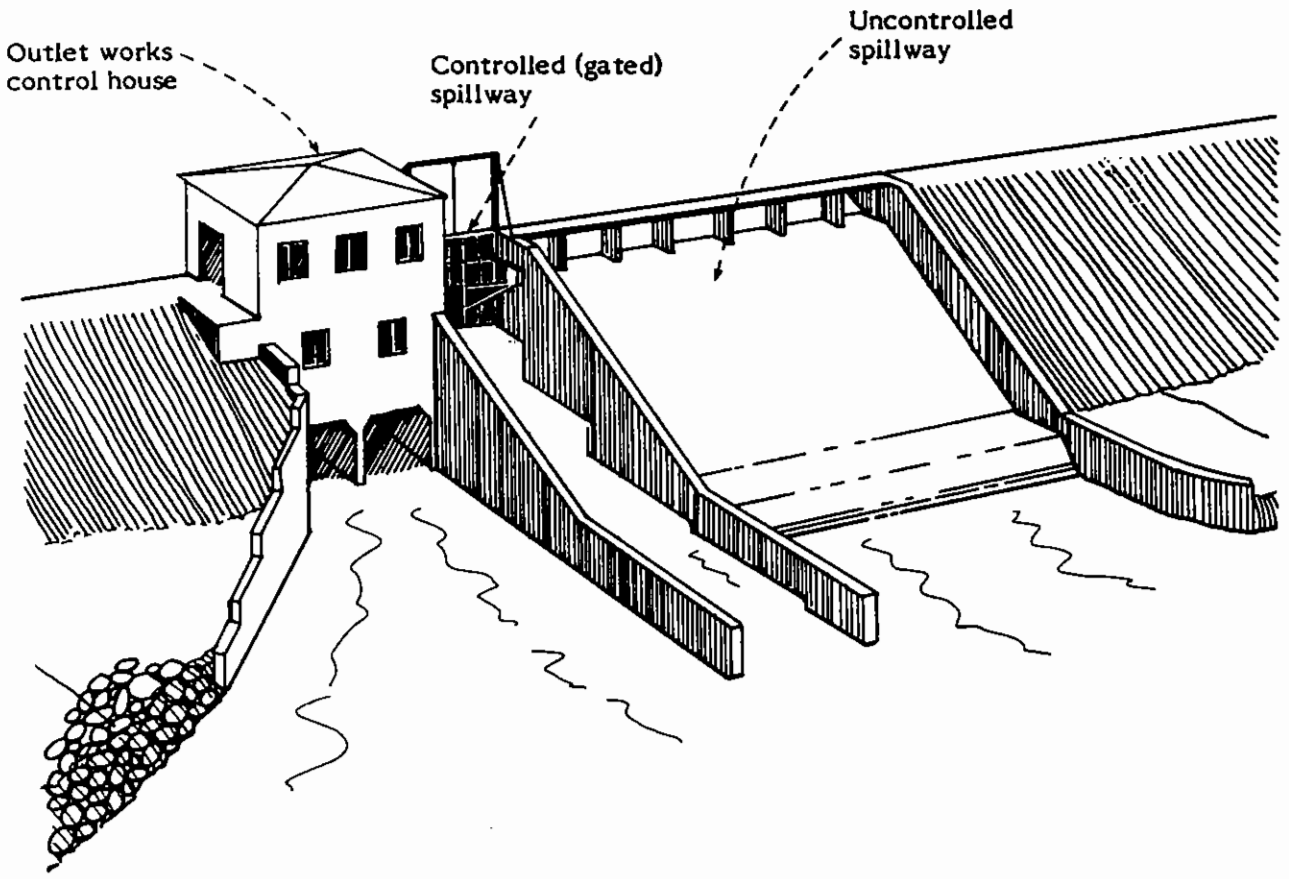
Mechanical systems are used to regulate these types of flows. Mechanical systems would also be used to evacuate the reservoir, should it become necessary to lower the pool to a safe level adequate to correct conditions that might threaten the integrity of the dam.

Continued . . .

I. MECHANICAL SYSTEMS: FUNDAMENTALS

FEATURES OF A DAM (Continued)

FIGURE I-1. FEATURES OF A LARGE DAM



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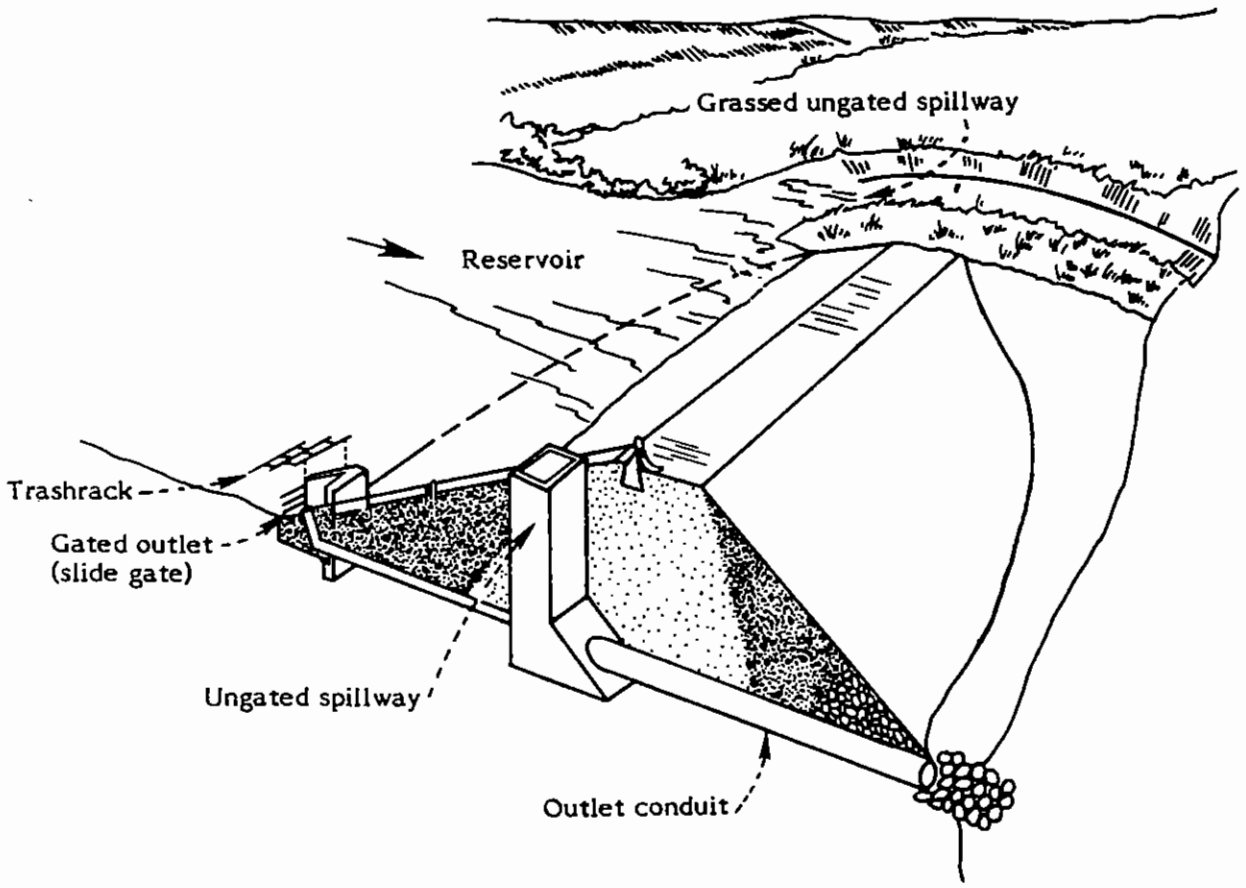
I. MECHANICAL SYSTEMS: FUNDAMENTALS

FEATURES OF A DAM (Continued)

FIGURE I-2. FEATURES OF A SMALL DAM



I. MECHANICAL SYSTEMS: TYPES OF MECHANICAL SYSTEMS

INTRODUCTION

Listed below are the kinds of mechanical systems that are commonly used in dams. Depending on the size and type of dams that you will be inspecting, you may not encounter some of these types of equipment.

GATES AND VALVES

Gates and valves are devices used to control or stop the flow of water in a waterway. In general, gates consist of a leaf or member which is moved across the waterway from an external position. Valves, on the other hand, are fixed permanently within the waterway, and have a closure member that either is rotated or moved transversely or longitudinally in the waterway in order to control or stop the flow. There are two classifications of gates and valves, based on their function.

- **Control** gates and valves are designed to regulate water flows, and therefore can be used fully open, fully closed, and at any setting in between.
- **Maintenance/emergency** gates and valves are used upstream of control devices, to act as standby or reserve closure equipment, or to stop the flow of water so that a gate, valve, or fluidway downstream can be serviced. Maintenance/ emergency gates and valves are usually kept either fully open or closed.

HOISTS AND OPERATORS

Hoists and operators are the mechanisms used to adjust the position of gates and valves. Hoists are employed exclusively with gates, to move them into and out of waterways, while the term "operator" is used to refer to positioning systems for both gates and valves.

POWER SYSTEMS

Hoists and operators can be either manually, electrically, hydraulically, or pneumatically operated.

I. MECHANICAL SYSTEMS: TYPES OF MECHANICAL SYSTEMS

AUXILIARY POWER SYSTEMS

Auxiliary power systems are used in the event of failure of the primary power source (e.g., an electrical blackout). Some examples of these auxiliary systems are listed below.

- Manually operated system
- Compressed-air system
- Emergency engine-driven electrical generator
- Portable auxiliary power unit

MISCELLANEOUS EQUIPMENT

There are some other types of mechanical equipment that do not fall into the categories just discussed. These types of equipment are described below.

Sump pumps are small pumps used to remove internal seepage that is collected in drains ("sumps") within the dam structure.

Air bubbler systems are de-icing systems that are designed to protect structures or equipment from damage that can be caused by the force of expanding ice. They normally are used on the upstream side of intake structures, to circulate warmer water from the bottom of the reservoir to the top, in order to prevent icing around gate structures.

Weather barrier doors are doors, often insulated with weathertight seals, that are used to prevent equipment from becoming inoperable when temperatures are below freezing.

Air vents are steel pipes (or passages in formed concrete) that allow atmospheric air to pass to the downstream side of gates and valves. This air is needed to prevent the development of high negative or positive pressures that could cause damage to the gate/valve and downstream pipes.

Reservoir level gauges are instruments that indicate the current level of water in a dam's reservoir.

Trashracks are metal grates located at intakes to prevent floating or submerged debris from entering the intake.

I. MECHANICAL SYSTEMS: IMPORTANCE OF INSPECTING MECHANICAL SYSTEMS

INTRODUCTION

In this section, we will discuss why it is so crucial that a dam's mechanical systems undergo periodic inspection, testing, and maintenance.

THE CONSEQUENCES OF FAILURE

Proper operation of a dam in an emergency situation depends on the proper operation of its outlet works and gated spillways. Improper operation of the mechanical equipment can cause dam failure.

THE NEED FOR PERIODIC INSPECTION

Because some equipment is used very infrequently (often in emergency situations only), regular inspections must be conducted to ensure that equipment will function when needed. Since a large portion of this equipment is exposed to the elements, operating and structural problems can develop that may only be discovered through periodic inspections and testing.

I. MECHANICAL SYSTEMS: UNIT EXERCISE

INSTRUCTIONS: Use the information presented in this unit to answer the following questions. When you have completed all of the questions, check your answers against those presented in the answer key. The answer key can be found immediately following this exercise.

1. Write the letter of each dam feature listed below next to the matching definition.

DAM FEATURES		DEFINITIONS	
a.	Spillway	_____	A general term for the system of gates and valves with which flows are routed.
b.	Control Equipment	_____	A structure over or through which flood flows are routed.
c.	Outlet Works	_____	A structure through which normal releases are made.

2. List the three main purposes of the appurtenant works of a dam.

- _____
- _____
- _____

3. Complete the sentence below:

_____ are employed exclusively with gates, to move them into and out of waterways, while _____ are used to refer to positioning systems for both gates and valves.

4. Place a checkmark (✓) next to the item that is **NOT** a type of power system.

_____ Hydraulic System

_____ Electric System

_____ Emergency System

_____ Manual System

Continued . . .

I. MECHANICAL SYSTEMS: UNIT EXERCISE

5. Since gates and valves often are used infrequently, periodic inspection is less important than with other dam features.

   Is this an accurate statement? ☐ Yes ☐ No

   Explain the reason for your answer: _____

   _____

   _____

6. Write the letter of each item listed below next to the matching description.

MECHANICAL EQUIPMENT		DESCRIPTIONS	
a.	Reservoir Level Gauges	_____	Metal grates located at intakes to prevent debris from entering.
b.	Trashracks	_____	De-icing systems that circulate warmer water from the bottom of the reservoir to the top.
c.	Air Bubbler Systems	_____	Used to remove internal seepage.
d.	Sump Pumps	_____	Instruments that indicate the current level of water in the reservoir.
e.	Weather Barrier Doors	_____	Insulated structures with weathertight seals that are used to prevent equipment from freezing.

I. MECHANICAL SYSTEMS: UNIT EXERCISE — ANSWER KEY

INSTRUCTIONS: Compare your answers to the answers given below to see how well you learned the information presented in this unit.

1. Write the letter of each dam feature listed below next to the matching definition.

DAM FEATURES		DEFINITIONS	
a.	Spillway	**b**	A general term for the system of gates and valves with which flows are routed.
b.	Control Equipment	**a**	A structure over or through which flood flows are routed.
c.	Outlet Works	**c**	A structure through which normal releases are made.

2. List the three main purposes of the appurtenant works of a dam.

   - **Flood Control**
   - **Normal Releases**
   - **Emergency Reservoir Drawdown**

3. Complete the sentence below:

   Hoists are employed exclusively with gates, to move them into and out of waterways, while **operators** are used to refer to positioning systems for both gates and valves.

4. Place a checkmark (✓) next to the item that is **NOT** a type of power system.

   _____ Hydraulic System

   _____ Electric System

   ✓ **Emergency System**

   _____ Manual System

Continued . . .

I. MECHANICAL SYSTEMS: UNIT EXERCISE -- ANSWER KEY

5. Since gates and valves often are used infrequently, periodic inspection is less important than with other dam features.

   Is this an accurate statement? ☐ Yes ☑ **No**

   Explain the reason for your answer:

   Inspections must be conducted to ensure the equipment will work when needed. Since this type of equipment is exposed to the elements, operating and structural problems can develop that may be discovered only through periodic inspections and testing. If the equipment fails to work when needed, the dam may fail, which can result in loss of property and life.

6. Write the letter of each item listed below next to the matching description.

MECHANICAL EQUIPMENT		DESCRIPTIONS	
a.	Reservoir Level Gauges	**b**	Metal grates located at intakes to prevent debris from entering.
b.	Trashracks	**c**	De-icing systems that circulate warmer water from the bottom of the reservoir to the top.
c.	Air Bubbler Systems	**d**	Used to remove internal seepage.
d.	Sump Pumps	**a**	Instruments that indicate the current level of water in the reservoir.
e.	Weather Barrier Doors	**e**	Insulated structures with weathertight seals that are used to prevent equipment from freezing.

I. MECHANICAL SYSTEMS: SUMMARY

This unit provided information on major dam components, and the role of mechanical systems in the operation of a dam. The next unit will discuss how you should prepare to inspect a dam's mechanical systems, and gives you some general guidelines for inspecting these systems.

UNIT II

GENERAL INSPECTION GUIDELINES

II. GENERAL INSPECTION GUIDELINES: OVERVIEW

INTRODUCTION

This unit will provide you with some general information on inspecting and testing mechanical systems. More detailed inspection guidelines for specific types of mechanical equipment will be presented in Unit III. The topics to be covered in this unit include . . .

- Preparation
- Inspection
- Documentation

UNIT OBJECTIVES

After completing this unit, you will be able to . . .

- Properly prepare for a dam inspection by assembling the materials and equipment you will need to conduct the inspection.
- Describe general techniques for conducting visual inspections and test operations of mechanical systems.
- Carry out post-inspection duties, including preparing the required documentation.

II. GENERAL INSPECTION GUIDELINES: PREPARATION

INTRODUCTION

In this section, we will examine the duties that you should carry out **before** actually beginning an inspection. Planning ahead and conducting some preliminary research can save you time and make for a more effective inspection. For more information on preparation, see the TADS module Preparing To Conduct A Dam Safety Inspection.

PREPLANNING

If possible, you should begin planning for an inspection at least two to three months before the scheduled date of the inspection, and often up to a year in advance. By preplanning, you can attempt to schedule your inspection when . . .

- Reservoir water levels will be acceptable for testing of equipment.
- Equipment will be accessible.
- A variety of seasonal influences can be evaluated over several years of inspections.
- You will have time to assemble a team (dam operating personnel, mechanics, divers, etc.) to help you with test operations and access to equipment.
- The date of your inspection will be coordinated with scheduled water releases, so that test operations can be conducted without violating water conservation restrictions or minimum stream flow requirements.

You should also make sure that you have prepared an agenda before the day(s) scheduled for inspection and testing, and that you have sent a copy of the agenda to the dam owner/operator.

DOCUMENT REVIEW

For any given dam you are to inspect, there should be a wide variety of sources from which you can learn about the inspection history of the mechanical equipment on that dam. These sources are described below and on the following page.

As-Built Drawings

It is important that you review the as-built drawings of the dam's mechanical equipment, to determine the type and location of the equipment to be inspected. Photographs and manufacturers' drawings of equipment at the dam may also prove helpful.

II. GENERAL INSPECTION GUIDELINES: PREPARATION

Design And Operating Documents

You should obtain and review the written standing operating procedures (SOP) and designer's operating criteria (DOC) for the components of the dam, if they are available.

By reading these documents, you will know how equipment is designed to operate, and you will be able to check during the inspection that the operating procedures described in the SOP are the same as those actually used by dam operating personnel.

Past Records

You should examine trends in the behavior and deterioration of specific pieces of equipment, by reading through previous inspection reports. Take special note of prior inspectors' observations in the "Summary" section of the inspection reports, which should include conclusions and recommendations. Make a copy of the last inspection report filed, and take it with you as a reference on the inspection.

If any other forms of documentation, such as related correspondence files, manufacturers' specifications or acceptance reports, etc., are available and seem helpful, you should review them before departing for your inspection.

GENERAL INSPECTION GUIDELINES

There is some general information that you should understand before beginning an inspection of a dam's mechanical equipment. This information is presented below and on the following pages.

Tools And Equipment Needed

Some of the types of tools and equipment that you may need during an inspection are listed below.

- Notebook and pencil
- Pocket tape measure
- Waders or other watertight boots
- Flashlight
- Camera with flash
- Electrical test equipment (e.g., megger, tachometer, ammeter, voltmeter, etc.) as required by your organization

II. GENERAL INSPECTION GUIDELINES: PREPARATION

Good Inspection Techniques

Periodic visual inspection and test operation of mechanical equipment is the most practical way to keep it operating smoothly and safely. The two most basic ways that you can be sure to conduct a comprehensive inspection are by:

- Using a checklist that includes a logically ordered procedure for conducting the inspection, with specific problem areas to examine and operational tests to be conducted for each type of equipment inspected.

- Making note of **anything** that seems to be out of the ordinary, or that you think could present a safety, maintenance, or operational problem in the future, and including the problem area in your inspection report.

☞ **INSPECTION TIP:** When developing and writing out the checklist to use on the inspection, leave plenty of room in the margins so that, as you conduct the inspection, you can write notes, observations, and specific areas or items to reinspect.

Remember To "SMPL"

If you do find any problem areas, remember to . . .

S **Sketch** what you have observed, if a photograph would not capture important aspects of the deficiency.

M **Measure** and record any appropriate data.

P **Photograph** the deficiency and describe its characteristics in your notes.

L **Locate** the deficiency in relation to some standard reference point (e.g., a feature of the dam or permanent monument) and record the location in your notes.

Personnel Safety

During an inspection, your first concern should always be safety. Every dam has its own set of hazardous situations to be evaluated, and you must determine the precautions to be taken before attempting an inspection. You must be physically capable of withstanding the rigor of the inspection.

You must be properly clothed and equipped for the inspection. Consideration should be given to the use of a hardhat, safety shoes, safety gloves, foul weather gear, goggles, safety belts, etc. You should carry a first aid kit. Whenever a boat is used in an inspection, those in the boat should be wearing life jackets. In addition, life jackets should be worn whenever there is a potential for falling in the water during an inspection (e.g., when working near a stilling basin).

Continued . . .

II. GENERAL INSPECTION GUIDELINES: PREPARATION

Personnel Safety (Continued)

You should make sure that any dam equipment that has the potential for falling or moving has been blocked or otherwise secured before beginning your inspection.

"Red tag" and lockout procedures are used to prevent inadvertent use of equipment which, if activated, would endanger personnel and equipment. Before starting your inspection, you should go over the electrical and mechanical "red tag" and lockout procedures with authorized project personnel, so that no gate, valve, or electrical circuit can be moved or energized without proper safety procedures being observed. If you are inspecting in an area where "red tagging" is not widely used or recognized, ensure your own safety by providing padlocks and chains to physically restrict use of equipment controls.

Adequate ventilation must be provided before you enter a conduit, well, or other confined area. Use an air monitor to verify that the area is adequately ventilated.

In addition, you should be aware of the hazards of walking on wet and slippery floors. Use slip-prevention techniques when walking, such as pulling with the front foot rather than pushing with the rear foot. Ladders and inclined surfaces may require fall-prevention devices, such as safety lines, self-arresting systems, etc.

Before you enter a conduit for an inspection, it's a good idea to alert someone (for example, one of the dam operating personnel). Decide upon a time at which you plan to finish your inspection and exit the conduit, and have the person come in after you if you do not emerge at this prearranged time. That way, if you slip and hurt yourself, or encounter noxious air, your whereabouts will be known and you can be rescued.

You must be careful when working near equipment that has rotating parts, such as motors, pumps, gears, etc. Do not wear loose clothing in these areas, and take care in the placement of your hands and feet.

Do not operate dam equipment yourself. Only authorized and qualified dam tenders or operators should operate equipment. When inspecting electrical items, do not reach into open control panels or push buttons or switches.

Frequency Of Inspection

The length of time allowed between periodic inspections of mechanical equipment depends, of course, on the type of mechanical equipment, the age of the mechanical equipment, and the regulations of the State or Federal agency that oversees the use of the dam. Special inspections are performed after unusual occurrences, such as floods, earthquakes, and sabotage.

II. GENERAL INSPECTION GUIDELINES: INSPECTION

INTRODUCTION

In this section, we will look at the duties you should carry out during the inspection itself. Remember that in this unit we are discussing only general inspection guidelines, and that more specific inspection information will be presented in Unit III.

Your first step upon arriving at the dam site is to meet with the dam owner or operator to explain what mechanical equipment you want to inspect and test operate. This is accomplished most easily by going over the agenda that you sent to the owner/operator. Discuss with the dam owner/operator any problems that have been experienced since the last inspection.

VISUAL INSPECTION

In conducting your visual (non-operational) inspection, you should check first any areas that have been dewatered for the inspection. By checking those areas after they have been rewatered, you can gain a more complete understanding of the condition of mechanical equipment found there. For example, if a gate had been dewatered for the purpose of your inspection, you could inspect the condition of the upstream side of the gate leaf upon your arrival, since it would not be under water. You could then return after the gate had been rewatered to check for leakage at the downstream side of the gate (which would now be under reservoir elevation, or head).

Checking Indicators

You should check the availability of all indicators at the dam. Examples of some of the indicators to be checked are provided below.

- ✓ Reservoir level indicators
- ✓ Gate position indicators
- ✓ Hydraulic cylinder pressure indicators

Reviewing Operating Instructions

As you inspect the various pieces of mechanical equipment at a dam, you should make sure that there are operating instructions for all equipment that requires instructions, and check that the labeling of all controls on equipment (e.g., dials, indicators, switches, etc.) is consistent with the instructions.

II. GENERAL INSPECTION GUIDELINES: INSPECTION

Checking For Cavitation Damage And Galvanic Corrosion

Two of the most common defects associated with gates and valves are **cavitation damage** and **galvanic corrosion.** Cavitation occurs when a critical combination of the flow velocity, the flow pressure, and the vapor pressure in the water is reached. An offset or irregularity on a flow surface exposed to high velocities produces turbulence. This turbulence creates negative pressures that cause water to vaporize and form bubbles, or cavities, in the water. Bubbles collapse when subjected to higher pressure downstream from the formation site.

Bubble collapse dynamics then create shock waves that can damage the flow surface. Popping and crackling noises (crepitation) accompany the collapse of the cavities. The impact of the shock waves can produce pressures up to 100,000 pounds per square inch. Repetition of these high-energy blows eventually forms the pits or holes known as cavitation damaged. (The TADS module Identification Of Material Deficiencies contains more information on cavitation damage.)

Galvanic corrosion is the result of electrical/chemical reactions between two dissimilar metals. Corrosion damage on a painted surface is indicated by areas of the surface in which the paint has been removed and the underlying metal has flakes and nodules of rust. The rust of ferric materials is usually brown and has a rough or flaky texture. Where pinholes have occurred in the paint surface the underlying metal will be pitted. Corrosion damage on an unpainted metallic surface will appear as a more uniform distribution of rust, except where erosion has removed the rust surface, resulting in differential removal of the metal.

It is very important that you check the extent of cavitation damage and galvanic corrosion when inspecting a gate. Below and on the following pages, we will discuss other defects associated with the components of gates and valves, and the consequences of those defects.

Inspecting The Gate Leaf

The **gate leaf** must be checked for seal damage, cracks, and damaged structural members.

Seal Damage. Seals used with gates can be either flexible (e.g., neoprene or rubber) or rigid (e.g., metal). Flexible seals may be damaged when the gate is handled during routine maintenance, when debris has caught between the seal and the gate frame, or when the surface that the seal mates with moves toward the gate leaf (causing the seal to be pinched or crushed). Flexible seals may also be damaged when the gate is exercised in the dry, as a result of the softer seal material rubbing against a harder material with debris particles caught between the two surfaces. Damage to rigid seals is usually due to foreign materials being caught between the mating surfaces.

The primary consequence of seal damage is leakage past the gate leaf. The loss of water may in some cases be acceptable, while in others it may not. If leakage occurs in the winter, ice can form downstream of the gate, over a period of time becoming thick enough to restrict flow when the gate is operated, or falling and damaging equipment located downstream from the gate. Ice forming around the seal will also increase friction and could result in the hoist being unable to operate the gate.

Continued . . .

II. GENERAL INSPECTION GUIDELINES: INSPECTION

Inspecting The Gate Leaf (Continued)

When leakage occurs past a seal on a gate leaf that is subjected to high hydraulic head, the velocity of the leaking water will be high. If there are any particles in the water, they will act as an abrasive on the downstream side of the gate leaf and the adjacent fluidway, resulting in progressive erosion of the leaf and fluidway.

Cracks. Cracks can occur in a gate leaf due to fatigue, overloading, or stress corrosion. If a crack reaches a critical length, that portion of the gate leaf will fail, resulting in loss of the whole leaf or just a section of the leaf. In either case, the leaf will not function as intended.

Damaged Structural Members. Structural members are often damaged by overloading the leaf. This can occur if a piece of debris becomes stuck under the gate leaf when the gate is being closed. The gate operator will exert its full pressure, since there is no signal from the limit switch to stop the operator, and the stress will be absorbed by the structural members in the leaf.

Damage can also occur when debris strikes the structural members. The result of damage to the structural members is a reduction in the structural integrity of the gate leaf, possibly leading to failure of the leaf.

Inspecting The Gate Frame

Damage to the **gate frame** can cause the gate to leak and/or make the gate operate poorly or not at all. There are several defects that can affect the performance of a gate frame.

Bent Gate Guides And Seat. Damage to a gate frame is often incurred when an attempt is made to close the gate while debris is lodged in the gate opening. This action can bend the gate guides and/or the seat.

Warp Or Misalignment. Differential settlement in the structure that houses the gate can also damage the gate frame. Such settlement will result in warp or misalignment of the seat and/or guides, which are attached to the structure.

When inspecting a gate frame, look for leakage, which is an indication that something is wrong (i.e., the seat or guides are bent or warped).

Inspecting The Lifting Assembly

The operation of a gate's **lifting assembly** can be impaired by corrosion and by a damaged stem or stem guides.

Continued . . .

II. GENERAL INSPECTION GUIDELINES: INSPECTION

Inspecting The Lifting Assembly (Continued)

Corrosion. Corrosion damage at the hoisting connection can eventually break the attachment between the stem and gate. The stem and stem guides can also be damaged by corrosion, especially if the gate is infrequently operated and/or the assembly is improperly lubricated. When inspecting a lifting assembly, look for corrosion at the hoisting connection and on the stem and stem guides, and check the assembly for proper lubrication.

Bent Stem And Stem Guides. Debris, ice, or other large matter slamming into the hoisting assembly can bend the stem and/or break, deform, misalign, or dislodge the stem guides. Forcing the gate into operation when debris is wedged in the gate opening or when the gate is "frozen" in place can have the same destructive effect on the stem and stem guides. When inspecting a lifting assembly, look for improper alignment of the stem and for misaligned, damaged, or missing stem guides. A bent gate stem may be an indication of improper limit switch operation or setting.

Inspecting The Air Vent

If an air vent has been included for use with a gate, it must be checked for clogging and for inadequate sizing.

Clogging. An air vent that is clogged, by either debris or corrosion, cannot perform its design function.

Inadequate Sizing. If a vent is too small to allow sufficient air into the conduit that it services, it will not function as designed. You should review design criteria prior to your inspection and check the criteria against field conditions. Judgments concerning proper vent sizing will have to be made by an experienced and qualified engineer.

Air vents are provided to ensure adequate ventilation to the area downstream from a gate or valve. The consequences of a clogged vent or an inadequately sized vent, both of which would result in an insufficient amount of air being allowed into the conduit, are very serious.

In the case of an emergency gate or valve, if there is inadequate ventilation, the sudden closure of the gate (or valve) in an emergency will result in subatmospheric pressures occurring downstream from the gate (or valve). These subatmospheric pressures may cause collapse of the conduit if insufficient stiffening was provided.

In the case of a control or maintenance gate, ventilation is needed so that cavitation will not occur when the gate is in operation.

An air vent also allows release of air to the atmosphere when filling a conduit. If some of the air in the conduit is not allowed to escape, it will become compressed and create an air bubble in the conduit, possibly causing separation of the water column. If separation occurs, damaging pressure waves may develop in the conduit the next time water releases are made.

II. GENERAL INSPECTION GUIDELINES: INSPECTION

Inspecting Valves

The valves that you are likely to encounter vary greatly in design and construction, so there are relatively few inspection tasks that apply to all valves. Deficiencies associated with most types of valves are discussed below.

Surface Damage. The surfaces of a valve are, of course, susceptible to galvanic corrosion and cavitation damage. Paint or other protective coatings are often applied to the exposed surfaces of a valve. Such coatings can be damaged by corrosion and cavitation, and also by debris striking the valve surface.

Damaged Seals And Seats. A valve's seals and seats are also subject to deterioration over time, and to damage by foreign objects. Damage to seals or seats can result in leakage past the valve, vibration, and cavitation damage.

Damaged Structural Members. The structural members of a valve are most often damaged by vibration produced when the valve is operated. If damaged structural members are not repaired, they will continue to deteriorate, ultimately resulting in failure of the valve.

Checking For Illegal Or Improper Use Of Gates And Valves

Gates and valves sometimes are installed illegally or improperly, to increase the storage of the reservoir or to take advantage of reservoir head. While visually these gates and valves may appear to be appropriate, they will decrease the capacity of the spillway, or pressurize a conduit not meant to be pressurized. Examples of illegally or improperly used equipment include:

- A structure placed in the spillway crest to increase reservoir storage capacity, which may impair the proper operation of the dam in a flood situation.
- A valve installed at the downstream end of a nonpressurized pipe, which will pressurize the pipe, cause it to leak, and lead to piping through the embankment.
- Flashboards placed on radial gates.

Your pre-inspection document review will help to identify illegally or improperly used gates and valves at the site. Check the approved "as-built" drawings against all installed gates and valves.

Inspecting Auxiliary Power Systems

All of the backup power systems at a dam must be visually inspected and test operated periodically, to ensure that they will perform properly if needed in an emergency situation.

Inspecting Hoists And Operators

Inspect all hoists and operators, and their control systems.

II. GENERAL INSPECTION GUIDELINES: INSPECTION

Evaluating Security

Security of dams is a complex issue. A dam's security needs are directly related to the consequences of illegal or unauthorized operation of the dam outlet equipment or the disablement of that equipment. The security provided must be commensurate with the consequences. For some dams the security system may only require locking in place the handwheels that operate gates or valves. Other dams may require a sophisticated security plan, the implementation of which involves extensive locking, alarms, fencing, and security personnel.

When checking the adequacy of a dam's security system, you must be aware of the consequences of any potential unauthorized operation or illegal acts affecting the safety of the dam. For example, a dam with spillway gates that could be made inoperable, causing the dam to overtop in a storm, may require a sophisticated security system. On the other hand, a dam which has ungated spillways for flood control, and gated outlets capable of releasing relatively small flows for irrigation, minimum streamflow, etc., would have little need for security. Unauthorized operation of equipment on this type of dam would mainly affect the owner and would not have an impact on dam safety.

Most dams requiring sophisticated security systems will have a security plan. For these dams, your inspection should include a review of the plan, an evaluation of the adequacy of the plan, and a check to see that the plan is being fully implemented. If such a dam does not have a security plan, you should recommend that one be developed and fully implemented.

For dams requiring minimal security, your inspection should include checking to see what security has been implemented, and determining its adequacy. Make recommendations for upgrading the security system, if needed. Check that handwheels are locked in place, control houses are locked, and access to critical areas is restricted.

The TADS module Evaluation Of Facility Emergency Preparedness contains additional guidelines for assessing site security.

Responding To Problems

If problems are noted during your visual inspection, you should:

- Recommend that maintenance problems be corrected, and that measures be taken to improve routine maintenance.
- Get assistance from an experienced and qualified engineer, if required.
- Document fully any problems you find, using the "SMPL" method discussed earlier in this unit.

II. GENERAL INSPECTION GUIDELINES: INSPECTION

TEST OPERATION

A test operation of a gate or valve ideally consists of operating it through a complete "cycle," from fully closed to fully open to fully closed, under maximum reservoir head. Your main inspection concern should be that the gate or valve in question operates, and does so smoothly.

☞ **INSPECTION TIP:** In certain circumstances, it may not be practical, or even possible, to open or close a gate or valve fully. In such cases, you will have to adjust your test operation procedure accordingly. In addition, you may encounter equipment that you cannot observe in operation, such as gates or valves that are embedded in concrete. You can consult the dam's logbooks to learn more about the past operating histories of such equipment. These logbooks will include information on problems previously encountered with the mechanical systems, and the dates of recent gate and valve openings.

Your main inspection concern should be that the gate or valve in question operates properly. The following are indications of potential operating problems with gates and valves:

- ✓ Jerky or rough operation
- ✓ Leakage
- ✓ Vibration
- ✓ Abnormal noises
- ✓ Binding

All primary and auxiliary power systems should be inspected and used during the test. Operate the equipment being tested through one cycle using the primary power system, then one cycle using the auxiliary power system. If there is more than one piece of equipment of the same type, operate one or more using the primary and auxiliary power systems.

During the test operation, observe the pressures indicated by the pressure gauges on the power system and on the operators to see whether unusual resistance is encountered during the operating cycle. Such resistance would be an indication of potential equipment malfunction. The normal operating pressures should be defined in the operating instructions. An indication of potential problems can be determined by comparing the pressures recorded from previous test operations.

Check the operation of the limit switches. This is done by operating the equipment through a full cycle and allowing the limit switch to deactivate the power source.

II. GENERAL INSPECTION GUIDELINES: INSPECTION

Conditions For Testing

Whenever possible, testing should be conducted under the maximum anticipated head and flow for a given conduit or gated spillway. Emergency gates in particular must be designed to operate under "unbalanced conditions" (i.e., they must be capable of being closed under maximum flow and pressure differences on the gate), since malfunctioning of the primary gate will result in uncontrolled flow.

Some gates should be tested under "balanced conditions," meaning that pressure on both the upstream and downstream sides of the gate is equalized (e.g., equal water pressure against both sides).

☞ **INSPECTION TIP:** Never perform an emergency test operation without first ensuring that the gate or valve is adequately vented. An emergency test operation is opening or closing a gate in an **unbalanced** condition. An experienced and qualified engineer will have to verify that the venting is adequate.

Responding To Problems

If you find that a gate or valve is not operating, or doesn't do so smoothly, you should:

- Note the gate or valve position(s) at which problems exist.
- Check for loose mounting bolts.
- Check for trash and debris.
- Note the elevation of both the reservoir and the downstream pool, to help in the analysis of the problem by an experienced and qualified engineer.
- Inspect the seals and seats for binding and damage.
- Check for misalignment of parts.
- Check the equipment's lubrication, if applicable.
- Document fully any problems you find, using the "SMPL" method discussed earlier in this unit.

If you have not discovered the cause of the problem after checking these items, ask for assistance from an experienced maintenance superintendent and/or an experienced and qualified engineer.

II. GENERAL INSPECTION GUIDELINES: DOCUMENTATION

INTRODUCTION

Proper documentation of the results of your inspection will ensure that both the dam owner/operator and future inspectors of the dam will benefit from your efforts. For more information on documenting your inspection, see the TADS module Documenting And Reporting Findings From A Dam Safety Inspection.

FOLLOWUP REPORT

Filing a followup report that includes your observations and recommendations for the dam will provide a valuable source of information for the next person assigned to inspect the dam. Properly documenting the results of your inspection will also help the dam owner/operator implement any needed changes.

☞ **INSPECTION TIP:** There should be no surprises in your inspection report. Make sure that you have tactfully discussed any problem areas with the dam owner/operator (either in person or over the phone) before you file the report, and let the owner/operator know what your preliminary conclusions and recommendations are.

II. GENERAL INSPECTION GUIDELINES: UNIT EXERCISE

INSTRUCTIONS: Use the information presented in this unit to answer the following questions. When you have completed all of the questions, check your answers against those presented in the answer key. The answer key can be found immediately following this exercise.

1. Preplanning saves time and makes for a more effective inspection. List two reasons why preplanning is important.

   - _____
   _____
   - _____
   _____

2. What does "SMPL" stand for?

   S = _____

   M = _____

   P = _____

   L = _____

3. List two of the indicators discussed in this unit that should be checked during an inspection.

   - _____
   - _____

Continued . . .

II. GENERAL INSPECTION GUIDELINES: UNIT EXERCISE

4. During a visual inspection, an inspector notices a problem. The problem appears to be very easy to remedy and there are no dam personnel in the immediate area. The inspector decides to fix the problem. Do you agree with the inspector's decision?
☐ Yes ☐ No

   Explain your answer: _____

   _____

5. A test operation of a gate or valve ideally consists of operating it through a complete cycle under maximum reservoir head, and ensuring that the gate or valve operates, and does so smoothly. As an inspector, you may encounter circumstances where it may not be possible or practical to open or close a gate fully. Is it your responsibility to inspect the component under these circumstances? ☐ Yes ☐ No

   If you think the component should be inspected, describe how you would do so.

   _____

   _____

6. During an inspection, your first concern always should be _____.

7. During a visual inspection of a gate, an inspector should look for potential deficiencies. List five examples of potential gate deficiencies.

   - _____
   - _____
   - _____
   - _____
   - _____

Continued . . .

II. GENERAL INSPECTION GUIDELINES: UNIT EXERCISE

8. List three things you should do if you find that a gate or valve is operating roughly.

- _____
- _____
- _____

II. GENERAL INSPECTION GUIDELINES: UNIT EXERCISE — ANSWER KEY

INSTRUCTIONS: Compare your answers to the answers given below to see how well you learned the information presented in this unit.

1. Preplanning saves time and makes for a more effective inspection. List two reasons why preplanning is important.

   Any two of the following:

   - **Reservoir water levels will be acceptable for the testing of equipment.**
   - **A variety of seasonal influences can be evaluated over several years of inspections. By preplanning your inspection you can be sure to conduct the inspection during the same season as before.**
   - **You will have time to assemble an inspection team (dam operating personnel, mechanics, divers, etc.) to gain access to the equipment and to conduct needed tests.**
   - **By preplanning the date of your inspection you will be coordinated with scheduled water releases, so that test operations can be conducted without violating water conservation restrictions.**

2. What does "SMPL" stand for?

   S = Sketch

   M = Measure

   P = Photograph

   L = Locate

3. List two of the indicators discussed in this unit that should be checked during an inspection.

   Any two of the following:

   - **Gate position indicator**
   - **Reservoir level indicator**
   - **Hydraulic cylinder pressure indicator**

Continued . . .

II. GENERAL INSPECTION GUIDELINES: UNIT EXERCISE — ANSWER KEY

4. During a visual inspection, an inspector notices a problem. The problem appears to be very easy to remedy and there are no dam personnel in the immediate area. The inspector decides to fix the problem. Do you agree with the inspector's decision?
☐ Yes ☑ **No**

Explain your answer:

The inspector should never attempt to repair or operate dam equipment.

5. A test operation of a gate or valve ideally consists of operating it through a complete cycle under maximum reservoir head, and ensuring that the gate or valve operates, and does so smoothly. As an inspector, you may encounter circumstances where it may not be possible or practical to open or close a gate fully. Is it your responsibility to inspect the component under these circumstances? ☑ **Yes** ☐ No

If you think the component should be inspected, describe how you would do so.

You can consult the dam's logbooks to learn more about the operating history of the equipment. The logbooks also include information on previous problems, and the dates of recent gate and valve openings. If problems have occurred, speak with the operating personnel who are at the dam to gather additional information.

6. During an inspection, your first concern always should be **safety**.

Continued . . .

II. GENERAL INSPECTION GUIDELINES: UNIT EXERCISE — ANSWER KEY

7. During a visual inspection of a gate, an inspector should look for potential deficiencies. List five examples of potential gate deficiencies.

Any five of the following:

- **Overall**
  - **Cavitation damage**
  - **Galvanic corrosion**
- **Gate Leaf**
  - **Seal damage**
  - **Cracks**
  - **Damaged structural members**
- **Gate Frame**
  - **Bent gate guides and seat**
  - **Warp or misalignment**
- **Lifting Assembly**
  - **Corrosion**
  - **Bent stem and stem guides**
- **Air Vent**
  - **Clogging**
  - **Inadequate sizing**

8. List three things you should do if you find that a gate or valve is operating roughly.

Any three of the following:

- **Note the gate or valves position(s) at which problems exist.**
- **Check for loose mounting bolts.**
- **Check for trash and debris.**
- **Note the elevation of both the reservoir and the downstream pool, to help in the analysis of the problem by an experienced and qualified engineer.**
- **Inspect the seals and seats for binding and damage.**
- **Check for misalignment of parts.**
- **Check the equipment's lubrication, if applicable.**
- **Document fully any problems you find, using "SMPL."**

II. GENERAL INSPECTION GUIDELINES: SUMMARY

This unit presented information on how you should prepare for, conduct, and follow up your inspection of a dam's mechanical systems. The next unit will examine in greater detail the types of mechanical systems you are most likely to encounter in an inspection, and provide specific guidelines for inspecting and testing these systems.

VIDEO PRESENTATION

At this point you should watch the video presentation on inspecting mechanical systems. To watch the video presentation . . .

- Turn on your video player.
- Load the videocassette.
- Watch the video presentation.

After watching the video presentation, return to the next unit in this text.

UNIT III

SPECIFIC INSPECTION GUIDELINES

III. SPECIFIC INSPECTION GUIDELINES: OVERVIEW

INTRODUCTION

This unit will provide you with detailed descriptions of specific types of mechanical systems to be inspected. Included in the descriptions will be the function of each type of equipment, and problems commonly associated with the equipment. Specific inspection tasks will also be included in these descriptions.

UNIT OBJECTIVES

After completing this unit, you will be able to . . .

- Describe the various mechanical systems found in a dam, including how each type of equipment works, and where it is used in the dam.
- Discuss design limitations and common problem areas associated with each type of equipment.
- Participate in a visual inspection and a test operation of each mechanical system.

CONTENTS OF THE UNIT

There is a description in this unit of each type of equipment you are likely to encounter. The writeups are grouped together as follows:

- Gates
- Valves
- Power Systems
- Auxiliary Power Systems
- Hoists And Operators
- Miscellaneous Equipment
- Related Issues

Table III-1 on the next page lists all the equipment descriptions included in this unit, along with the page number on which each description can be found. You may decide to read only the sections that cover the types of equipment you will be inspecting or you may decide to read all of the writeups. The choice is yours.

Continued . . .

CONTENTS OF THE UNIT (Continued)

NOTE: We have included in this unit only the inspection tasks that are unique to each specific equipment type, with the assumption that you will also inspect for the common deficiences that were listed in Unit II (cavitation damage, leakage, damaged structural members, etc.).

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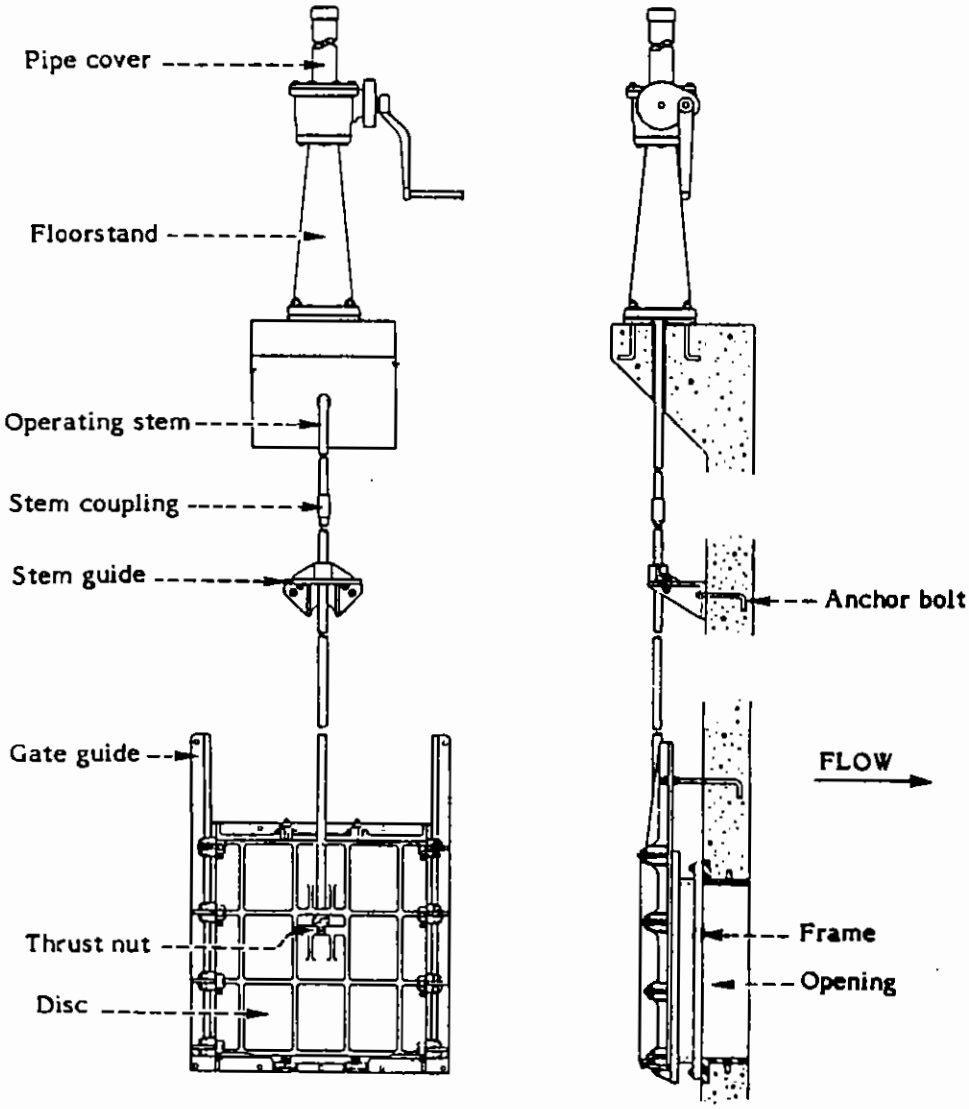
III. SPECIFIC INSPECTION GUIDELINES: GATES

SLIDE GATE

A typical slide gate, also known as a "sluice gate," consists of a leaf or disk that is opened or closed by sliding in seating guides, generally with metal to metal sealing contact. Slide gates are used at the upstream end of outlet conduits and in wet wells, and can be installed either vertically or at an incline. A typical slide gate installation is shown in Figure III-1 below.

FIGURE III-1. SLIDE GATE



Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: GATES

SLIDE GATE (Continued)

Slide gates generally require a certain head of water in order to seal in their closed position, or use a system of wedges to ensure proper sealing. They move in seating guides on each side of the gate, and are raised and lowered using a gate stem and operator. The gate stem is supported at intervals by guides to prevent bowing and buckling of the stem. The operator for smaller gates is usually a handwheel. Power operators are required for larger gates.

Slide gates are used:

- As control gates, to regulate the downstream water flow.
- As maintenance/emergency gates, to allow maintenance and/or inspection of downstream regulating valves.

Design Limitations

The following design limitations must be considered in the installation and inspection of slide gates:

- The conduit must be vented just downstream of the gate if used to regulate flow, and to allow filling of the downstream conduit.
- The adjustable guides, wedges, and stops that are used to ensure accurate seating and thus prevent leakage require precise setting. With gate use these items become loose, which can result in excessive leakage.

Problem Area

Cavitation damage can develop just downstream of any offsets in the fluidway, usually low in the corners.

Visual Inspection

When the gate is below the waterline, you should check for leakage on the downstream side.

When the gate is dewatered, or divers are being used in the inspection, you should make sure that the gate frame is firmly attached to the inlet structure, and that all fastening nuts are in place and tight.

Test Operation

To test the gate, operate it under balanced, no-flow conditions (if possible), and ensure that the leaf moves smoothly and without binding.

After ensuring that the downstream side of the leaf is adequately vented, operate the gate through full travel with full flow while subjected to maximum head (if possible). Ensure that the leaf moves smoothly and without binding.

III. SPECIFIC INSPECTION GUIDELINES: GATES

HIGH-PRESSURE GATE

The high-pressure gate is basically a slide gate that consists of a rectangular or square leaf encased either in a cast iron or welded steel body. The top of the body is connected to a bonnet with a bonnet cover, above which the operator is mounted. An example of a high-pressure gate is shown in Figure III-2 on the following page.

High-pressure gates are used in tunnels, conduits, or pipes near the center of earthfill dams, or at the downstream end of conduits or pipes. Often, high-pressure gates are used in tandem.

The gate leaf moves in seating guides positioned on the sides of the leaf. A stem connected to the top of the leaf passes through the bonnet and is attached to the hydraulic operator. High-pressure gates are used:

- As maintenance/emergency gates in tunnels, conduits, or pipes.
- As regulating gates at the end of conduits or pipes.
- In tandem, with the upstream gate acting as the guard gate, and the downstream gate acting as the regulating gate.

Design Limitation

The pipe or conduit must be vented just downstream of the gate if the gate is being used to regulate flow, and to allow filling of the downstream conduit.

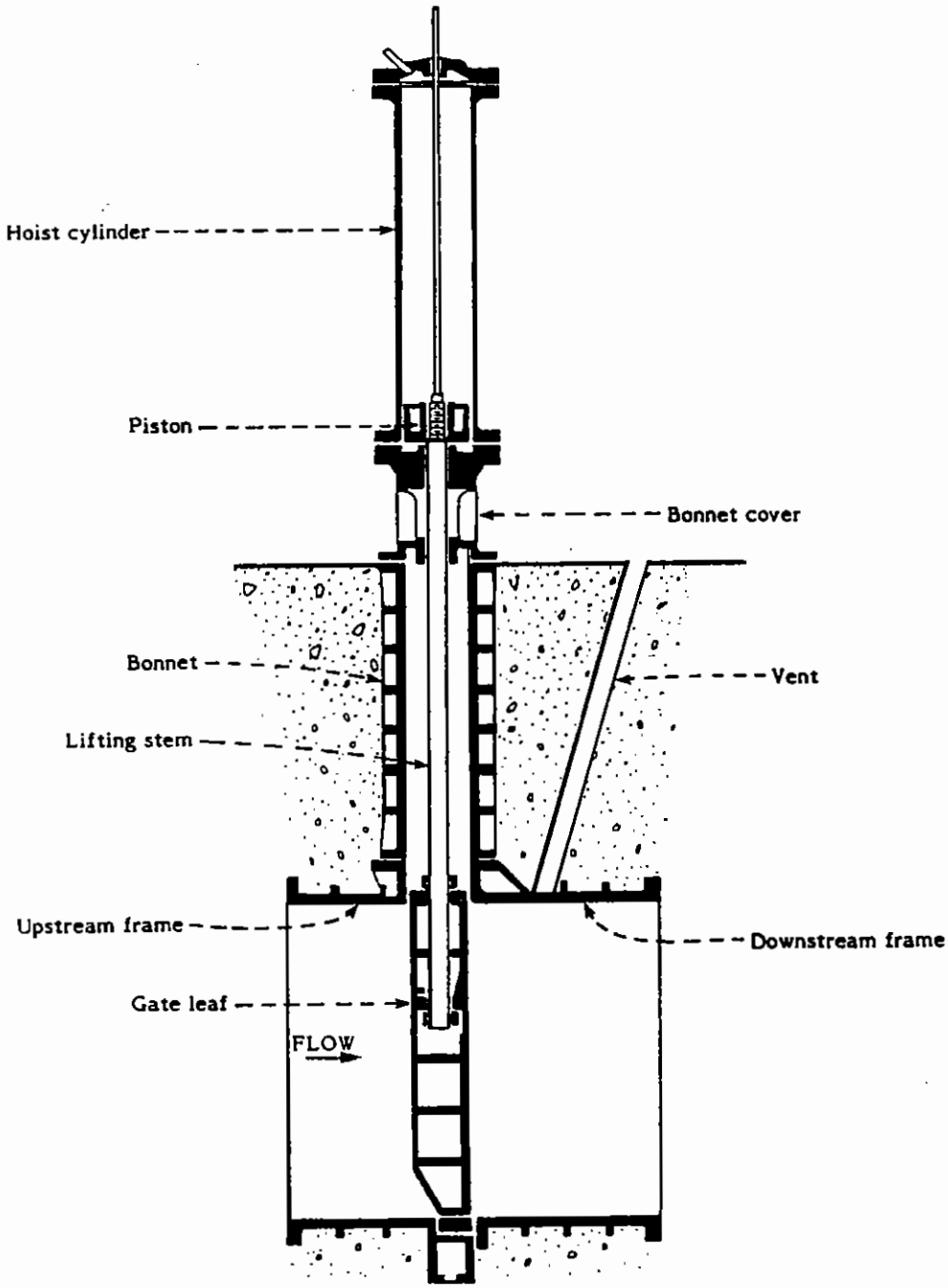
Problem Area

Cavitation damage can develop just downstream of any offsets in the fluidway, usually low in the corners.

Continued . . .

HIGH-PRESSURE GATE (Continued)

FIGURE III-2. HIGH-PRESSURE GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a high-pressure gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Gate Body And Bonnet	✓	Check for heavily corroded areas or areas damaged by cavitation, particularly on the sidewalls just downstream from the guide slots, and on the floor just downstream from the sill. Also, ensure that there are no damaged seats, loose or missing seat bolts, or clogged ventilation holes.
Bonnet Cover	✓	Look for cracks in the cover or leaky gaskets at the flange where it joins the bonnet. Check for leakage at the piston stem packings (i.e., oil leaking from the upper packings, and water from the lower packings).
Leaf	✓	Inspect for heavily corroded areas or areas damaged by cavitation along the leaf bottom, cracked or broken ribs, loose stem connections, and damaged or badly worn seating surfaces.

Test Operation

To test the gate, operate it under balanced, no-flow conditions (if possible), and ensure that the leaf moves smoothly and without binding.

After ensuring that the downstream side of the leaf is adequately vented, operate the gate through full travel with full flow while subjected to maximum head (if possible). Ensure that the leaf moves smoothly and without binding.

III. SPECIFIC INSPECTION GUIDELINES: GATES

ROLLER-MOUNTED GATE

"Roller-mounted gate" is a term used to refer to several types of gates, all of which are modifications of one basic design concept: a flat, structural-steel stiffened gate leaf consisting of a skinplate, beams, girders, and a roller train system which carries the waterload from the gate leaf to tracks that are embedded in concrete on either side of the fluidway. We will now examine each of the design modifications individually.

The design which today is referred to as a **roller-mounted gate** (but was formerly known as a "coaster" gate) has one or more sets of rollers contained in endless chains mounted on fixed carriages on each side of the gate leaf. The gate is raised to open and lowered to close. It may be installed vertically or on a slope. Figure III-3 on the next page shows a typical roller-mounted gate.

The **Stoney gate** resembles the roller-mounted gate except that the rollers are not in the form of a continuous chain. Instead, they are mounted between rigid vertical bars at each side of the gate, and are attached to neither the gate nor the gate guide. The rollers transmit the hydraulic gate load from the leaf to the track and move vertically between the two as the gate is moved; the roller moves only one-half the distance of the gate movement. The larger spillway types of gates are operated by counterweighted wire rope or chain hoists.

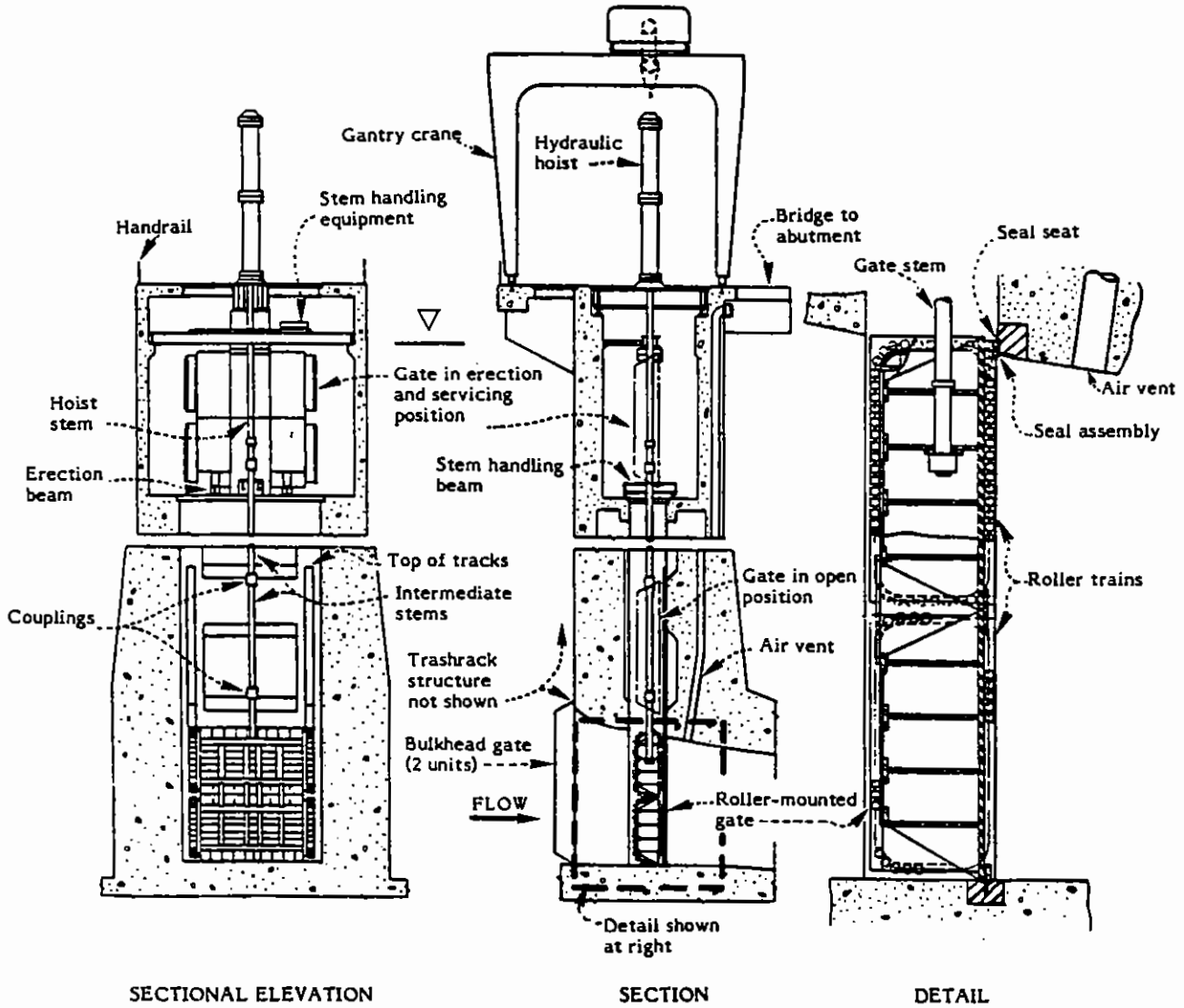
The **caterpillar** gate is like a roller-mounted or Stoney gate that is installed on an inclined surface, except that it is lowered to open and raised to close; the hoist stem crosses through the flow path.

The **tractor** gate is also similar to the roller-mounted gate, but it involves a more complex design. The roller carriages move away from the gate leaf when the gate seats, allowing the water pressure on the leaf to be transferred directly to the seating surfaces.

Continued . . .

ROLLER-MOUNTED GATE (Continued)

FIGURE III-3. ROLLER-MOUNTED GATE



Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: GATES

ROLLER-MOUNTED GATE (Continued)

The two primary applications of roller-mounted gates are:

- As a low-head spillway gate, for regulating reservoir releases.
- As a high-head emergency gate, on the upstream face of the dam.

Design Limitations

Recent designs have not used roller-mounted gates for spillway regulation because other gates (radial or wheel-mounted) are better suited. Current use of roller-mounted gates is restricted to high-head emergency-gate types of installations.

Problem Areas

All roller-mounted gates contain numerous small moving parts in the roller trains that are vulnerable to seizing caused by corrosion and debris. Once a roller seizes, rolling friction becomes sliding friction, which is many times higher. If enough rollers seize, the hoist will not have the capacity to raise the gate, nor will the gate weight be sufficient to lower the gate.

Recent designs of the roller-mounted gate incorporate double stem seals that are pressure-actuated from the reservoir head. The clamps and water passage ports for these seals must be kept free of corrosion and debris so the seals can extend properly once the gate is closed.

The stem of the caterpillar gate installed in a spillway is vulnerable to damage from floating debris and ice.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a roller-mounted gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Sinkplates, Beams, And Girders	✓	Look for corrosion or cavitation-damaged areas, cracked welds, broken structural members, and missing or broken rivets or bolts. Pay particular attention to the bottom of the leaf.
Roller Assemblies And Carriages	✓	Check for broken, deformed, or missing rollers, pins, or links; flattened rollers (indicating that they have been sliding instead of rolling); and deformed or broken carriages.
Track	✓	Look for deformations, corrosion, damaged surfaces, and missing or damaged bolts and clips.
Frame	✓	Look for badly corroded parts, damaged or missing bolts, and cavitation damage, especially downstream from slots and along the floor.
Seal Seats	✓	If possible, check for badly corroded or pitted seal seats.
Seals	✓	Check that seals operate properly.

Test Operation

To test the gate, operate it under balanced, no-flow conditions (if possible), and ensure that the leaf moves smoothly and without binding.

After ensuring that the downstream side of the leaf is adequately vented, operate the gate through full travel with full flow while subjected to maximum head (if possible). Ensure that the leaf moves smoothly and without binding.

III. SPECIFIC INSPECTION GUIDELINES: GATES

WHEEL-MOUNTED GATE

A wheel-mounted gate (also referred to as a "fixed-wheel" gate) is a flat structural-steel stiffened gate leaf with steel wheels. The gate is used at intakes for penstocks, tunnels, and spillway structures. Water pressure on the skinplate face of the gate is transferred by the wheels to a steel track embedded in the gate slot. The gate normally is designed to be lowered by its own weight, but at some installations it can be powered down. In some installations, the gate seals are pressure-actuated by water in the seals after the gate has been closed. Wheel-mounted gates are used as emergency gates, or as regulating spillway gates for low-head applications. An example of a wheel-mounted gate is shown in Figure III-4 on the following page.

Problem Areas

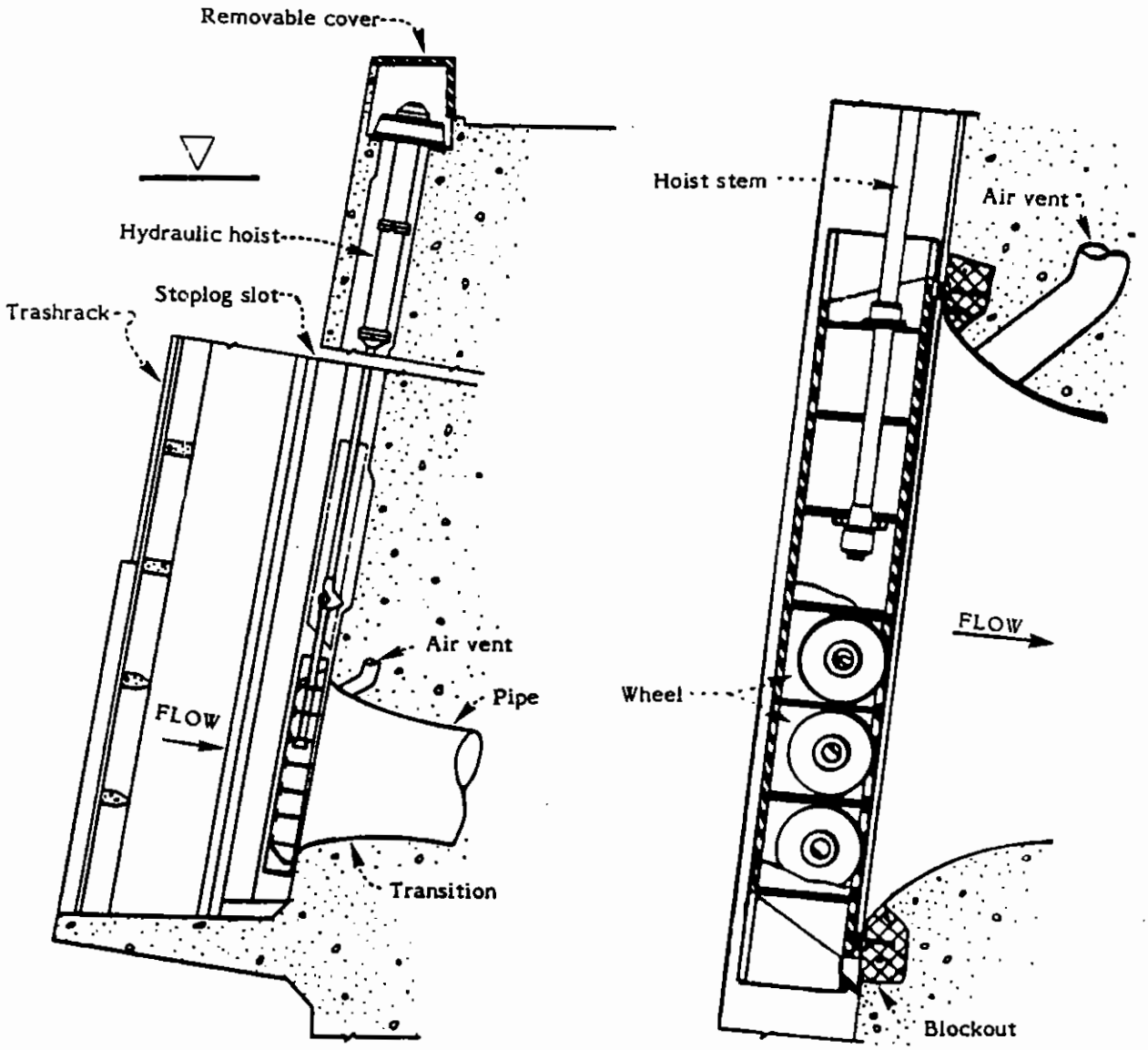
The deficiencies most commonly associated with wheel-mounted gates are:

- Misalignment of wheels and tracks.
- Seizing of wheels from corrosion and debris.
- Clogging of passages for pressure-actuation of seals (if applicable).
- Cavitation damage downstream of gate slots.

Continued . . .

WHEEL-MOUNTED GATE (Continued)

FIGURE III-4. WHEEL-MOUNTED GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a wheel-mounted gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Seal Bars	✓	Make sure that seal bars are not loose or missing, and do not have corroded hardware.
Wheels	✓	Check that wheels are properly lubricated and free to turn. Flattened wheels indicate that wheels have been sliding instead of rolling.
Seals	✓	Check that seals operate properly.
Tracks	✓	Look for deformations, corrosion, and missing or broken bolts and clips.

Test Operation

To test an intake gate, raise and lower it under balanced, no-flow conditions. At spillways, raise and lower the gate to ensure that there are no restrictions.

As an emergency test, the intake gate should be closed under maximum reservoir head with unbalanced conditions (if possible). Check that the wheels turn freely as the gate moves in the slots.

III. SPECIFIC INSPECTION GUIDELINES: GATES

JET-FLOW GATE

The jet-flow gate consists of a flat, rectangular leaf encased in a steel body, with a circular cross-sectioned fluidway opening in the upstream body and a modified circular cross-sectioned opening in the downstream body. The top of the body connects to a bonnet with a bonnet cover upon which the operator is mounted. The fluidway passage and seal arrangement are the unique features of the jet-flow gate. Generally, the opening at the downstream end of the fluidway passage is at least 20 percent larger in diameter than the opening at the upstream end of the fluidway passage. In other words, the fluidway passage tapers out toward the downstream end. A floating seal, actuated by water pressure, is mounted at the downstream end of the fluidway passage and rides against the flat upstream face of the leaf. The leaf is contained on either side by slots in the gate body. Air vents are provided in the downstream body. An example of a jet-flow gate is shown in Figure III-5 on the following page.

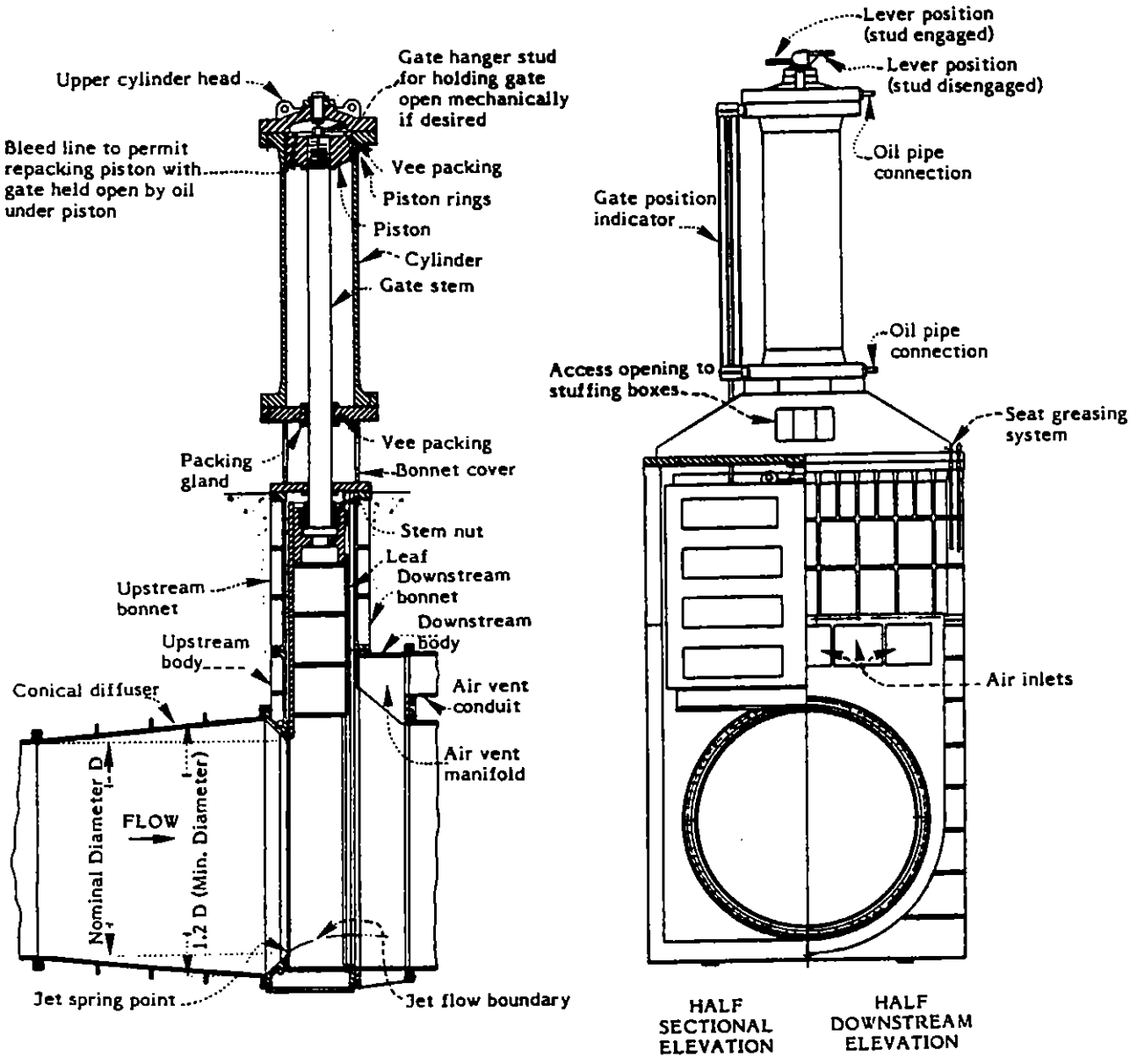
Jet-flow gates can be found in tunnels, conduits, or pipes near the center of earthfill dams, or at the downstream end of conduits or pipes. The leaf is raised and lowered by means of a hydraulic operator. The shape of the fluidway passage causes the discharging jet to contract and spring free of the slots in the body, giving a very efficient hydraulic flow pattern. Jet-flow gates are designed for use as regulating gates either under free or submerged discharge conditions.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: GATES

JET-FLOW GATE (Continued)

FIGURE III-5. JET-FLOW GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a jet-flow gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Gate Body And Bonnet	✓	Check for heavily corroded areas or areas damaged by cavitation, particularly on the sidewalls just downstream from the guide slots, and on the floor just downstream from the sill. Also, ensure that there are no damaged seats, loose or missing seat bolts, or clogged ventilation holes.
Bonnet Cover	✓	Look for cracks in the cover or leaky gaskets at the flange where it joins the bonnet. Check for leakage at the piston stem packings (i.e., oil leaking from the upper packings, and water from the lower packings).
Leaf	✓	Inspect for heavily corroded areas or areas damaged by cavitation along the leaf bottom, cracked or broken ribs, loosened stem connections, and damaged or badly worn seating surfaces.

Test Operation

Operate the gate through full travel under balanced, no-flow conditions (if possible), and ensure that the leaf moves smoothly and without binding.

Operate the gate under full design head, if possible, to an opening that gives the maximum design discharge of the outlet. Also, check for smooth operation of the leaf.

III. SPECIFIC INSPECTION GUIDELINES: GATES

RING-FOLLOWER GATE

The ring-follower gate consists of a flat leaf with a "follower" attached to the bottom of the leaf. The leaf and follower are encased in a steel body having a circular fluidway opening on either side. Attached to the top of the body is an upper bonnet with a bonnet cover, and attached to the bottom of the body is a lower bonnet with a cover containing one or more drains. The body, both bonnets, and the lower cover are embedded in concrete. A hydraulic hoist is mounted on top of the upper bonnet cover with the piston stem connected directly to the leaf. An example of a ring-follower gate is shown in Figure III-6 on the following page.

The leaf and follower are moved up to open the gate and down to close it. The follower and the leaf are the same thickness and move up and down in continuous slots of equal width in the body and both bonnets. The follower has a circular opening through it that matches the opening in the upstream and downstream body halves when the gate is open. This follower opening completely shields the flow from the gate slots and, as a result, only a negligible hydraulic head loss is incurred in flows through the gate.

The ring-follower gate, which is designed exclusively for use as an emergency gate, is operated either wide open or closed and is never used for regulation. The hydraulic load on the leaf is supported by compressive loads acting in bearing and sliding on the metal seal/seats all around the opening in the downstream body half. An air inlet manifold is incorporated in the top of the downstream body half to admit air downstream from the leaf during emergency gate closures.

Design Limitation

Because the gate has metal-to-metal seal/seats, care must be exercised during the manufacturing process and while embedding the gate in concrete to ensure that the seal/seats are in a near-perfect plane so the gate will not leak.

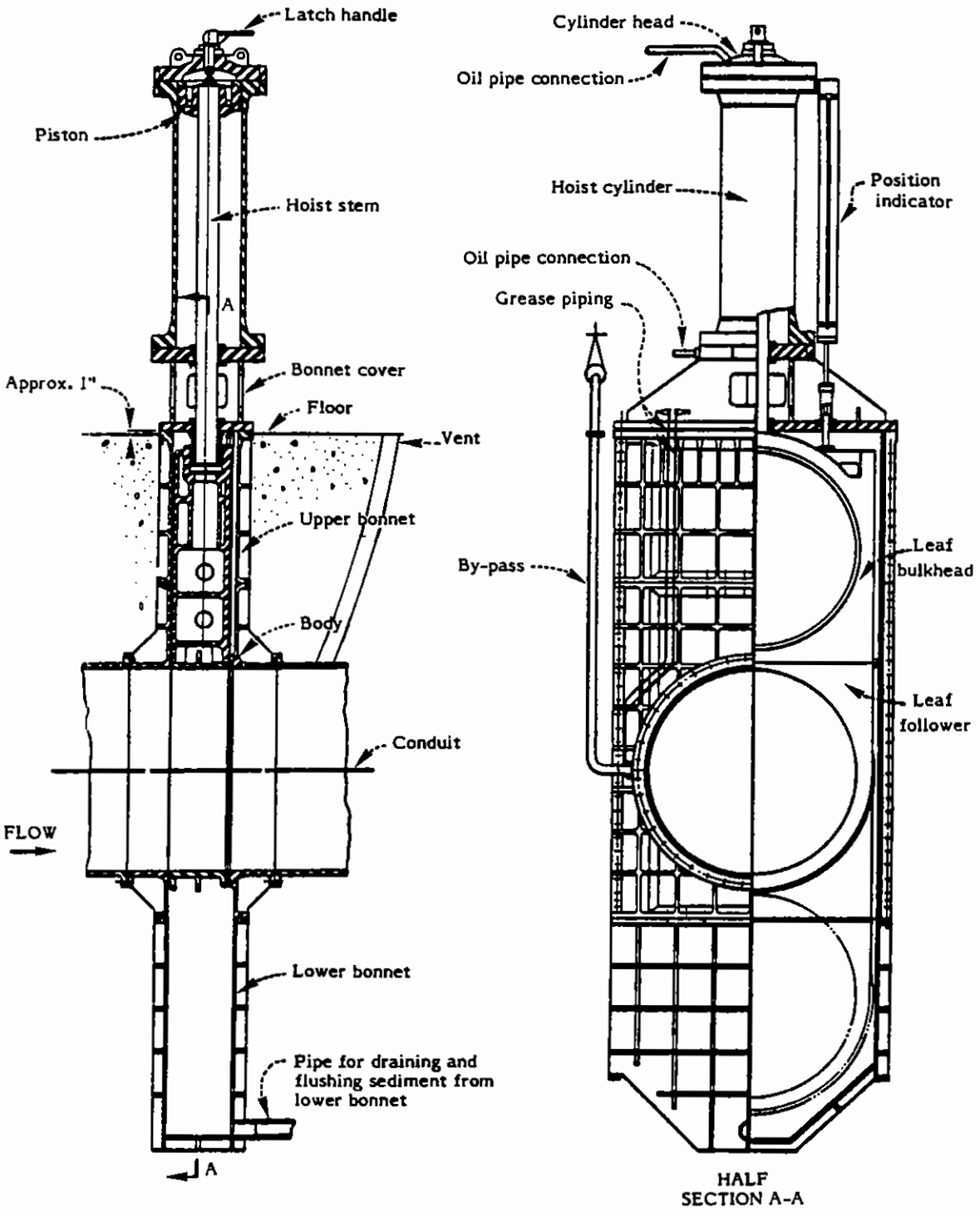
Problem Area

When the gate is in the open position, the circular opening in the follower must align very closely with the circular openings in the upstream and downstream body halves. Otherwise, an offset in the fluidway is produced which could cause damage from cavitation.

Continued . . .

RING-FOLLOWER GATE (Continued)

FIGURE III-6. RING-FOLLOWER GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a ring-follower gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Gate Body And Bonnets	✓	Examine the interior fluidway surfaces of the body and look for heavily corroded areas or areas damaged by cavitation, particularly at the top and bottom of the fluidway, where a misaligned follower could have caused an offset. By using the drains from the lower bonnet, check for silt accumulation in the bonnet.
Upper Bonnet Covers	✓	Look for cracks in the cover or leaky gaskets at the flange where it joins the bonnet. Where a hydraulic hoist is used on the ring-follower gate, look for leakage at the piston stem packings (i.e., oil leaking from the upper packings and water from the lower packings).
Leaf And Follower	✓	Look for heavily corroded areas or areas damaged by cavitation, cracked or broken ribs, and loosened stem connections.

Test Operation

To test the gate, operate it through full travel under balanced, no-flow conditions (if possible). Ensure that the leaf moves smoothly and without binding and that the gate, gate hanger (where applicable), hoist, and controls all function properly.

After ensuring that adequate venting is provided to the downstream side of the leaf, perform an emergency closure test at the maximum head (if possible), and ensure that the gate, hoist, and controls function properly.

III. SPECIFIC INSPECTION GUIDELINES: GATES

RING-SEAL GATE

The ring-seal gate is similar to the ring-follower gate, but instead of carrying the hydraulic leaf load by sliding contact on seal/seat surfaces, it utilizes antifriction endless roller trains on the leaf, and wheels on the follower, both of which ride on tracks in the downstream body and bonnet halves. The ring-seal gate is intended for use in circular conduits or pipes, and is designed exclusively for use as a maintenance/emergency gate. An example of a ring-seal gate is shown in Figure III-7 on the following page.

The most unique feature of the ring-seal gate, and the feature from which the name is derived, is the action of the seal when the gate is closed. A moveable ring is actuated hydraulically by water taken from the conduit, to move laterally to form a watertight seal between the leaf and the body. On some gates, the ring is located in an annular recess in the downstream gate body and is concentric with, and around, the opening in the body. The seal moves to bear against the seat in the downstream body. Thus, the hydraulic leaf load always remains on the roller/track system when the leaf is closed. However, like the paradox gate, the force required to move the leaf is relatively small, and twin, electric-motor-driven screw hoists are used to operate the leaf. It, too, has an air inlet manifold to admit air to the downstream side of the leaf during emergency closures.

Problem Areas

When the gate is in the open position, the circular opening in the follower must align very closely with the circular openings in the upstream and downstream body halves. Otherwise, an offset in the fluidway is produced which could cause damage from cavitation.

The ring-seal gate relies on seal movement produced by water pressure being applied to the back of the seals, but the water system is vulnerable to clogging by corrosion, mineral deposits, and silt.

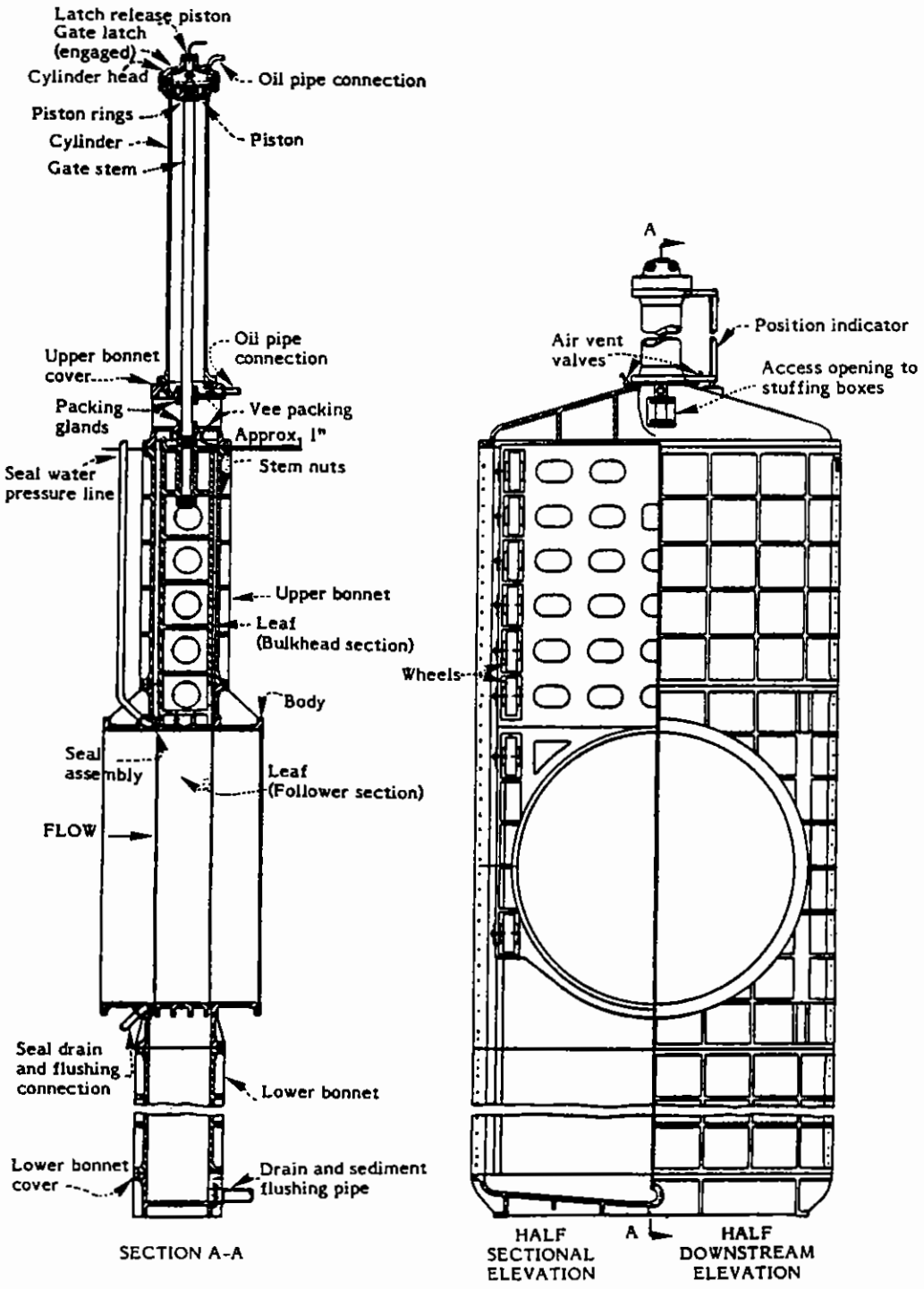
> **NOTE:** Because of the high manufacturing and maintenance costs, use of the ring-seal gate has been abandoned in recent years.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: GATES

RING-SEAL GATE (Continued)

FIGURE III-7. RING-SEAL GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a ring-seal gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Gate Body And Bonnets	✓	Examine the interior fluidway surfaces of the body and look for heavily corroded areas or areas damaged by cavitation, particularly at the top and bottom of the fluidway, where a misaligned follower could have caused an offset. By using the drains from the lower bonnet, check for silt accumulation in the bonnet.
Upper Bonnet Covers	✓	Look for cracks in the cover or leaky gaskets at the flange where it joins the bonnet. Check for leakage at the piston stem packings (i.e., oil leaking from the upper packings, and water from the lower packings).
Leaf And Follower	✓	Look for heavily corroded areas or areas damaged by cavitation, cracked or broken ribs, and loosened stem connections.

Test Operation

To test the gate, operate it through full travel under balanced, no-flow conditions (if possible), and ensure that the leaf moves smoothly and without binding and that the gate, gate hanger (where applicable), hoist, and controls all function properly.

After ensuring that adequate venting is provided to the downstream side of the leaf, perform an emergency closure test at the maximum head, if possible, and ensure that the gate, hoist, and controls all function properly.

III. SPECIFIC INSPECTION GUIDELINES: GATES

PARADOX GATE

The paradox gate is similar to the ring-follower gate in that it has a circular fluidway, ring-shaped follower on the bottom of the leaf, lower bonnet, and air inlets. The gates are also similar in that both are designed exclusively for use as emergency gates. However, when the leaf of the paradox gate is in any position other than seated, the hydraulic waterload acting on the leaf is carried by endless chains of rollers in carriages mounted along either side of the leaf and follower, that bear on tracks in the downstream halves of the body and lower bonnet. The paradox gate is intended for use in circular conduits or pipes, and has been used under heads in excess of 600 feet. An example of a paradox gate is shown in Figure III-8 on the following page.

During closure, the leaf movement is stopped by lugs in the lower bonnet, but the roller carriage continues to descend. This withdraws the inclined roller trains and moves the leaf downstream to seat the metal seal ring on the leaf against the metal seat ring in the downstream body half. The action is reversed when the leaf is raised. Thus, the vertical movement of the leaf and follower is accomplished without sliding contact, and only when they are supported on the roller train systems; consequently, the forces required for raising and lowering the leaf are relatively small. Twin, electric-motor-driven screw hoists mounted on the upper bonnet cover supply these forces.

Problem Areas

When the gate is in the open position, the circular opening in the follower must align very closely with the circular openings in the upstream and downstream body halves. Otherwise, an offset in the fluidway is produced which could cause damage from cavitation.

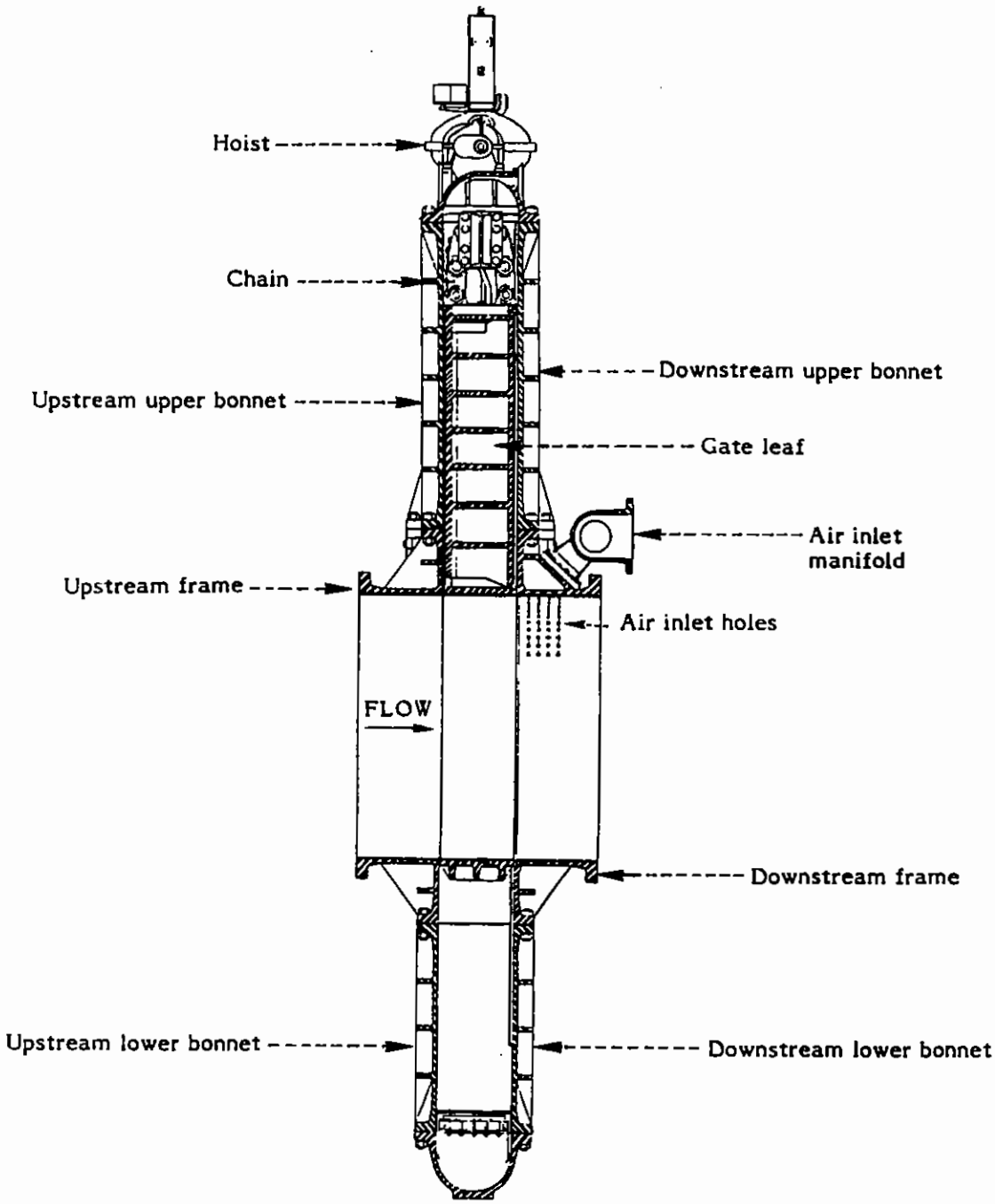
The paradox gate contains many small moving parts (e.g., roller trains, carriages, seals, guides, etc.) that are vulnerable to seizing caused by corrosion, mineral deposits, and silt. Once the rollers start to slide instead of roll, the required hoisting effort increases radically and the screw hoists may no longer move the leaf.

> **NOTE:** Because of the high manufacturing and maintenance costs, use of the paradox gate has been abandoned in recent years.

Continued . . .

PARADOX GATE (Continued)

FIGURE III-8. PARADOX GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a paradox gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Gate Body And Bonnets	✓	Examine the interior fluidway surfaces of the body and look for heavily corroded areas or areas damaged by cavitation, particularly at the top and bottom of the fluidway, where a misaligned follower could have caused an offset. Using the drains from the lower bonnet, check for silt accumulation in the bonnet.
Upper Bonnet Covers	✓	Look for cracks in the cover or leaky gaskets at the flange where it joins the bonnet.
Leaf And Follower	✓	Look for heavily corroded areas or areas damaged by cavitation, cracked or broken ribs, and loosened stem connections.

Test Operation

To test the gate, operate it through full travel under balanced, no-flow conditions (if possible), and ensure that the leaf moves smoothly and without binding. Also, ensure that the gate, gate hanger (where applicable), hoist, and controls all function properly.

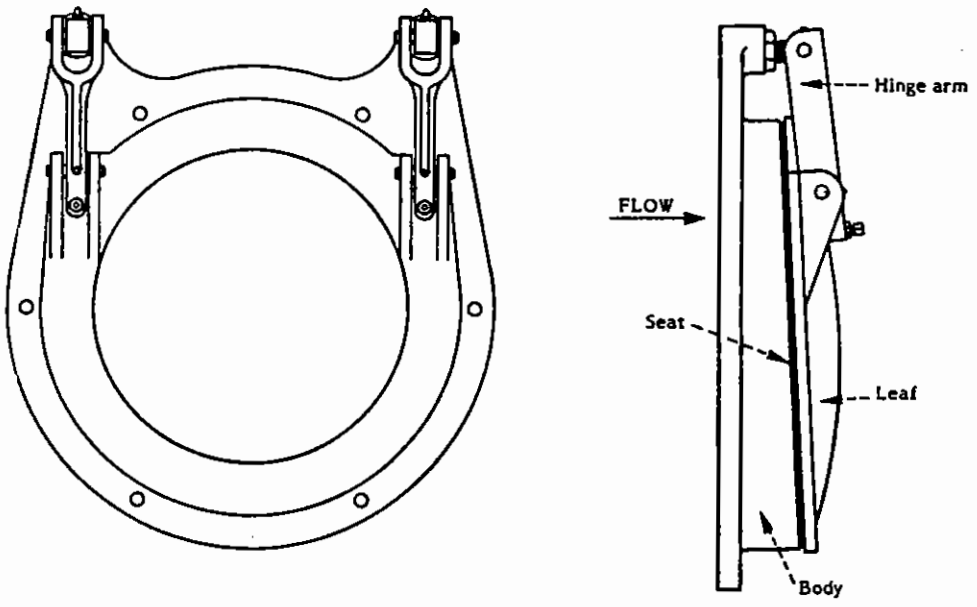
After ensuring that adequate venting is provided to the downstream side of the leaf, perform an emergency closure test at the maximum head, if possible, and ensure that the gate, hoist, and controls all function properly.

III. SPECIFIC INSPECTION GUIDELINES: GATES

FLAP GATE

A flap gate is a gate hinged along one edge, usually the top edge, that is designed to allow flows in only one direction. A typical flap gate is shown in Figure III-9 below. Flap gates are used as guard gates at the end of outlet conduit in levees, and at the end of sump pump pipe and drain pipe from galleries.

FIGURE III-9. FLAP GATE



The operating principle behind the flap gate is simple. With no water on the upstream or downstream side of the flap, the flap will be in the closed position. When water pressure on the upstream side is sufficient to overcome the reaction of the gate flap, the flap will open, releasing water. The seating arrangement makes it impossible for the downstream water pressure to open the flap.

Problem Areas

The deficiencies most commonly associated with flap gates are:

- The flap binding, making the gate inoperable
- Silting up
- Corrosion and wear at the hinged point

III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a flap gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Gate Frame	✓	Examine the interior fluidway surfaces of the body and look for heavily corroded areas or areas damaged by cavitation. Check for silt accumulation in the fluidway.
Leaf	✓	Look for cracks in the leaf or leaky gaskets in the seat area.
Hinge Assembly	✓	Look for heavily corroded areas or areas damaged by cavitation, and cracked or damaged hinge pins.

Test Operation

To test the gate, operate it (by hand, if possible) through full travel under balanced, no-flow conditions.

III. SPECIFIC INSPECTION GUIDELINES: GATES

CYLINDER GATE

The moveable portion of a cylinder gate resembles a large cylinder or barrel, with no top or bottom, that is reinforced to withstand external pressure. Most cylinder gates are located in conduits or inside intake towers which have ports. Cylinder gates are used either as emergency gates or for regulating downstream flow. An example of a cylinder gate is shown in Figure III-10 on the following page.

The gate is raised and lowered by stems which are connected to hoist operators in the top of the tower. When the cylinder gate is raised, it allows water to enter the tower through porting in the tower. When the gate is in the closed position, there are two circumferential sealing surfaces, one at the top and the other at the bottom of the gate.

Design Limitation

The long gate stems that must be used with a cylinder gate can become elastic, and accentuate the variation in flow forces acting on the bottom of the gate.

Problem Areas

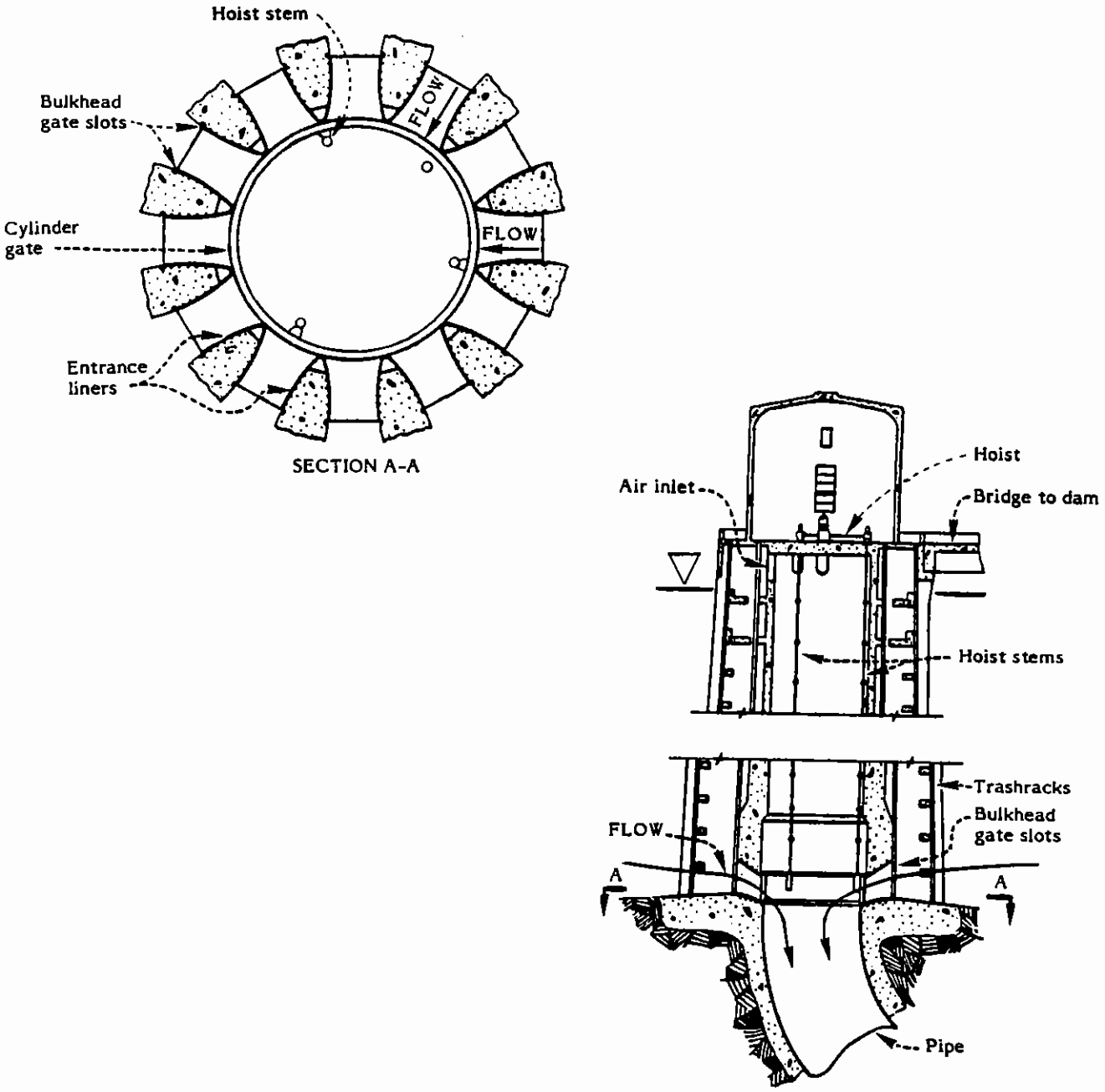
The deficiencies most commonly associated with cylinder gates are:

- Deviations in gate profile. The profile of the bottom of the gate determines the magnitude of the downpull force. If this detail deviates from the original design (i.e., changes have been made to the profile because of seat wear), the gate may be subjected to higher loading than the design load.
- Corrosion on the inside of the gate.
- Cavitation damage to throat and seats, both upper and lower.
- Difficulty in preventing leakage at two separate sealing surfaces.
- A tendency for the stem guides to become damaged due to vibratory forces.
- A tendency for the gate to become "cocked" and jam in the opening in the tower unless all the stems move at **exactly** the same rate.

Continued . . .

CYLINDER GATE (Continued)

FIGURE III-10. CYLINDER GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a cylinder gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Rectangular Conduit Linings, Throat Liners, And Guides In Tower	✓	Look for damaged, badly worn, or missing parts. Check for cavitation damage to throat and seats, both upper and lower.
Stems And Guides	✓	Inspect for damage, corrosion, or loose connections on the stems and guides.

Test Operation

To test the gate, operate it through full travel under balanced, no-flow conditions (if possible).

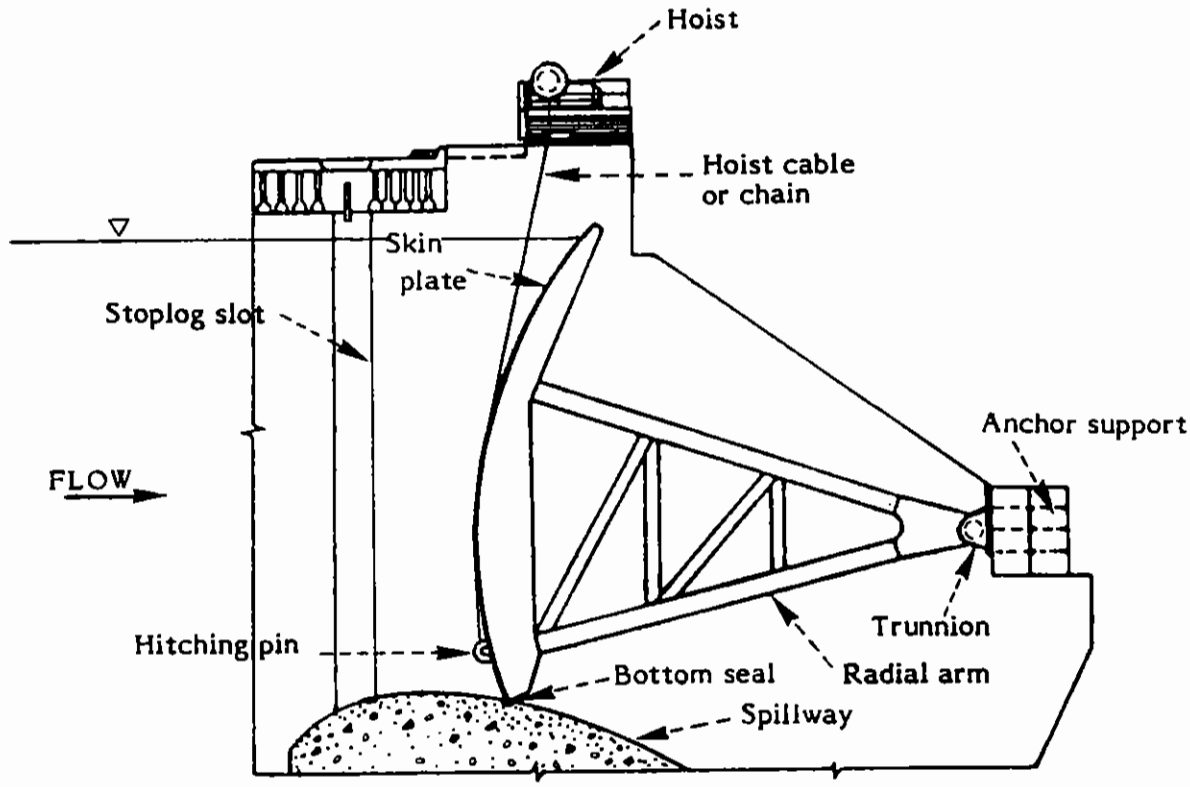
Discharge water through the gate, from fully closed, to fully open, and back to fully closed.

III. SPECIFIC INSPECTION GUIDELINES: GATES

SPILLWAY RADIAL GATE

A spillway radial gate, also known as a "tainter gate," consists of a curved upstream skinplate and radial arms that are hinged to piers or other supporting structures. The gate rests on the spillway crest between piers, as shown in Figure III-11, and rotates around a pivot called a trunnion. Water is sealed off at the spillway crest and pier faces, and is released under the gate. A hoisting unit located on the spillway deck is used to lift the gate.

FIGURE III-11. SPILLWAY RADIAL GATE



Spillway radial gates are used to:

- Retain water in the reservoir.
- Release water from the reservoir during floods.
- Regulate the downstream water flow.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Design Limitations

The operation of spillway radial gates is sometimes limited by the following design factors:

- Many operate at a slow speed.
- Large gates at times will not close by gravity, while other gates will slam down due to gravity.
- Overtoppings will damage some gates.

Problem Areas

The deficiencies most commonly associated with spillway radial gates are:

- Corrosion and wearing of the hitching pin (the piece that connects the gate to the hoist cable or chain).
- Corrosion at the waterline.
- Corrosion and wear caused by hoisting cables resting against the gate.
- Insufficient lubrication of the trunnion bearings.
- Vibration of gates during operation.
- Shifting of gate structure walls.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a spillway radial gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Seal Bars	✓	Make sure that they do not have corroded hardware, and that their fasteners are not loose or missing.
Gate Stop	✓	Check to see if there is any evidence that it has been used; if it has, there could be some damage to the structure. The use of the gate stop may mean that the gate control circuit is not functioning properly. **(NOTE:** Not all gates have gate stops.)
Trunnion	✓	Make sure that the trunnion is anchored securely.
Clearances	✓	Check that there is a minimum clearance between the edge of the skinplate and the side-seal plates, and rollers where provided.
Hoisting Connections	✓	Check that each connection (e.g., pin or clevis) is structurally sound and is not worn.
Hoist Rope	✓	Inspect for broken strands, wear, and splices, and make sure that the rope is lubricated properly.
Hoist Chain	✓	Spot-check for cracked, deformed, and severely corroded links. Check that the chain is lubricated properly.
Sinkplates, Beams, And Girders	✓	Look for corrosion or cavitation-damaged areas, cracked welds, broken structural members, and missing or broken rivets or bolts. Pay particular attention to the bottom of the leaf.
Gate Sill And Wall Plates	✓	Check for corrosion.

Test Operation

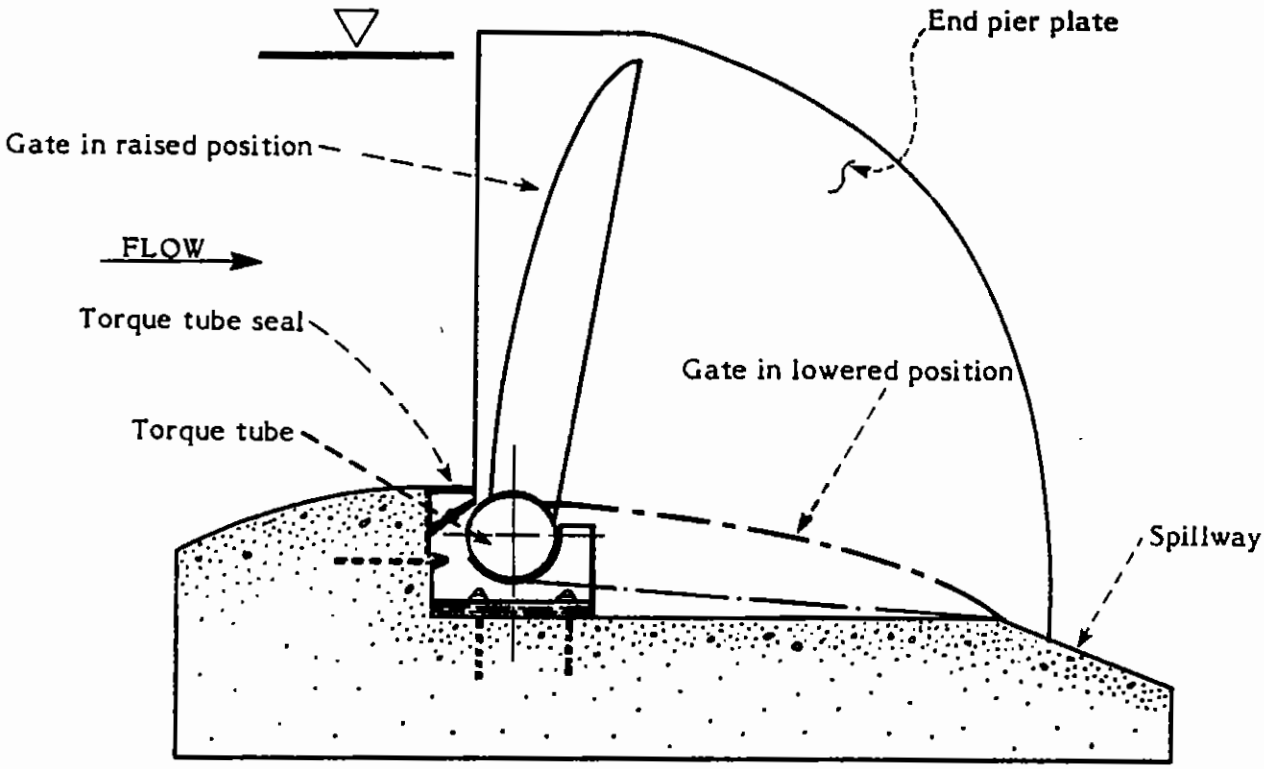
Use the criteria listed in Unit II (pages II-12 and II-13).

III. SPECIFIC INSPECTION GUIDELINES: GATES

CREST GATE

A crest gate is a bottom-hinged gate located on the crest of a spillway. Crest gates are usually hydraulically operated, with the operators located either in piers at the ends of the gate, or along the downstream side of the crest. In the lowered position, the gate conforms to the flow line of the spillway. An example of a crest gate is shown in Figure III-12.

FIGURE III-12. CREST GATE



Crest gates are used to:

- Retain and release flood water.
- Regulate the downstream water flow.
- Increase reservoir storage.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Design Limitations

The operation of crest gates is sometimes limited by the following design factors:

- When designed with operators at the ends of the gate, the required torque tube may be too large to make the gate economical to manufacture.
- Operators located along the gate on the downstream side of the spillway require additional space, and complicate the construction of the crest.

Problem Areas

The deficiences most commonly associated with crest gates are:

- Corrosion at the waterline
- Inadequate venting of the downstream side of the gate
- Leakage
- Vibration of the gate during operation
- Movement restricted by icing

Visual Inspection

Your visual inspection of a crest gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Skinplate, Beams, Girders, And Arms	✓	Look for heavily corroded areas, cracked welds, broken structural members, and missing or broken rivets or bolts.
Seals	✓	Check for damaged or missing seals, clamp bars, and bolts.
Wallplates And Sill	✓	Look for damaged surfaces where the seals rub, and for missing concrete adjacent to the sill or wallplates.

Test Operation

The procedure for test operating the gate depends upon the reservoir level at the time of the inspection.

If possible, operate the gate under both balanced and unbalanced conditions through full travel, checking that it moves smoothly and there is no interference or binding.

III. SPECIFIC INSPECTION GUIDELINES: GATES

DRUM GATE

A drum gate is a long, buoyant vessel constructed of skinplates attached to internal bracing. The gate is hinged, usually along its upstream side, to one side of a gate chamber that is recessed in the top of a spillway structure. The cross-section of the gate has a triangular shape with curved surfaces on the exposed sides.

The gate rises when the gate chamber is filled with water from the reservoir, and lowers when the water is drained from the gate chamber (See Figure III-13 on following page). The flows into and out of the gate chamber are controlled by valves, either manually set or controlled automatically for a preset gate position. The purpose of the drum gate is to:

- Retain water in the reservoir.
- Release flood water.
- Regulate the downstream water flow.

It should be noted that flashboards should not be used on drum gates to increase the reservoir water level or to provide wave splash control unless such an installation has been approved and is shown on the "as-built" drawings.

Problem Areas

The deficiences most commonly associated with drum gates are:

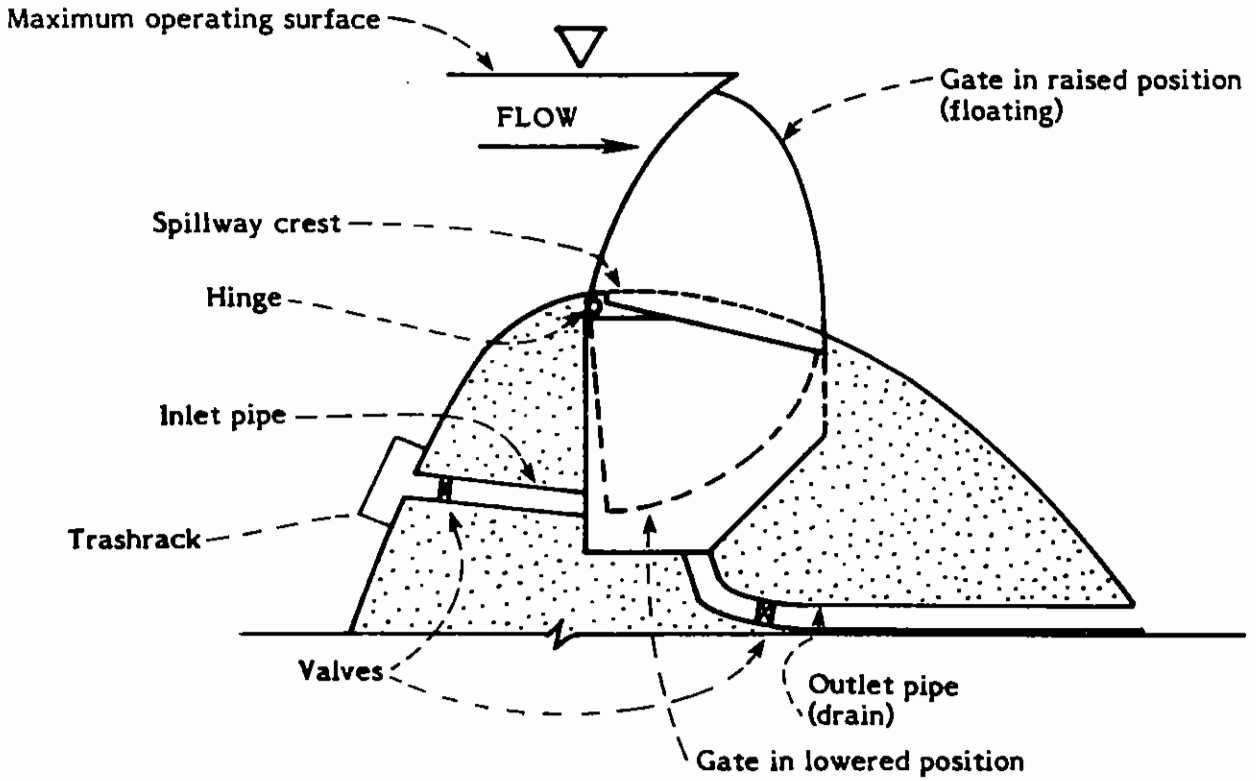
- Broken hinges
- Corrosion at the waterline
- Binding between gate and sealing surfaces
- Vibration of gates during operation (may need nape breakers)

The gates are buoyant vessels and any internal leakage is removed through flexible hoses attached to the gate and to an external drain. Failure of the skinplates or any of these hoses will allow the interior of the gate to fill with water and will cause the gate to inadvertently sink to the full open position. Plugging of the intake to the flexible hose in the drum will also cause the gate to lower if there is internal leakage.

Continued . . .

DRUM GATE (Continued)

FIGURE III-13. DRUM GATE



III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a drum gate should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Sinkplates, Beams, And Girders	✓	Look for corrosion or cavitation-damaged areas, cracked welds, broken structural members, and missing or broken rivets or bolts. Pay particular attention to the bottom of the gate.
Seal Bars And Seals	✓	Make sure that seal bars and seals are not loose or missing, and do not have corroded hardware.
Hinge And Hinge Anchorage	✓	Look for broken fitting or bushing parts. On early models, the self-lubricating hinge bushings, which contained graphite, may seize up over the years. This results in broken bushings, which will lead to nonuniform load distribution at the hinges. The internal gate structure will then become overloaded, leading to failure of the gate structure. Look for spalled or chipped concrete indicating anchor movement. This will require inspecting the outside of the gate, at the hinge location, and the inside of the gate chamber.
Flexible Drain Hoses And Swivel Joints	✓	Examine from within the gate chamber: look for plugged, cracked, broken, or missing drain hoses. Check that swivels are not "frozen."
Inlet Pipe	✓	If possible, check the trashrack at the inlet pipe for debris.
Control Valves	✓	Check for proper operation.
Interior Of Drum	✓	Look for silt buildup around the internal drain.

Test Operation

If the gate can be set at intermediate positions, check that it can hold a position; if it "hunts" (keeps moving about the set position), the controls should be checked.

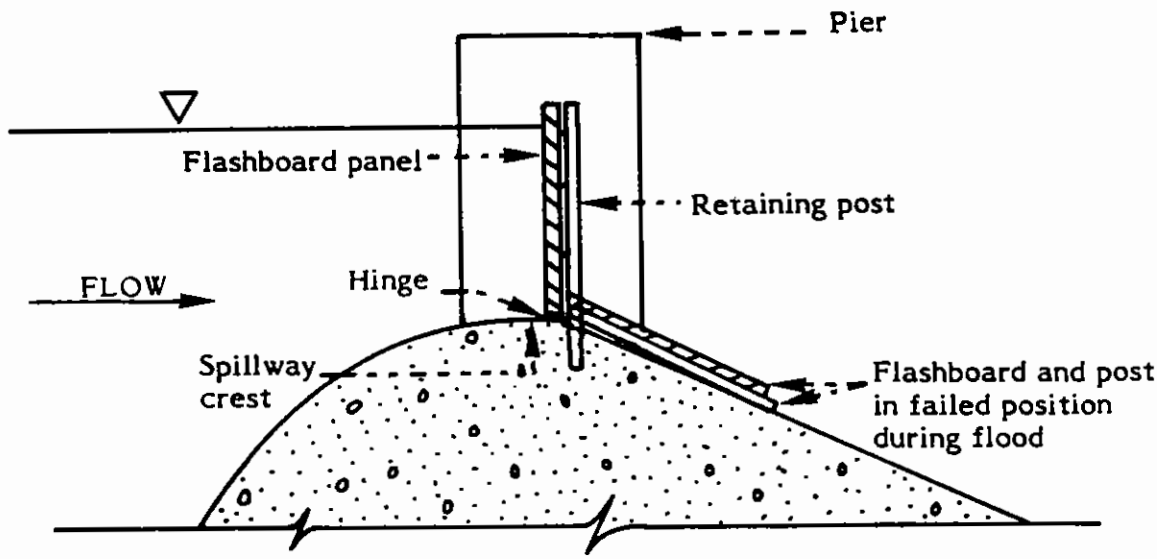
III. SPECIFIC INSPECTION GUIDELINES: GATES

FLASHBOARDS

Flashboards are boards or panels installed between piers on a spillway crest that can be removed quickly or will fail automatically when the reservoir rises to a certain level during a flood.

At normal reservoir levels, flashboards are hinged or seated on the spillway crest, and supported or retained in an upright position by struts, studs, shear pins, or other devices. (See Figure III-14 below.) During a flood, the support device either is removed manually or fails due to increased pressure on the flashboard.

FIGURE III-14. FLASHBOARDS



Flashboards are used to:

- Retain water in the reservoir.
- Release water from the reservoir during floods.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: GATES

FLASHBOARDS (Continued)

Flashboards serve the same purpose as spillway gates, but they do not provide the capability for regulating flows that spillway gates provide. When they do fail as designed, it is generally a nuisance to reset them. Depending on the flashboard design, they may also be washed downstream, requiring replacement of any missing sections. Because of the nuisance and cost of resetting and replacement, some dam operators have been known to "fix" the release device, so that the flashboards will not fail when required. This can result in reservoir levels greater than those considered in the project design, possibly leading to overtopping of the dam or failure of some appurtenant structure.

Design Limitations

The operation of flashboards is sometimes limited by the following design factors:

- They are difficult to release manually during flood level conditions, due to their inaccessibility.
- It is difficult and time consuming to reinstall them in their normal position after a failure.
- It is difficult to select a retention device design that will fail precisely at or near the desired reservoir level.
- They allow high amounts of leakage during normal conditions.
- Spillway piers must be closely spaced, which results in trash accumulation during floods, reducing the capacity of the spillway.

Problem Areas

The deficiencies most commonly associated with flashboards are:

- Dry rot of wooden boards and panels.
- Corrosion of metal panels.
- Binding of sealing surfaces.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of flashboards should include the following checkpoints:

ITEM	WHAT TO LOOK FOR
Retaining Device	✓ Check for oversized or added struts, posts, or shear pins that may have been installed "illegally" to prevent possible flashboard failure during a minor flood. Check the existing equipment against approved "as-built" drawings to verify that additional supporting devices have not been added.
	✓ Look for corrosion or other material defects that could result in failure at a lower or, possibly, higher reservoir level than intended.

Test Operation

Test operation of flashboards to predict appropriate failure during a flood generally is not possible. The failure point is computed analytically during design and may have been verified under simulated test conditions. During the inspection, records of the last flood operation of the flashboards should be reviewed, to see if the flashboards failed near the reservoir level at which they were designed to fail.

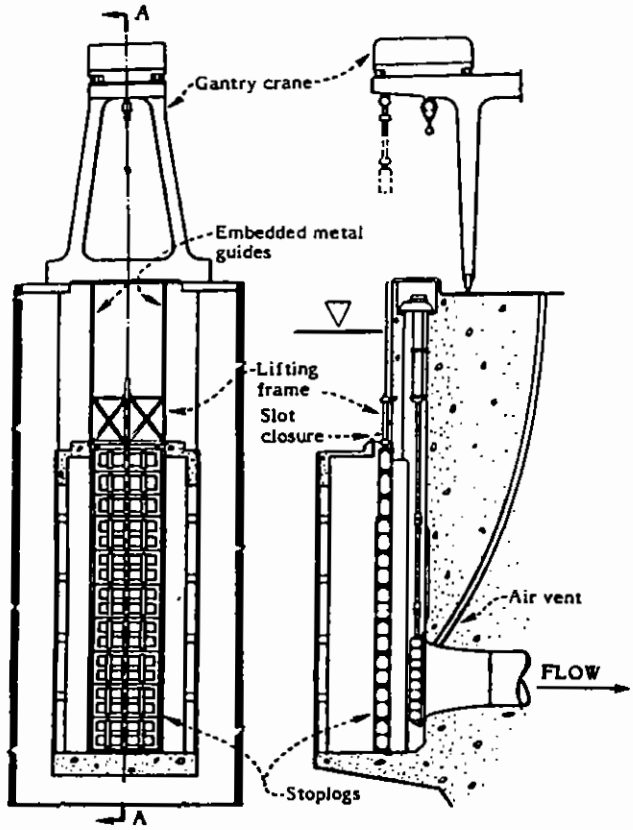
If there are no records documenting flashboard failure, and the condition of the flashboards and retaining device indicate that the flashboards may not fail at the required reservoir level, limited special tests could be performed during the next flood. If there is no reason to question flashboard failure, but no records documenting failure exist, data should be recorded during the next flood to verify that the failure occurs near desired reservoir levels. The data recorded should contain the reservoir elevation and the time at which each flashboard panel fails.

III. SPECIFIC INSPECTION GUIDELINES: GATES

STOPLOGS

Stoplogs are large logs, timbers, steel beams, or welded structural panels that are placed horizontally on top of each other to seal off an intake upstream of a gate or valve. The stoplog ends slide into guides located in the walls on each side of the intake. They are placed (using either a sling or lifting beam) to the height required, forming a watertight barrier. (See Figure III-15 below.) The steel beams normally have neoprene seals to reduce leakage. Stoplogs are used to make a temporary closure so that repairs or inspections can be carried out.

FIGURE III-15. STOPLOGS



Design Limitations

One design-related limitation concerning stoplogs is that they normally can be inserted only under no-flow conditions. Another limitation is that unless the seal detail (in the case of a steel or aluminum stoplog) is well designed and accurately fabricated, there may be considerable leakage.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Problem Areas

The deficiencies most commonly associated with stoplogs are:

- Stoplogs becoming jammed in guides.
- Trash and silt accumulating in stoplog slots.

Visual Inspection

Your visual inspection of stoplogs should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Number Of Logs	✓	Check that there are enough logs for maximum lake conditions.
How Logs Are Stored	✓	Make sure that the logs are stored: . So that they will not be warped. . So that the seals will not be damaged. . Where they can be reached with a crane or other hoisting apparatus under any climatic condition. (**NOTE:** The logs must not be stored in the flood-plain.)
Lifting Beam	✓	If a lifting beam is used, check that it is in good condition and its moving parts are lubricated.

Test Operation

Normally it will not be practical to set the stoplogs in position for a routine inspection, because of the time required to set the logs. You should, however, make sure that the project management knows where the equipment used to set the logs is located, and ensure that the equipment is in good operating condition. Also, try to see that you are notified of when the project management is going to install the logs, or verify that they have been installed.

III. SPECIFIC INSPECTION GUIDELINES: GATES

BULKHEAD

A bulkhead is a one-piece gate that is positioned temporarily in a dam intake or outlet structure to isolate a gate, valve, or penstock for inspection or maintenance work. A typical bulkhead is shown in Figure III-16 on the next page.

The bulkhead may be constructed of aluminum, steel, or concrete. In some cases it is circular and positioned horizontally over a conduit or penstock intake. Normally there are flexible seals on the perimeter of the bulkhead to ensure a watertight seal. Because there is only one sealing perimeter on a bulkhead, it is superior to stoplogs for isolating a structure when only minimal leakage can be tolerated.

Design Limitations

One design-related limitation concerning bulkheads is that they normally can only be inserted under no-flow conditions. Another limitation is that unless the seal detail is well designed and accurately fabricated, there may be considerable leakage.

Ultimately, handling the weight of the bulkhead is the deciding criteria. When it becomes uneconomical to provide a handling system that is adequate for the bulkhead weight, the alternative is to provide stoplogs.

Problem Areas

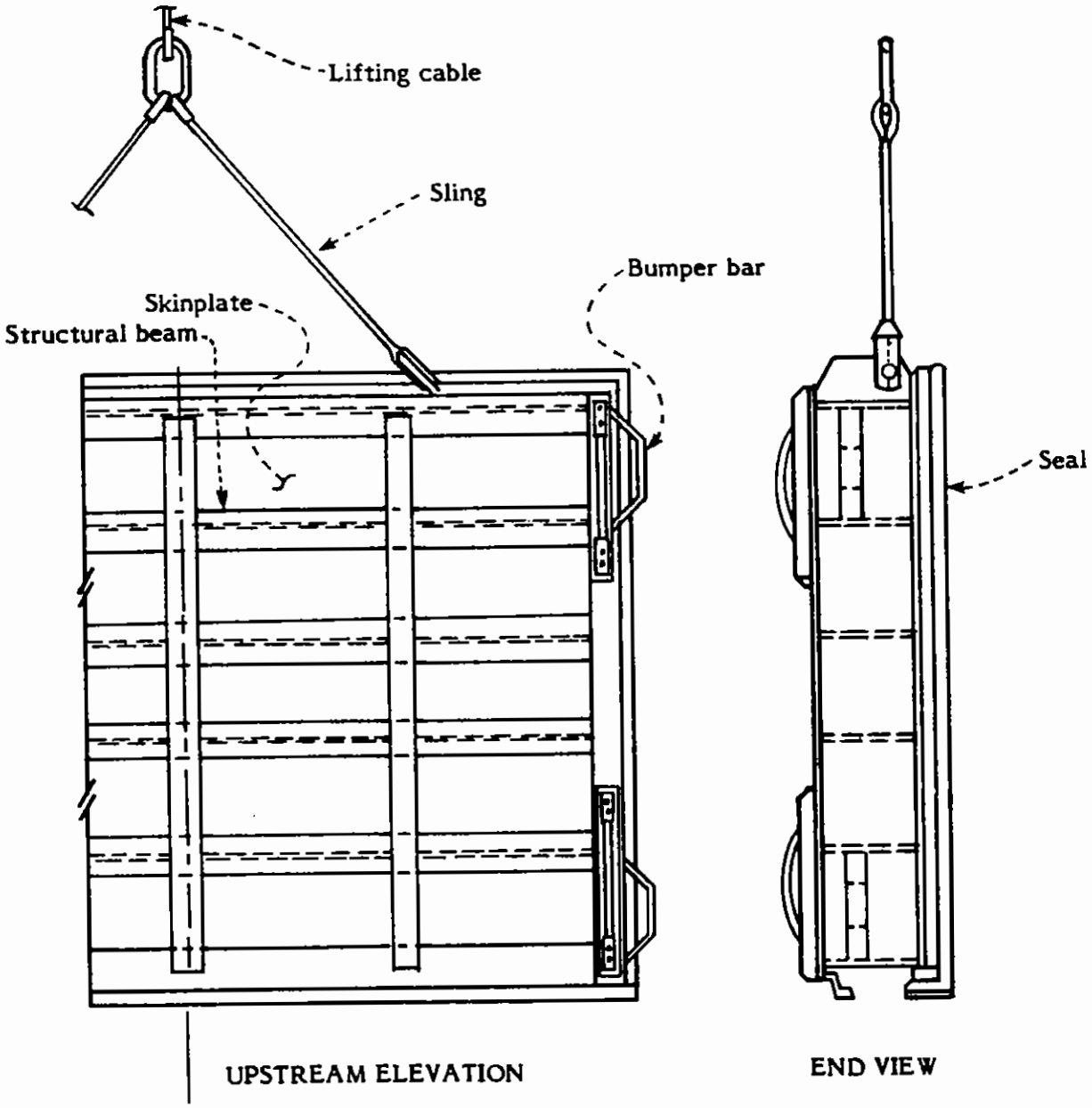
The deficiencies most commonly associated with bulkheads are:

- Bulkhead becoming jammed in guides.
- Trash and silt accumulating in bulkhead slots.
- Filling valve malfunctioning.

Continued . . .

BULKHEAD (Continued)

FIGURE III-16. BULKHEAD



Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: GATES

Visual Inspection

Your visual inspection of a bulkhead should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
How The Bulkhead Is Stored	✓	Make sure that the bulkhead is stored: . So that it will not be warped. . So that the seals will not be damaged. . Where it can be reached with a crane or other hoisting equipment under any climatic condition. (**NOTE:** The bulkhead must not be stored in the floodplain.)
Lifting Beam	✓	If a lifting beam is used to install the bulkhead, check that it is stored in an accessible place and is in working condition.
Filling Valve	✓	If the bulkhead has a filling valve, check that it will function by opening the valve using its operating mechanism.

Test Operation

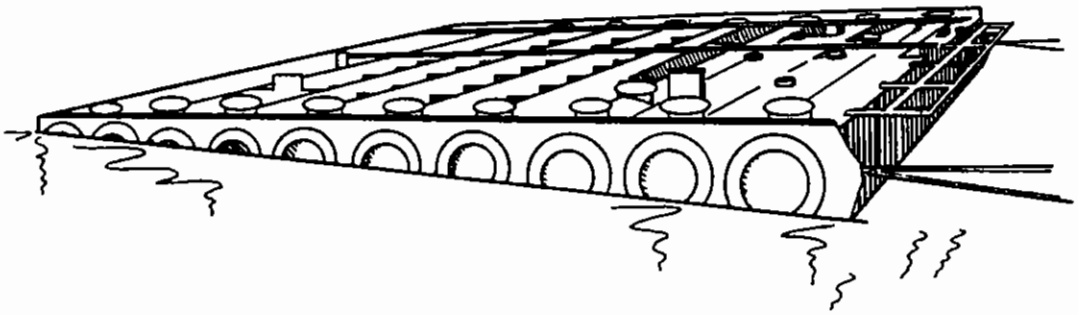
Normally it will not be practical to observe the installation of a bulkhead and to see how watertight it seals, because of the time and cost required to set the bulkhead under balanced pressure conditions and then inspect the downstream side of the bulkhead.

III. SPECIFIC INSPECTION GUIDELINES: GATES

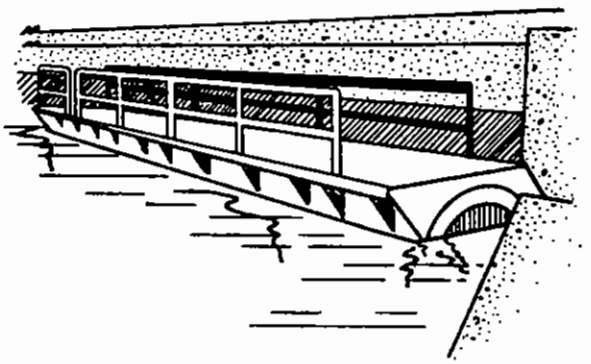
FLOATING BULKHEAD

A floating bulkhead, shown in Figure III-17 below, is a tank that can be placed just upstream from a gate, to provide a means for dewatering the gate for maintenance or inspection. The bulkhead spans the gate opening, sealing against the piers and along the face of the dam underneath the gate.

FIGURE III-17. FLOATING BULKHEAD



Moored



In Use

Floating bulkheads usually are stored near the upstream face of the dam and moved by boat to the gate opening. A trained operating crew is needed to use the bulkhead. As the bulkhead is leveled and positioned, the water between the bulkhead and gate is drained. When the water is drained, the waterload is applied to the upstream side of the bulkhead, causing it to seal against the face of the dam.

III. SPECIFIC INSPECTION GUIDELINES: GATES

Design Limitations

Floating bulkheads are slow, complicated, and difficult to install. Storage and maintenance are also difficult.

Test Operation

The inspector usually is not involved in the setting of the bulkhead. If you notice leakage around the seals of an installed bulkhead, the support sill should be checked for trash or other obstructions. This procedure will require divers.

III. SPECIFIC INSPECTION GUIDELINES: VALVES

NEEDLE VALVE

Needle valve is a general term used to refer to a large family of valves used in dams for regulating releases from the outlet works. The most commonly used types have an egg-shaped body with truncated ends. The body supports and encloses a stationary cylinder that has a fixed needle tip on the upstream end and mates with a moveable needle that has the tip on the downstream end. An example of a needle valve is shown in Figure III-18 on the following page.

Movement of the needle regulates the flow through the valve and effects valve closure. Needle movement is accomplished by varying the water pressure in counterbalancing chambers within the cylinder and needle, or by an electric-motor-driven operator supplying the force to move the needle. The needle tip sits against a seat ring mounted in the fixed support ring, which is anchored to the concrete. Most types of needle valves are intended for use at the downstream end of an outlet pipe, under free discharge conditions, in order to regulate high-velocity flows.

Design Limitation

The operation of needle valves is sometimes limited by the fact that they are hydraulically inefficient, relative to other types of gates and valves.

Problem Areas

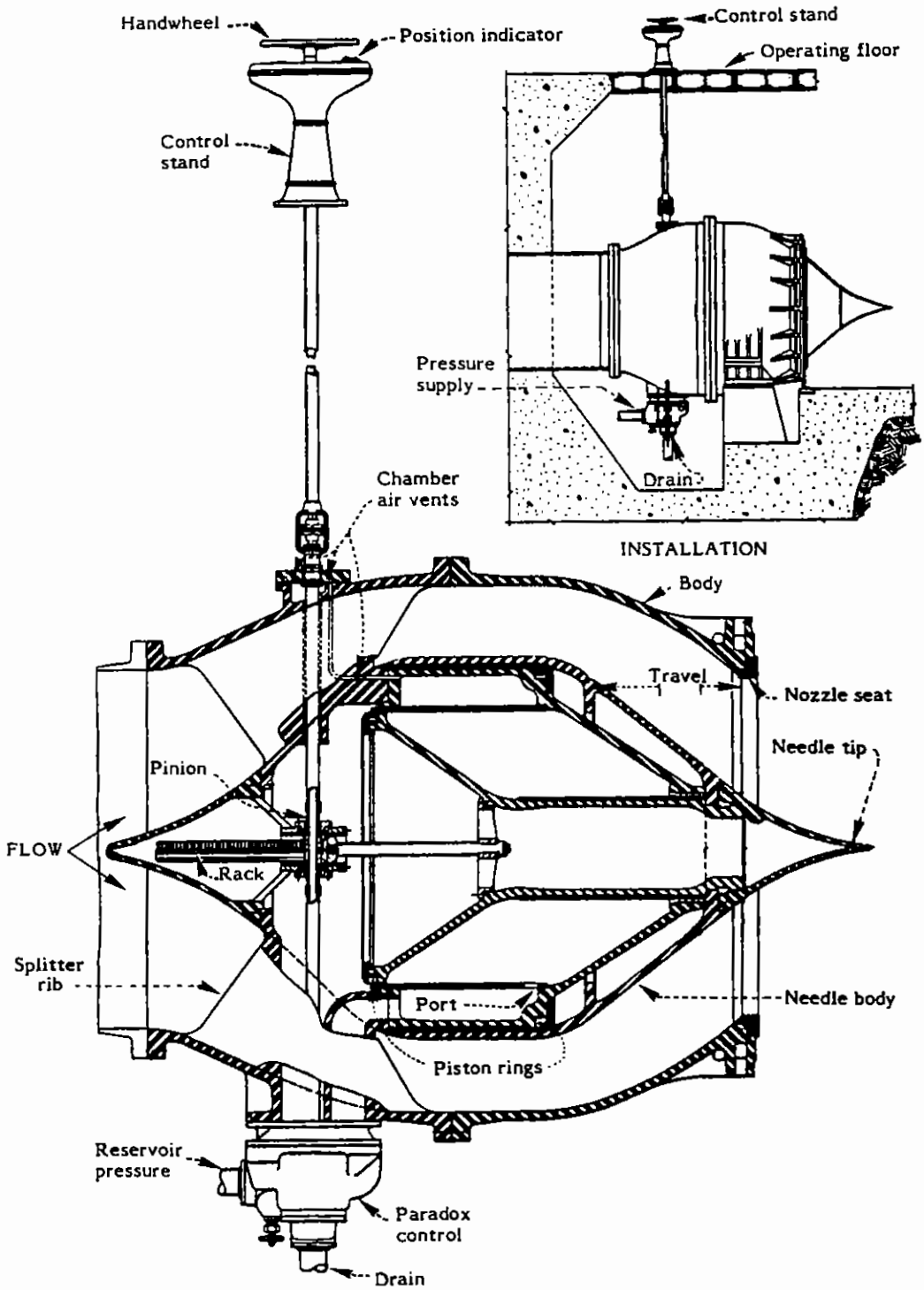
The deficiencies most commonly associated with needle valves are:

- Cavitation damage to the paradox controls, and cavitation damage along the needle nose and the body seat.
- Buildup of mineral deposits, silt, and other debris in the internal hydraulic chambers and in the paradox control valves.
- The possibility of the valve malfunctioning unless the ventilating system is regularly and properly maintained. Malfunction may result in rapid closure of the valve with the resulting dynamic pressures damaging the valve itself or causing upstream piping.
- Difficulty in maintaining tolerances on mating parts. This may give rise to internal leakage between pressure chambers, resulting in faulty operation.

Continued . . .

NEEDLE VALVE (Continued)

FIGURE III-18. NEEDLE VALVE



III. SPECIFIC INSPECTION GUIDELINES: VALVES

Visual Inspection

Your visual inspection of a needle valve should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Valve Controls	✓	Check for water leaking from damaged or plugged water supply lines and valves. Also look for broken or damaged handwheels, control stands, and control stems.
Valve Body And Needle		
Exterior	✓	Look for cracks, broken or missing bolts, damage to the paradox control, piping valves, support brackets, or any unauthorized modifications.
Interior	✓	Look for damage from cavitation, vibration, corrosion, debris, or any other defects, especially on the nozzle seat and along splitter ribs.
Needle	✓	Inspect for cavitation damage, especially on the needle tip, or any other damage.
Vents	✓	Check that air vents are not blocked.

Test Operation

Use the criteria listed in Unit II (pages II-12 and II-13).

III. SPECIFIC INSPECTION GUIDELINES: VALVES

HOLLOW-JET VALVE

The hollow-jet valve is essentially one-half of a needle valve, in which the needle moves upstream to effect closure. There is no converging fluidway or downstream needle tip, as in the needle valve. Consequently, the flow emerges from the annular fluidway in the form of a hollow jet. The valve consists of a bell-shaped body that supports and encases a cylindrical needle with a conical tip, facing upstream, and a means of operating the needle. An annular water passage surrounds the needle. Historically, there have been two basic designs: the older, mechanically operated type, and the more recent hydraulically operated type. An example of a mechanically operated hollow-jet valve is shown in Figure III-19 on the following page.

Movement of the needle varies the area of the annular orifice formed between the needle and the body, thereby controlling the discharge. Splitter ribs between the body and the needle support admit the air necessary for the interior of the jet. Both the hydraulically and mechanically operated hollow-jet valves are intended for use at the downstream end of an outlet pipe, discharging freely into the atmosphere. Hollow-jet valves are used to regulate high-velocity flows.

Design Limitations

Design factors sometimes limit the operation of hollow-jet valves, requiring the following precautions:

- Because the jet discharged from the valve is hollow, the angle of discharge must be closely monitored to ensure that the jet will not:
  - Stay on the stilling basin surface and fail to dissipate (if it is discharged parallel to the water surface), or
  - Cause chemical imbalances (nitrogen supersaturation) in the stilling basin (if the angle of discharge is too great), which can harm fish life.
- The valve should not be used for regulation at openings of less than 5 percent for long periods, since this may cause cavitation damage.

Problem Areas

The deficiencies most commonly associated with hollow-jet valves are:

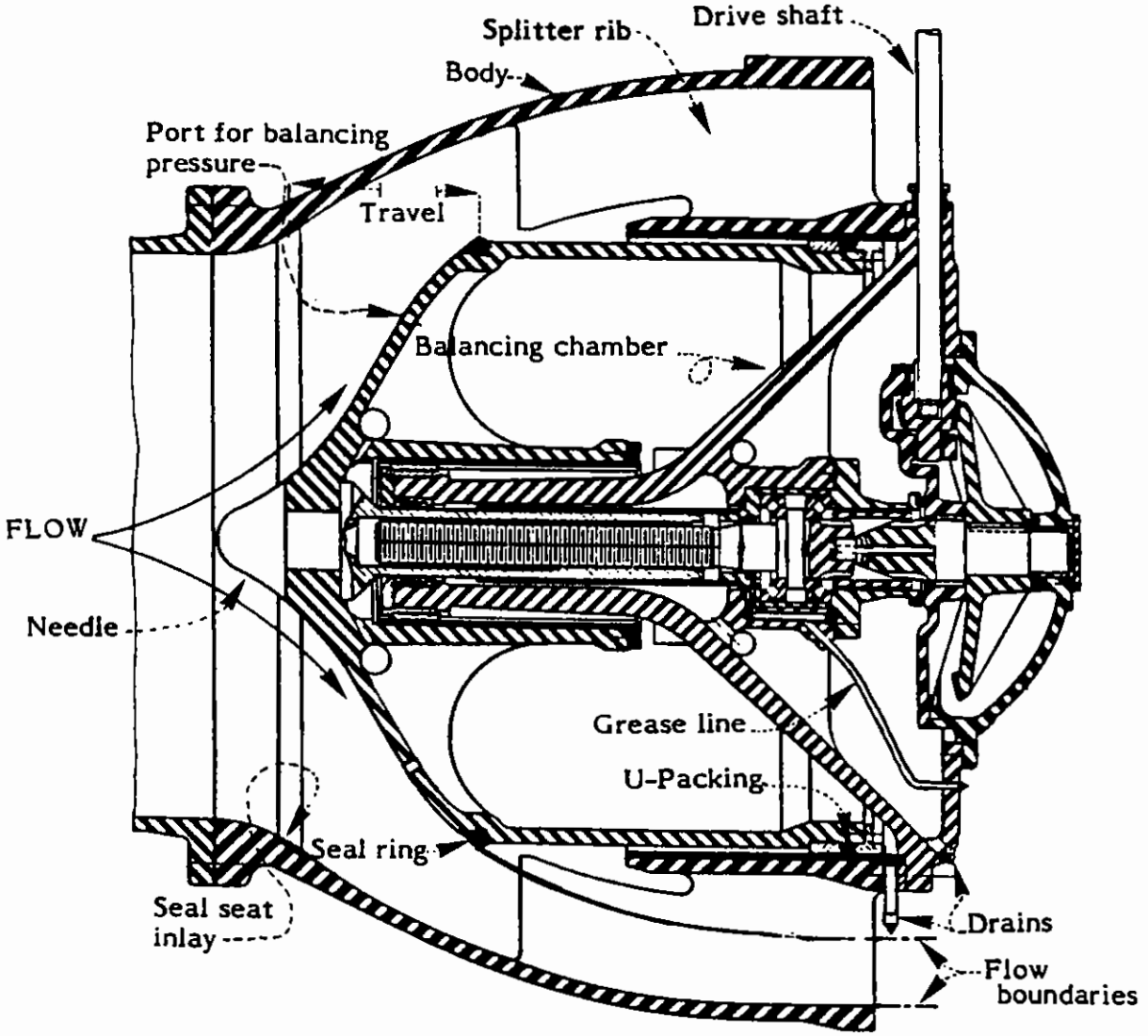
- The interior seals on the mechanically operated valves tend to leak water into the bevel gear case, which can cause gear damage.
- The interior seals on the hydraulically operated valves, which maintain the oil pressure in the operating cylinder for the needle, tend to leak hydraulic oil into the stilling basin.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: VALVES

HOLLOW-JET VALVE (Continued)

FIGURE III-19. HOLLOW-JET VALVE



III. SPECIFIC INSPECTION GUIDELINES: VALVES

Visual Inspection

Your visual inspection of a hollow-jet valve should include the following checkpoints:

ITEM	WHAT TO LOOK FOR
Valve Operator	✓ Check for damaged or broken parts on manual and motorized operators.
	✓ Ensure that there is no oil leaking from seals, pipes, pumps, valves, and gauges on oil hydraulic systems.
Valve Body And Needle	
Exterior	✓ Look for cracked, broken, missing, or heavily corroded parts. Also, check for leakage when the valve is closed and subjected to full head.
Interior	✓ Check for damage due to cavitation, corrosion, and debris, especially along splitter ribs.
	✓ Inspect for leaky gaskets or packings, and water in the gear case oil on the mechanically operated valves.
	✓ Ensure that no oil is leaking on the hydraulically operated valves.
Needle	✓ Inspect for cavitation damage or debris on the conical part of the needle.
	✓ Ensure that the balancing ports on the face of the needle are open on the mechanically operated valve.

Test Operation

Use the criteria listed in Unit II (pages II-12 and II-13).

III. SPECIFIC INSPECTION GUIDELINES: VALVES

TUBE VALVE

A tube valve is a modification of the needle valve, designed to eliminate damage from cavitation. The fluidway is essentially the same as in the needle valve, except that the downstream end of the needle is omitted, leaving only the tube portion of the needle to move for regulation and stoppage of the flow. (See Figure III-20 on the next page.) The tube portion of the valve is operated by a mechanical screw, which is driven by bevel gears from a handwheel or motorized operator, rather than by hydraulic chambers.

Tube valves are used at the downstream end of outlet pipes, to regulate high-velocity flows.

Design Limitations

The free-discharge jet from a tube valve has considerable instability at openings of less than 35 percent, which creates spray problems. Also, some valves have demonstrated a tendency to vibrate at the nearly full-open or nearly closed position.

Visual Inspection

Your visual inspection of a tube valve should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Valve Operator	✓	Check for damaged or broken parts on manual and motorized operators.
Valve Body And Tube		
Exterior	✓	Check for cracked, broken, missing, or heavily corroded parts, leaky gaskets or packings, and water in the gear case oil.
Interior	✓	Inspect fluidway surfaces and tube seats for cavitation damage.
Tube	✓	Examine the seating and other finished surfaces for damage.

Test Operation

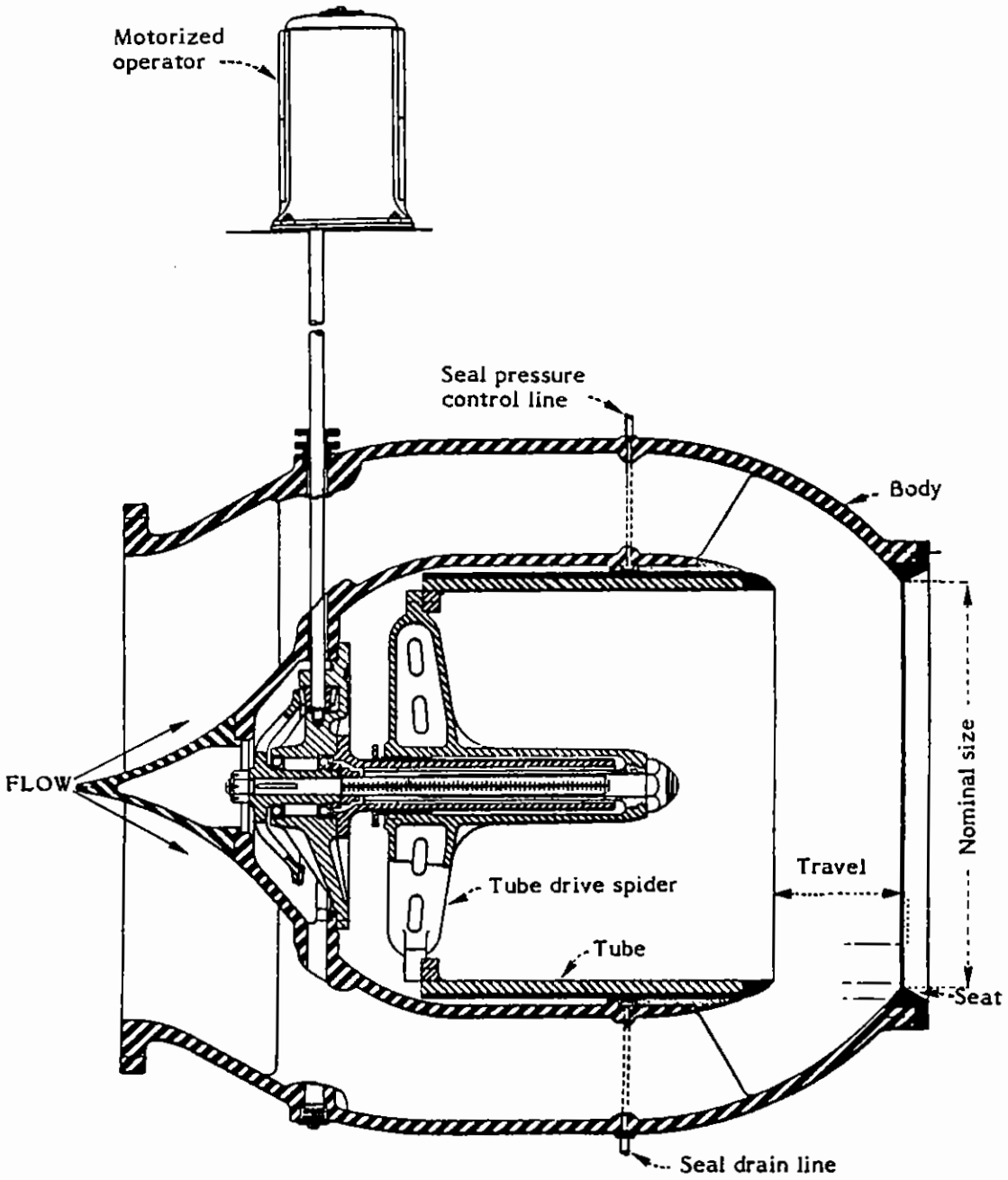
Use the criteria listed in Unit II (pages II-12 and II-13). If the valve is discharging with the jet submerged, check that an air vent is provided and that it is clear to function properly.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: VALVES

TUBE VALVE (Continued)

FIGURE III-20. TUBE VALVE

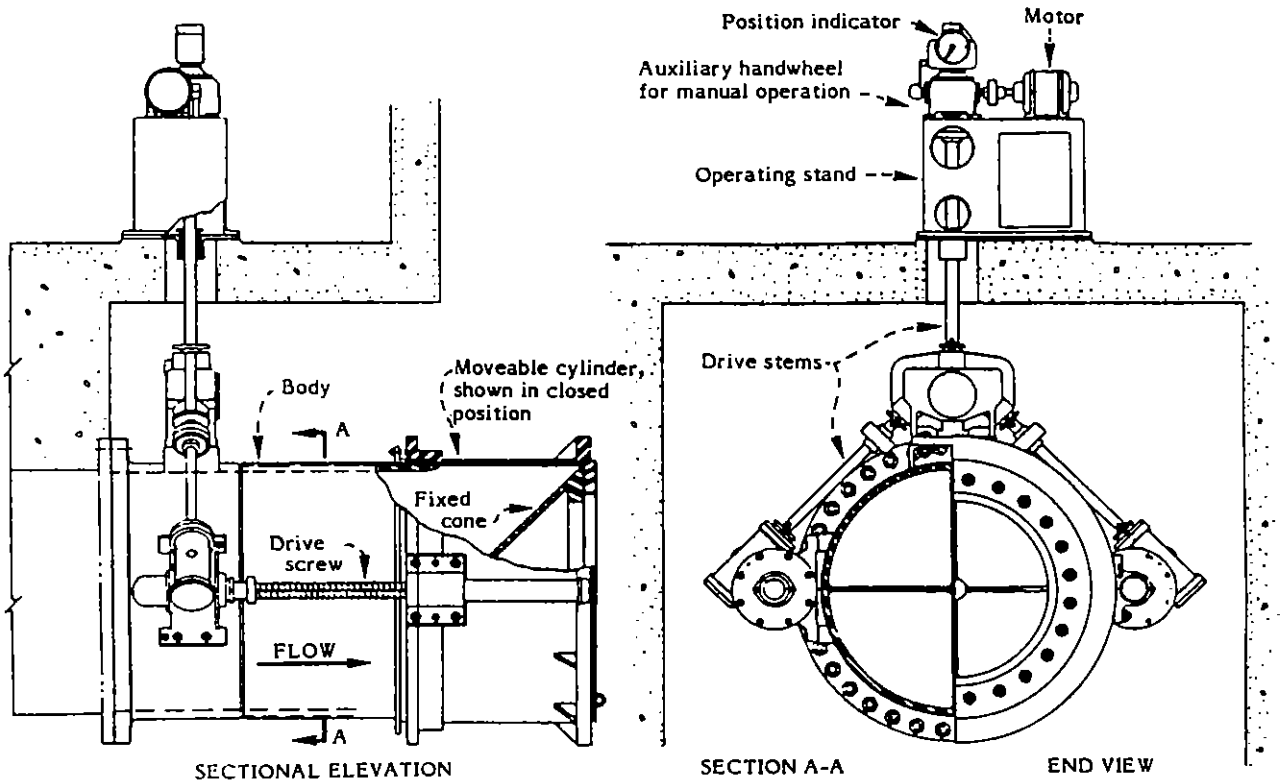


III. SPECIFIC INSPECTION GUIDELINES: VALVES

FIXED-CONE VALVE

The fixed-cone valve, more commonly known as the "Howell-Bunger" valve, is used to regulate releases from outlet works. The fixed-cone valve body is made up of a cylindrical body portion that is bolted to the downstream end of the outlet pipe. The valve has internal, radial ribs connecting it to a conical portion that is spaced a short distance downstream from the end of the cylinder. The conical portion is a 45-degree cone with the apex pointed upstream and is rigidly fixed to the body (hence the name fixed-cone valve). An example of a fixed-cone valve is shown in Figure III-21 below.

FIGURE III-21. FIXED-CONE VALVE



Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: VALVES

FIXED-CONE VALVE (Continued)

Fixed-cone valves can be located at the downstream end of an outlet conduit or in an energy dissipating structure. A moveable cylindrical sleeve fits over the body and moves axially to seat against the fixed cone. The sleeve is long enough to completely block the opening between the cone and the end of the cylindrical portion of the body. The sleeve is moved axially to regulate the flow by an operator mounted externally on the body. There are three main types of fixed-cone valve operators:

- A screw-type device, with twin screws driven through shafting and gears from an overhead electric-motor-driven unit or hydraulically driven motor;
- A linkage-type device on either side of the body that is driven from a manually operated control stand located overhead; or,
- A device with twin hydraulic cylinders on either side of the body, driven by pressurized oil from an electric-motor-driven power unit.

Water discharging from the valve has an expanding, cone-shaped discharge pattern that results in great quantities of spray. When the spray cannot be tolerated, a hood or discharge guide is installed over the valve to confine and redirect the discharge into an acceptable jet.

Fixed-cone valves are excellent regulation valves, aeration devices, and energy dissipators. They are intended to regulate flows from an outlet pipe discharging freely into the atmosphere. However, fixed-cone valves also have been used to a much lesser extent for submerged-discharge operation.

Design Limitations

The operation of fixed-cone valves is sometimes limited by the following design factors:

- When operated without a hood, the valve is limited to applications where a great deal of spray from the discharging jet can be tolerated.
- When discharging freely, the valve requires a large air supply that must be furnished through ducts when a hood is used to confine the jet.
- The main design deficiency of the valve is the need to control the spray from the discharging jet. Use of a hood or discharge guide reduces the problem to an acceptable level, but increases the installation cost.
- Devices to control the jet, whether they be hoods or guides, are prone to damage from vibration and cavitation. To control the vibration, the mass of the guide is often increased by casting a concrete sleeve around the guide, resulting in higher cost.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: VALVES

Design Limitations (Continued)

- The internal ribs (sometimes called splitters) in the bodies of the larger valves have been known to crack, due to fatigue caused by vibrations produced by the flow through the valve. This problem was corrected in later designs by increasing the thickness of the ribs.

Visual Inspection

Your visual inspection of a fixed-cone valve should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Valve Operator	✓	Look for damaged or broken parts on manual and motorized operators. On oil hydraulic systems, look for leaking oil from seals, pipes, pumps, valves, and gauges.
Valve Body And Sleeve		
Exterior	✓	Look for cracked, broken, heavily corroded, or missing parts, and leakage when the valve is closed and subjected to full head.
Interior	✓	Inspect for damage to fluidway surfaces caused by corrosion or cavitation. Also, check internal ribs for signs of fatigue failure caused by vibration.
Sleeve	✓	Check for damage to seating surfaces and the finished surface against which the packing bears.

Test Operation

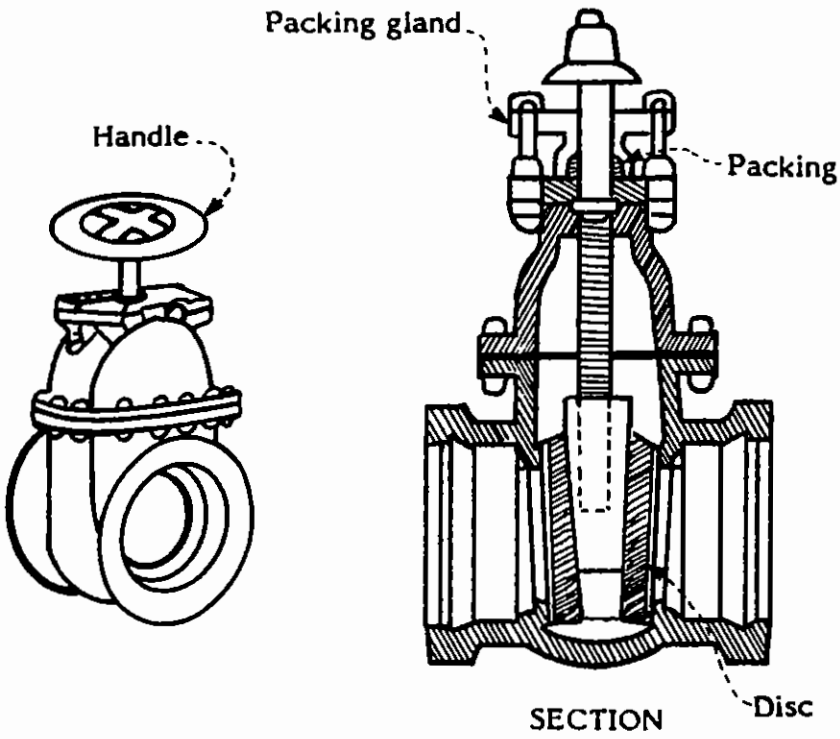
Use the criteria listed in Unit II (pages II-12 and II-13).

III. SPECIFIC INSPECTION GUIDELINES: VALVES

GATE VALVE

A gate valve is fitted to a conduit and has a closure member which moves transversely so as to control or stop flow. Gate valves can be used either as regulating valves or as maintenance/emergency valves. An example of a gate valve is shown in Figure III-22 below.

FIGURE III-22. GATE VALVE



Gate valves that are used for regulating flow are located on the downstream end of conduits; those used as maintenance/emergency valves are located upstream of flow-regulating valves. The closure member is wedge-shaped and seals into a tapered seat in the closed position. When the valve is opened, the closure member moves transversely, guided by tracks, into the bonnet of the valve housing. A gate stem attached to an operator is the apparatus used for opening and closing the valve. Among the different styles of gate valves are those which accommodate flow in one direction and those which accommodate flow in either direction.

Design Limitation

Valves used for controlling flows must be vented just downstream of the valve.

III. SPECIFIC INSPECTION GUIDELINES: VALVES

Problem Areas

The deficiencies most commonly associated with gate valves are:

- Difficulty in achieving proper adjustment of the stem packings
- Worn or damaged seats and tracks
- Cavitation damage
- Vibration during the operation of the valve
- Difficulty in opening and closing the valve

Visual Inspection

Your visual inspection of a gate valve should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Stem	✓	Check for damage to the stem. Ensure that the stem is aligned properly.
Packing And Packing Gland	✓	Inspect for leakage beyond tolerances accepted by the manufacturer.
Seat	✓	Inspect for damage or wear.
Closure Member	✓	Inspect for damage or wear.
Tracks	✓	Check for wear.

Test Operation

Operate the gate under a full head. During the test operation, inspect for the following potential problem areas:

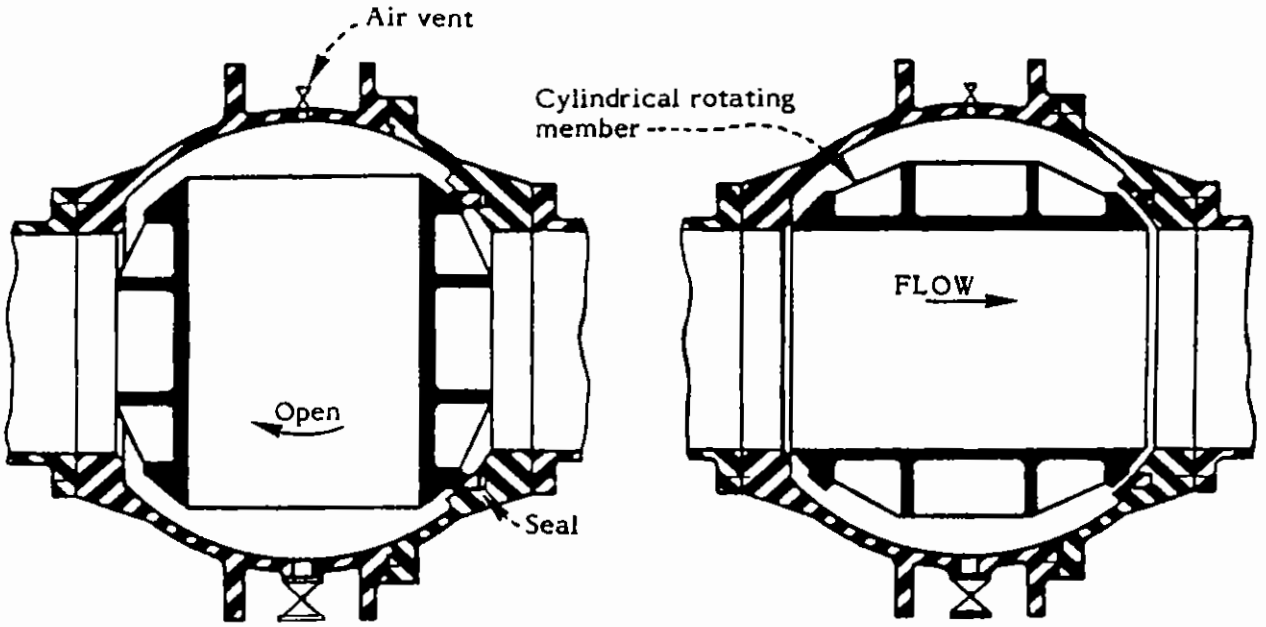
- Difficulty in cracking the valve open
- Leakage past the valve

III. SPECIFIC INSPECTION GUIDELINES: VALVES

SPHERE AND PLUG VALVES

A sphere valve contains an internal moveable sphere, or part of a sphere, that rotates 90 degrees between the open and closed positions. When the valve is in the open position, the fluidway is unobstructed; in the closed position, the fluidway is blocked. A plug valve works the same way except that the internal moveable member of the plug valve resembles a cylinder instead of a sphere. An example of a sphere valve is shown in Figure III-23 below.

FIGURE III-23. SPHERE VALVE



Sphere and plug valves frequently are actuated by mechanical operators, but oil hydraulic cylinders usually are used to operate the larger valves. These types of valves are used as guard valves in water supply conduits and are located upstream of high head turbines. They are suited ideally for installations in which the turbine and guard valve are very close together, because they function as a secondary device for shutting off the water flow in case the primary closure device becomes inoperable.

III. SPECIFIC INSPECTION GUIDELINES: VALVES

Design Limitations

The operation of sphere and plug valves is sometimes limited by the following design factors:

- The sphere valve is a heavy valve that is expensive to manufacture, and requires more space than some other valves (e.g., the butterfly valve).
- The valves must be operated either fully open or fully closed.

Problem Areas

The deficiencies most commonly associated with sphere and plug valves are:

- Cavitation and turbulence if the valve is not fully open or shut
- Leakage
- Accumulation of debris, silt, and mineral deposits on the valve seals and interior cavities
- Corrosion of the valve and stem

Visual Inspection

Your visual inspection of a sphere or plug valve should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Exterior	✓	Look for cracked, broken, loose, heavily corroded, or missing parts, and leakage from any of the flanged joints or valve components.
Interior	✓	Inspect for damage to the fluidway surface due to corrosion or cavitation.
Sphere/Plug	✓	Look for cavitation damage, corrosion, and damage to the sealing surfaces. Check the condition of the seals.

Test Operation

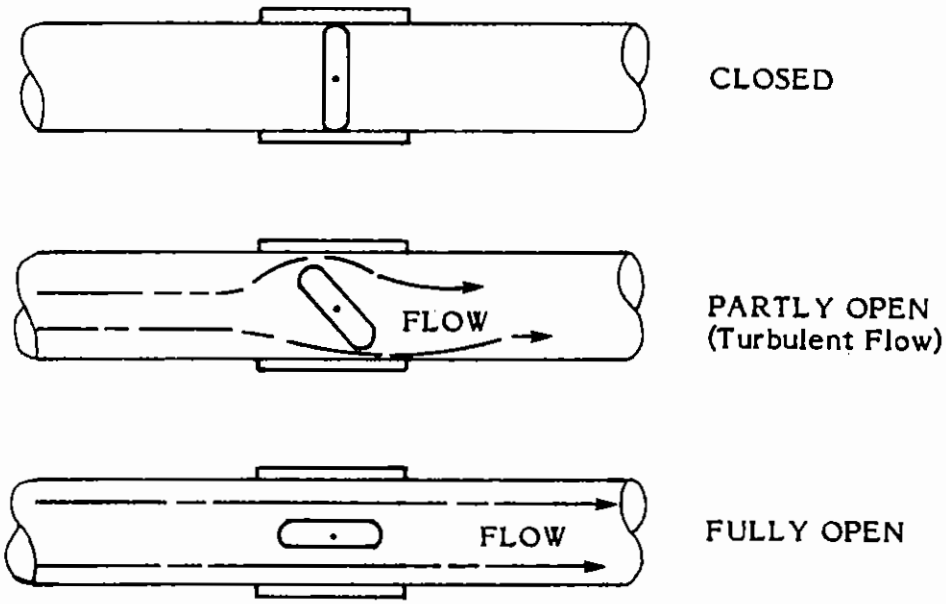
With the valve closed and subjected to full head, check for leakage.

III. SPECIFIC INSPECTION GUIDELINES: VALVES

BUTTERFLY VALVE

A butterfly valve is located in a conduit and consists of a closure member that is rotated to control or stop flow. The leaf (or disk) is rotated with a stem and operator. In the closed position, the closure member is rotated perpendicular to the flow so it rests against its seats. In the fully open position, the closure member is rotated so it is parallel to the flow. An example of a butterfly valve is shown in Figure III-24 below.

FIGURE III-24. BUTTERFLY VALVE



Butterfly valves normally are used as upstream maintenance/emergency valves, and are located upstream of flow control valves and turbines. Under special conditions, butterfly valves can be used as flow control valves.

III. SPECIFIC INSPECTION GUIDELINES: VALVES

Design Limitations

The operation of butterfly valves is sometimes limited by the following design factors:

- Application must be consistent with intended use. If used for regulation, certain valve openings cause turbulence and cavitation.
- An air vent is required downstream of the valve if it is being used for flow regulation.
- Because the closure member remains in the flow area when it is open, the flow is subject to high head losses.

Problem Area

The deficiency most commonly associated with the butterfly valve is leakage at the interface between the trunnion and leaf periphery of the closure member.

Visual Inspection

Your visual inspection of a butterfly valve should consist of the following checkpoints:

ITEM	WHAT TO LOOK FOR	
Exterior	✓	Check for water leakage around flanges and seal-adjusting screws.
Lubrication	✓	Make sure that the valve and operator are lubricated, if applicable.
Leaf	✓	Check for cavitation damage, especially on the downstream faces of the leaf. Also check for damage to seals.

Test Operation

To test the gate, operate it under a full head. Look for chattering, vibration, and binding.

III. SPECIFIC INSPECTION GUIDELINES: VALVES

SLEEVE VALVE

A sleeve valve usually consists of a vertical pipe with a moveable and controlled internal sleeve, and a horizontal, flat baseplate in the bottom of a square stilling well (or inside a steel vessel). **(NOTE:** The valve can also be positioned horizontally.) An illustration of a vertically positioned sleeve valve is provided in Figure III-25, on the next page.

In the closed position, the internal sleeve extends out of the pipe and seats against a cone centered on the baseplate. Moving the internal sleeve up into the pipe with the valve operator allows water to be discharged into the stilling well. Manual screw-type operators in a control stand are suitable for operating valves up to 24 inches in diameter; larger valves use either a motorized operator or a small hydraulic cylinder with an electric-motor-driven oil pump.

One variation of the standard sleeve valve design is the "multi-jet" sleeve valve, which has the addition of a cylindrical extension of the pipe, flanged and bolted to the baseplate, that has ports (round, oblong, or both) cut through its walls.

Sleeve valves are used in the outlet works of dams, to regulate the discharge from outlet pipes and to dissipate energy.

Design Limitations

The ports on the "multi-jet" type of sleeve valve (especially the very small ones, of 1-inch diameter or less) are susceptible to plugging by debris. Therefore, the use of the "multi-jet" is limited to installations where there is little likelihood of debris in the water. Another design limitation, associated with all types of sleeve valves, is that if the operator fails (i.e., the stem becomes disconnected from the sleeve), the sleeve will close, preventing emergency release of water through the valve.

Problem Areas

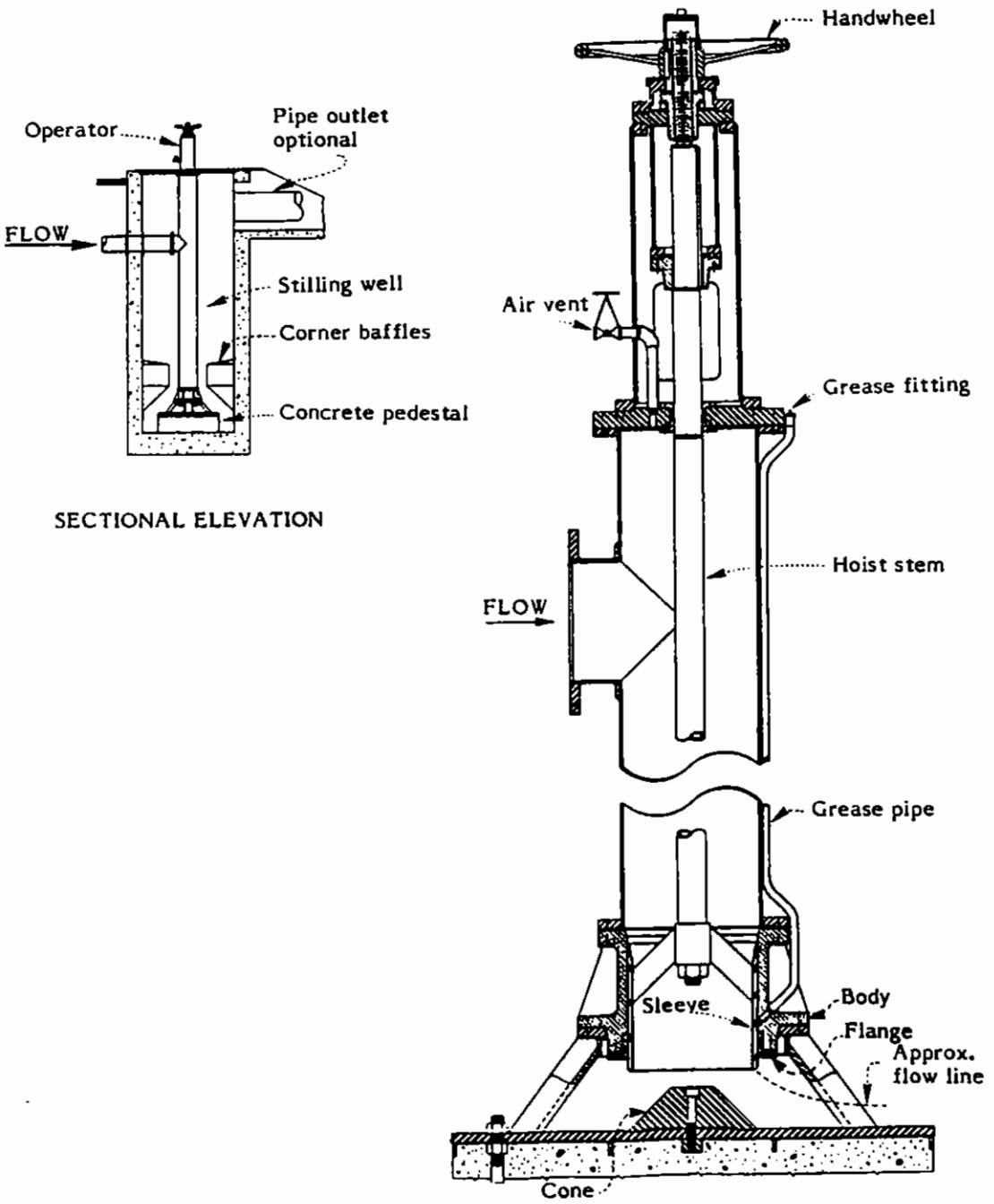
The problem areas most commonly associated with sleeve valves are that:

- The conical member and baseplate are both susceptible to cavitation damage.
- Vibration can loosen sleeve nuts, ultimately causing the stem to drop and close off the valve.

Continued . . .

SLEEVE VALVE (Continued)

FIGURE III-25. SLEEVE VALVE



III. SPECIFIC INSPECTION GUIDELINES: VALVES

Visual Inspection

Your visual inspection of a sleeve valve should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Surface And Coating Condition	✓	Look for cavitation or erosion damage to the cone, stem, and stem supports.
Hoisting Connections	✓	Ensure that stem nuts are tight and locked (pins or set screws in position).

☞ **INSPECTION TIP:** To examine the hoisting connections, and to check the condition of the valve's structural members, you will need to make an internal inspection of the valve and the access. This will require dewatering the stilling well.

Test Operation

The valve will be submerged during the test operation.

Problem indicators such as vibration, binding, and rough operation of the valve will have to be detected from the pressure readings on the operator, or by resistance at the hand operator. Vibration of the internal structure of the valve will also result in vibration of the upper structure and the operator. Abnormal noise may be an indication of wear or a problem with the internal structure of the valve.

You should operate the valve through full travel under balanced head conditions (i.e., no flow) and ensure that the valve, operator, and controls function properly, without chattering or binding.

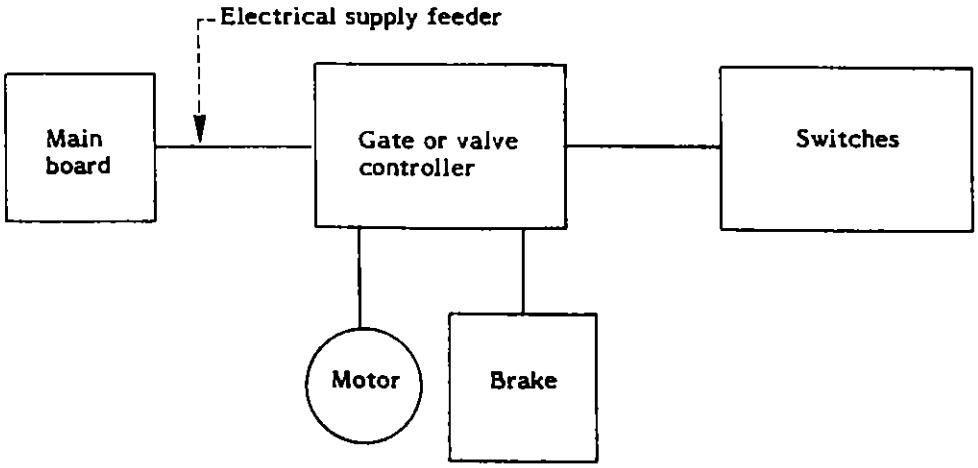
In addition, you should operate the valve under full head, if possible, to an opening that gives the maximum design discharge of the outlet, checking that the valve, operator, and controls function properly. No abnormal vibrations should be produced by the flow.

III. SPECIFIC INSPECTION GUIDELINES: POWER SYSTEMS

ELECTRICAL SYSTEM

Not all agencies require electrical inspection during an inspection of mechanical features. If your organization does not, then the information in this section will not apply to your inspection. However, you might want to review this section anyway, since the information it contains may help you understand better how electrical systems function. A typical electrical system utilizes an electrical supply feeder from the main power supply panel. The electricity then travels to each gate or valve control panel, and finally to the electric motor and all components. The purpose of the system is to supply electrical power for operating gates and valves. Figure III-26 below is an example of an electrical system.

FIGURE III-26. ELECTRICAL SYSTEM



Problem Areas

The deficiencies most commonly associated with electrical systems are:

- Motors overheating
- Damage to electrical wiring
- Malfunctioning of electrical components due to exposure to environmental conditions

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: POWER SYSTEMS

Problem Areas (Continued)

- Corrosion in enclosure and motors
- Physical damage to control switches
- Worn motor bearings
- Inadvertently tripped motor overloads

Visual Inspection

Before starting your inspection, go over the electrical and mechanical "red tag" and lockout procedures with authorized project personnel so that no gate, valve, or electrical circuit can be moved or energized without proper safety procedures being observed.

Your visual inspection of an electrical system should consist of the following checkpoints:

ITEM	WHAT TO LOOK FOR	
Motor Overloads	✓	Check to see if overloads have been tripped.
Heaters	✓	Feel the motor housing and control panel enclosure for heater operation.
Electrical Controls	✓	Check for wire insulation damage due to overheating, deterioration, or rodents.
	✓	Inspect controls for physical damage.
	✓	Check electrical compartments for moisture, dirt, spider nests, and other debris.
Ground Fault Detector (if applicable)	✓	On the main control board you should check to see if there is a ground fault system. This usually consists of three lights over a name tag saying ground fault detector. If all lights are on, your system is good. If one light is out, then there is a problem in the system.

III. SPECIFIC INSPECTION GUIDELINES: POWER SYSTEMS

Test Operation

To test the motors and electrical system, operate them under maximum loading conditions (if possible).

Your test operation of the electrical system should consist of the following steps:

- Before the test operation, megger all electrical supply conductors and motor windings. The reasons for these tests are to check the insulation resistance of conductors and motor windings.
- Take voltage readings before operation and during operation, to check for an excessive voltage drop in the electrical system.
- Take current readings when the gate or valve is being opened and again when it is being closed. The reason for this is to check for overloading on the motor.

During the test operation, look for the following occurrences that could indicate problems within the electrical system:

- Motor starter making noise or chatter.
- Circuit breaker tripping or fuses blowing.
- Motor bearings making noise (check by listening with the motor running).

III. SPECIFIC INSPECTION GUIDELINES: POWER SYSTEMS

HYDRAULIC SYSTEM

A hydraulic system consists of valves, fluid lines, hydraulic pumps, hydraulic cylinders, accumulators, hydraulic motors, electric motors and other control components used to convert electric power to hydraulic pressure to mechanical movement (usually a piston rod within a hydraulic cylinder).

In most hydraulic systems, an electric motor turns a hydraulic pump, which pressurizes hydraulic oil from a reservoir. The oil is directed to either end of the hydraulic cylinder by valves and controls, to allow the piston rod to extend, retract, or be positioned in any intermediate location as required by the operator.

The actuator (i.e., the hydraulic cylinder) is fixed at the rod end to the gate or valve. The cylinder end usually is anchored to the support structure. The rest of the components can be located in a convenient area with hydraulic lines connecting the power unit to the actuator.

In some applications, a gasoline or diesel engine is used instead of an electric motor. In addition, a hydraulic motor can be used in place of a cylinder to produce a rotational output.

A schematic diagram depicting a hydraulic system used to operate a gate is shown in Figure III-27 on the next page.

Problem Areas

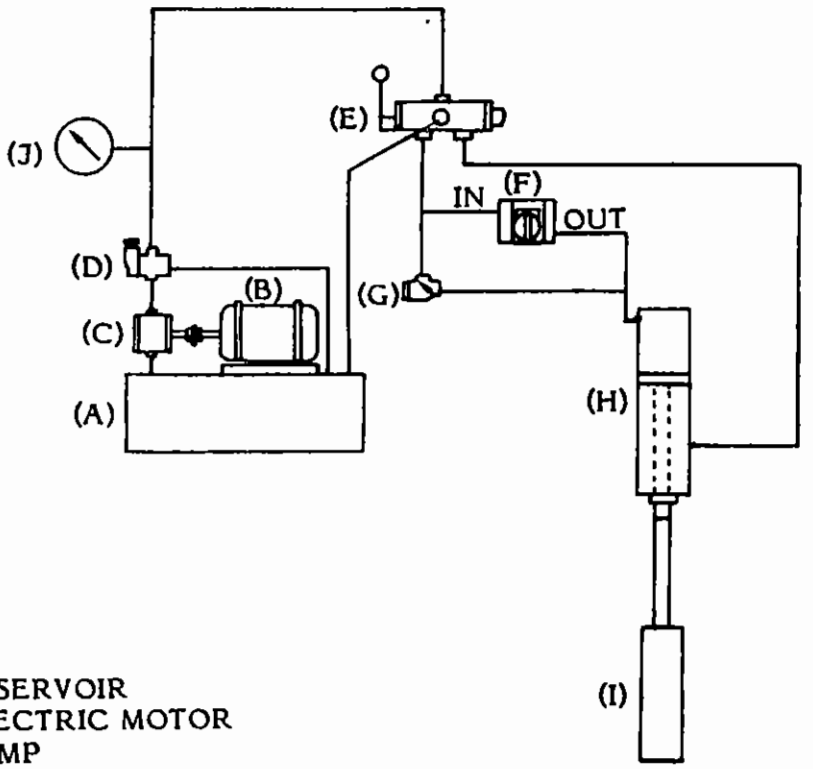
The following deficiencies are commonly associated with hydraulic systems:

- Internal leakage, which causes the actuator to drift unless a mechanical locking device is installed to keep the gate or valve in place
- Fluid leaks
- Incorrectly set switches and relief valves
- Sticky switches
- Dirty fluid

Continued . . .

HYDRAULIC SYSTEM (Continued)

FIGURE III-27. HYDRAULIC SCHEMATIC DIAGRAM



A - RESERVOIR
B - ELECTRIC MOTOR
C - PUMP
D - MAXIMUM PRESSURE (RELIEF) VALVE
E - DIRECTIONAL VALVE
F - FLOW CONTROL VALVE
G - RIGHT ANGLE CHECK VALVE
H - CYLINDER (GATE OPERATOR)
I - GATE
J - PRESSURE GAGE

III. SPECIFIC INSPECTION GUIDELINES: POWER SYSTEMS

Visual Inspection

Your visual inspection of a hydraulic system should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Hydraulic Power Unit, Lines, And Actuator	✓	Inspect for leaks.
Reservoir	✓	Check for water and sediment in the oil reservoir, by loosening the drain plug on the bottom of the reservoir before the unit has been operated, and letting any water or sediment drain out. Record the amount and determine if the amount is significant or just normal condensation. Make sure the proper amount of oil is in the reservoir.
Electrical Controls (if appropriate)	✓	Check for wire insulation damage due to overheating, deterioration, or rodents.
	✓	Inspect controls for physical damage.
	✓	Check electrical compartments for moisture, dirt, spider nests, and other debris.
Actuator Rod	✓	Look for residue, deposits, and damage to the actuator rod. Foreign material that collects on the rod can cause damage to packings and seals.

Test Operation

To test that the hydraulic system is working properly, you should observe its operation under normal conditions while operating a gate or valve from full open to close. During the test operation, look for the following problems:

- Abnormal noises in the hydraulic unit
- Above-normal or erratic operating pressure
- Sticky valves and controls
- Leakage

III. SPECIFIC INSPECTION GUIDELINES: AUXILIARY POWER SYSTEMS

MANUALLY OPERATED AUXILIARY SYSTEM

A manually operated auxiliary system is a means of manually opening a gate or valve when the main power operator is inoperative. Typically, engaging the manual system will simultaneously disengage the primary system, so that there is no possibility of injuries being caused by the primary system suddenly reengaging itself. Once the manual system is engaged, rotating the handwheel or crank will operate the gate or valve. Hydraulic systems may require operating hand valves prior to operation of the auxiliary power system.

Design Limitation

Operating a gate or valve with a manually operated auxiliary system is much slower than using the main power operator.

Visual Inspection

Your inspection of a manually operated auxiliary system should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Handwheel And Lever	✓	Check that these components are still present on the unit.
Operator	✓	Make sure there are no broken parts on the unit. Also inspect for proper lubrication.

Test Operation

With the gate or valve subjected to full head, engage the manual system and turn the handwheel until movement of the gate or valve is observed. Make sure that the manual operator functions smoothly, and that excessive force is not required to operate the system. Operate through a full cycle if possible.

III. SPECIFIC INSPECTION GUIDELINES: AUXILIARY POWER SYSTEMS

EMERGENCY ENGINE-DRIVEN ELECTRICAL GENERATOR

An emergency engine-driven electrical generator is a diesel, natural gas, propane, or gasoline engine-driven generating unit for supplying emergency electrical power.

The generator is designed to provide sufficient power, in an emergency situation when the main power supply fails, to operate the gate(s) or valve(s) deemed necessary to prevent a catastrophe or to meet downstream water requirements. The type and size of the auxiliary power supply is determined by the needs of each installation. Emergency engine-driven electrical generators can be either fixed or portable units.

Problem Areas

The deficiencies most commonly associated with emergency engine-driven electrical generators are:

- Large engine-driven generators that require hand-cranking to start the engine can be very demanding and quite tempermental.
- The reliability factor drops sharply with a balky engine, particularly during cold weather. Consequently, an engine-driven generator or pump that is battery-started using a battery that is kept fully charged by an automatic AC-powered charger generally is preferred (heating of oil and coolant increases reliability during cold weather).
- Gasoline-engine-driven units frequently have carburetion problems because of gum deposits caused by gasoline remaining in the carburetor or gas tank too long. Carburetors should be "run dry" at the completion of each engine operation when it is anticipated that the engine will be idle for some time. The gasoline in the gas tank should be renewed periodically and a gas filter should be installed between the tank and the carburetor and changed periodically.
- Diesel in the diesel tank should be renewed periodically and a diesel filter with a water separator should be installed between the tank and engine and changed periodically.
- Lack of regular exercising reduces reliability.
- Generators may not be sized accurately for power requirements.

III. SPECIFIC INSPECTION GUIDELINES: AUXILIARY POWER SYSTEMS

Visual Inspection

Your visual inspection of an emergency engine-driven electrical generator should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Engine	✓	Look for broken, damaged, or missing parts, leaky or empty radiator, dirty or contaminated oil or gasoline supply, dead or missing battery, etc.
Generator Or Pump	✓	Check for damaged, broken, or missing parts on the generator or pump, and excessive oil leakage around the pump and connecting piping.
Electrical Components	✓	Inspect for damaged or corroded parts or contacts, frayed wiring, loose or corroded connections, etc.
Start-Up Procedure	✓	Look for the procedure, or ask O&M personnel for their written procedures for start-up and for switching from main to auxiliary power. Find the limitation on load (how many gates, fans, pumps, etc. can be run at the same time).
Ventilation	✓	Check that an exhaust system is present and in working condition.

Test Operation

Start the auxiliary power unit and use it to operate at least one of the gates or valves. Refer to the standing operating procedure (SOP) for correct switching and operating procedures. The unit should start without undue effort or lost time and should operate the equipment without difficulty.

III. SPECIFIC INSPECTION GUIDELINES: AUXILIARY POWER SYSTEMS

COMPRESSED-AIR AUXILIARY POWER SYSTEM

A liquid-fuel-powered compressed-air auxiliary power system is used to operate spillway gates when the primary power source is lost. Compressed air is used to drive an air motor (typically a commercial air drill) that can be coupled to the shaft of the gate hoist gearbox.

The normal source of the compressed air is a permanently installed compressed-air system in an adjacent facility such as a powerhouse, with permanent piping running from the powerhouse to the dam or spillway. If a permanently installed system is not available, portable air compressors can be used to operate the gate hoists.

Design Limitation

The capacity of the air compressor to be used in an emergency must be adequate to fully open all spillway gates in sequence.

Problem Areas

The deficiencies most commonly associated with compressed-air auxiliary power systems are:

- Inappropriate piping being used to connect the air source to the spillway structure.
- Inappropriate coupling between the air drill and the gate hoist gearbox.
- Overloading of mechanical components.

Test Operation

After you have confirmed the availability of a compressed air source, the auxiliary power system must be tested. To do this, you should:

- Connect the air drill to the compressed air source.
- Connect the air drill to the shaft or gearbox.
- Open and close the gate a sufficient distance to verify that the source has an adequate capacity of compressed air. Operate the gate through its full cycle, when possible.

If possible, the test should be conducted with maximum loading on the gate.

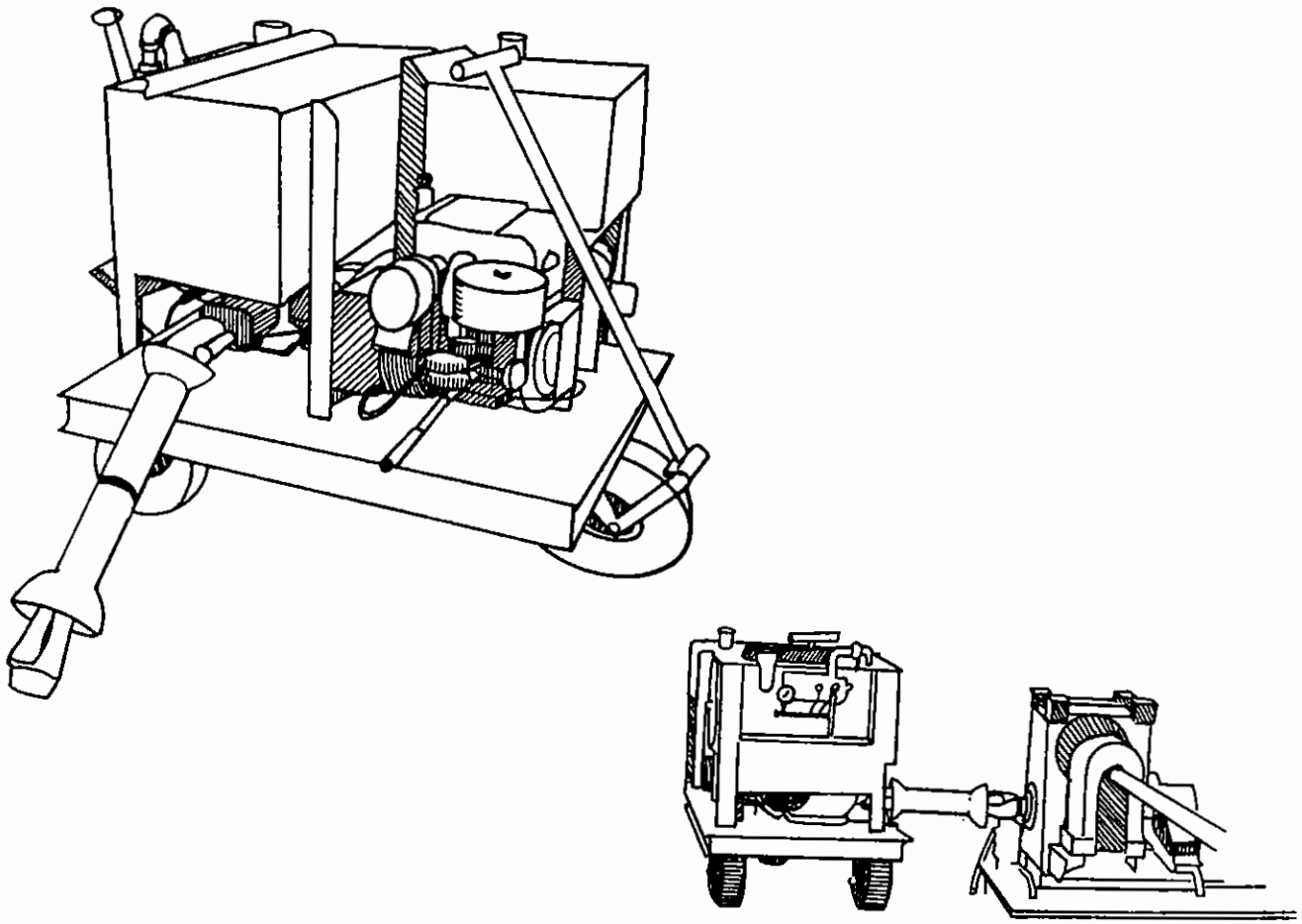
III. SPECIFIC INSPECTION GUIDELINES: AUXILIARY POWER SYSTEMS

PORTABLE AUXILIARY POWER UNIT

A portable auxiliary power unit is generally a liquid-fuel-powered hydraulic or gear-drive unit that can be mechanically attached to the input shaft of a gear reducer to lift a gate when the hoist motor or primary power fails. A typical portable unit is shown in Figure III-28 below.

The unit generally is stored nearby in a covered, secured area. When needed, it is moved into place. The unit has an extendable shaft that connects the output of the unit to the input shaft of the worm gear reducer, opposite the motor input. After the engine is started and warmed up, the control valve is set. The control valve has three positions: up, neutral, and down. The motor brake on the fixed gate hoist must be released manually before the gate can be raised.

FIGURE III-28. PORTABLE AUXILIARY POWER UNIT



III. SPECIFIC INSPECTION GUIDELINES: AUXILIARY POWER SYSTEMS

Design Limitations

The lifting speed of a portable unit is usually slower than the normal lifting speed. In addition, only one gate can be operated at a time.

Problem Areas

The deficiencies most commonly associated with portable auxiliary power units are:

- Balky starting and operation due to infrequent use
- Dead battery
- Inadequate security

Visual Inspection

Your visual inspection of a portable auxiliary power unit should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Hydraulic Reservoir	✓	Check that the oil level is sufficient.
Overall Unit	✓	Examine for corrosion, and for damaged or missing components.

Test Operation

Start the auxiliary power unit and use it to operate at least one of the gates or valves. Refer to the standing operating procedure (SOP) for correct switching and operating procedures. The unit should start without undue effort or lost time and should operate the equipment without difficulty.

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

MANUAL PRIMARY OPERATOR

A manual operator typically uses a handwheel or a crank to operate a threaded stem which is attached to a gate or valve. The stem may be exposed, or encased in a pipe that sometimes is filled with oil. The handwheel or crank is turned by hand to open or close the gate or valve. An example of a manual primary operator is shown in Figure III-29 on the following page.

Problem Areas

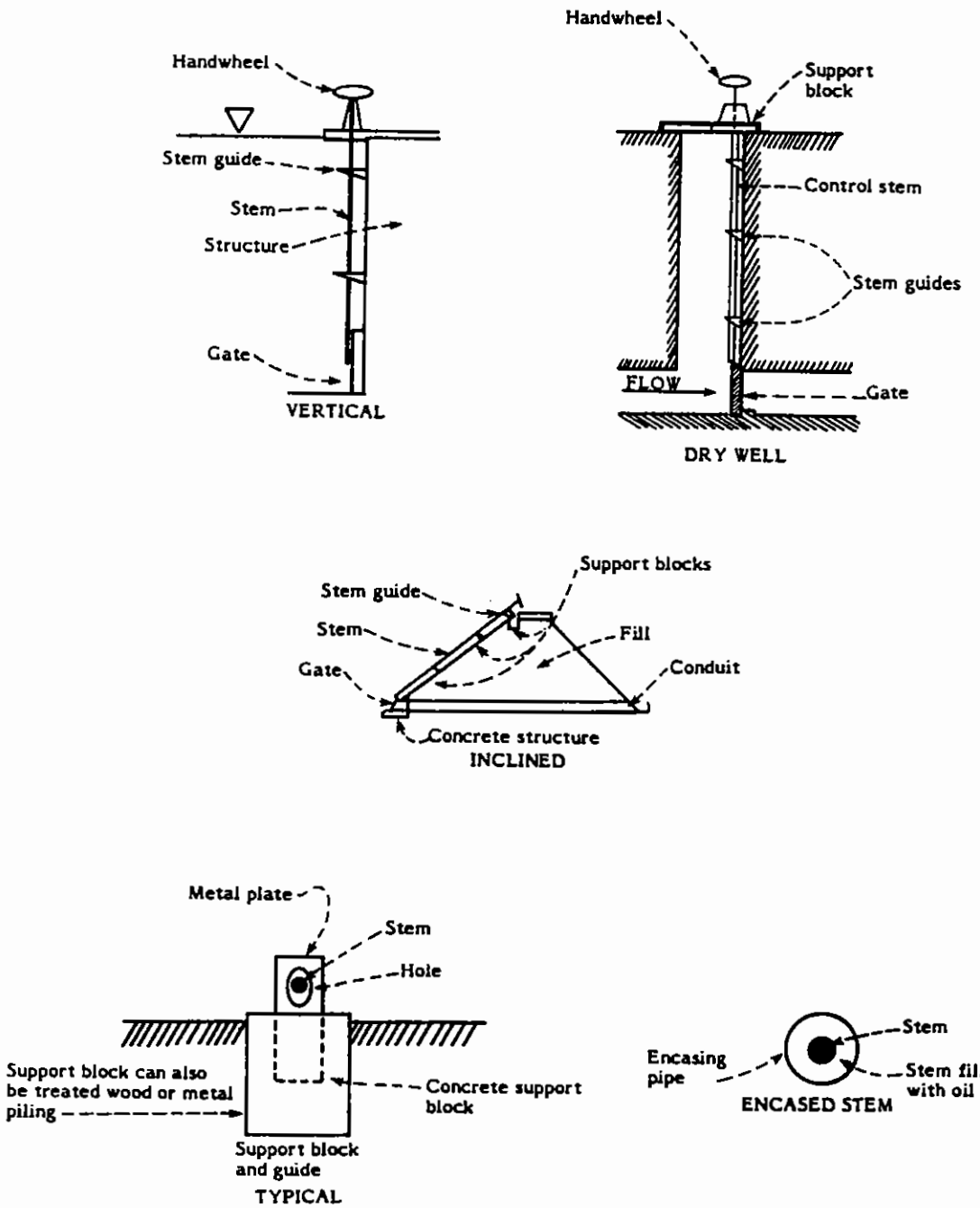
The deficiencies most commonly associated with manual primary operators are:

- The operating mechanism must be well lubricated at all times on all wear surfaces.
- The oil level must be maintained. If this is neglected, water could enter the encasement pipe and damage the upper and/or lower seals.
- All exposed metal on the outlet installation is subject to corrosion.

Continued . . .

MANUAL PRIMARY OPERATOR (Continued)

FIGURE III-29. MANUAL PRIMARY OPERATOR



III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

Visual Inspection

Your visual inspection of a manual primary operator should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Support Blocks	✓	Inspect for deterioration or cracking in the concrete.
	✓	Ensure that no settlement has occurred. This is indicated by the blocks tilting out of position.
Stem Guides	✓	Make sure that the stem guides are properly aligned and anchored. Check for corrosion or any other damage. Also, ensure that the device is well lubricated.
Stem	✓	Inspect for corrosion and thread damage, and make sure that the stem is not bent.
Stem Encasement	✓	Inspect for corrosion and damaged seals. Check the oil level and look for signs of oil leakage.
Handwheel Or Crank	✓	Make sure that it is in place. (Sometimes the handwheels and cranks are stolen by vandals.)

Test Operation

To test the manual primary operator, operate a gate or valve through full cycle under maximum head.

During the test operation, look for the following potential problem areas:

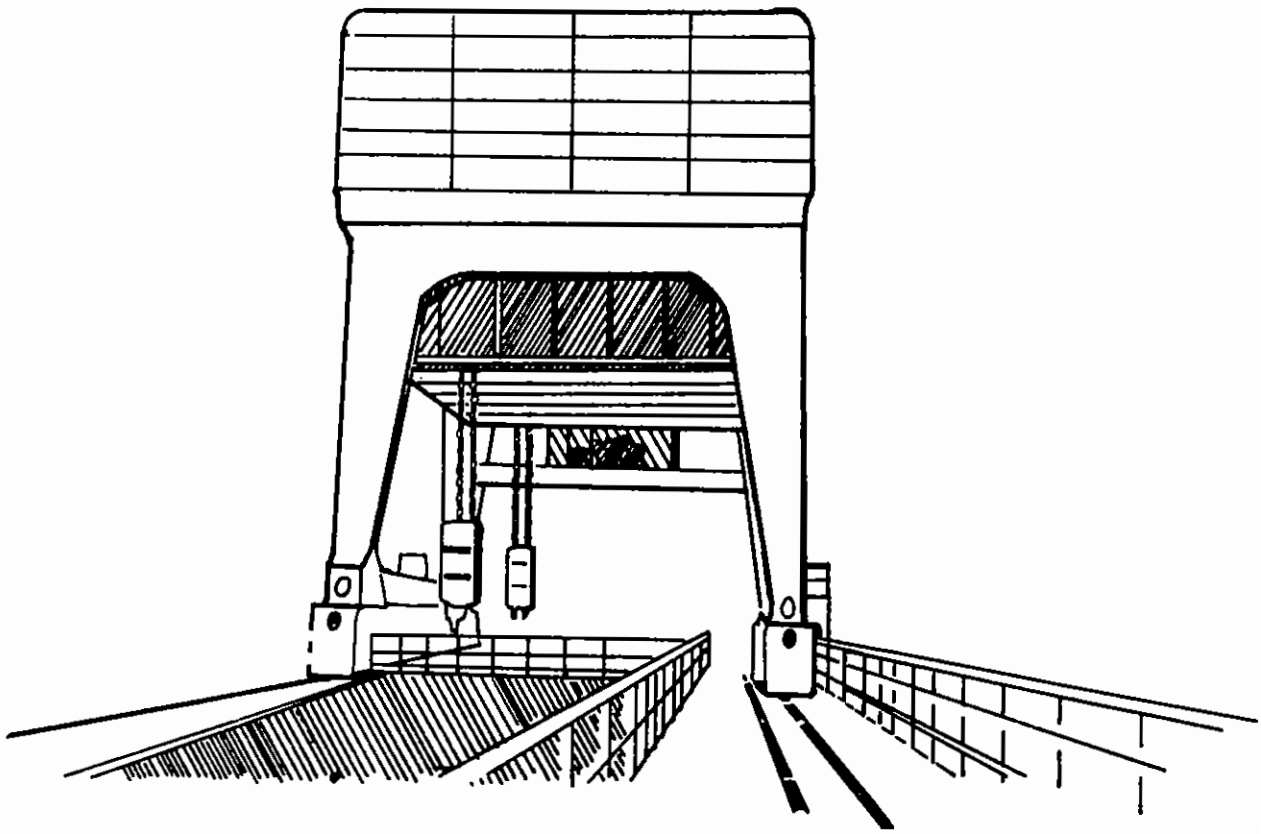
- Excessive force needed to open or close the gate or valve.
- Deflection of the stem.
- Jerky or rough operation.
- Thread left on the stem at both the fully open and the fully closed positions of the gate or valve.

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

GANTRY CRANE

A gantry crane is a traveling superstructure that moves on permanent rails set in the top of a dam (or other structure where installed). The crane is equipped with a traveling hoist trolley that moves on a short set of rails located on top of the superstructure. (See Figure III-30 below.) The rails on which a gantry crane is set travel over a dam's gate and/or valve recesses, and the crane hoists can be equipped with wire rope or chains for raising and lowering gates, valves, and trashracks, and for moving equipment. (Different lifting devices are required to handle the gates because of the different gate types.) Most hoists and travel machinery are driven by electric motor.

FIGURE III-30. GANTRY CRANE



III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

Design Limitations

The major limitation associated with this type of hoisting system is the time required to move the crane into position and accomplish the task of operating the gates. Another limitation is the fact that a gantry crane requires a minimum of two people: one in the cab, and one on the deck as spotter and handler.

Visual Inspection

A gantry crane consists of various systems, which are a combination of mechanical and electrical components. Each component must be inspected and maintained in order for the crane to operate safely.

ITEM		WHAT TO LOOK FOR
Hoist Chain	✓	Check that the chain is lubricated properly. Inspect the chain links for corrosion, wear, and pitting.
Hoist Rope	✓	Examine closely for proper lubrication, broken wires, wear, and localized reduction in diameter.
Thruster Brakes	✓	Check for wear and proper operation.
Gear Reducers	✓	Check for condensation in the oil sumps, and drain any water that is found. This must be done before the reducer is operated or the water will be mixed with the oil. Visually inspect the reducers for seal leakage and surface condition.
Gears And Pinions	✓	Check for uneven or excessive wear. Examine all support bearings for seal leakage and wear.
Shafts, Couplings, And Guards	✓	Inspect for loose bolts and broken parts.
Drums And Sheaves For Wire Rope	✓	Check for groove wear and fit. Inspect the bearings for wear and lubrication.
Electric Motors And Connections	✓	Make sure that equipment is clean and wires are in good condition. Inspect wire insulation for deterioration.
Trolley Wheels And Rails	✓	Examine for wear and misalignment.
Operator's Foot Brake	✓	Test for proper operation and adjustment.
Operator's Controls	✓	Check for proper operation.

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

Test Operation

Use the crane to raise and lower a gate, checking that all parts function properly and operate smoothly, and that the control of the load during lowering is accurate and not jerky.

ITEM		WHAT TO LOOK FOR
Hoist Mechanical Load Brake	✓	Verify that the brake is released during hoisting and engaged when stopped. The brake should also be engaged when lowering in all but the highest speed.
Gear Reducers	✓	Listen carefully for unusual noises that indicate possible failure of the unit.
Shafts And Couplings	✓	Note the alignment of shafts and couplings.
Drums And Sheaves For Wire Rope	✓	Make sure that no vibrations or unusual noises are produced when the hoist is operated.
Electric Motors	✓	Check the motors for bearing noise.

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

TRAVELING HOIST UNIT

A traveling hoist unit is a hoist, mounted on rails, that can travel the length of the spillway deck to lift gates one at a time.

When a gate must be lifted, the unit is spotted over the gate slot. The operating personnel attach the gate's lifting chains or ropes to the hoisting drums on each end of the hoist unit. The hoist is operated to raise the gate to the desired height, at which point a dogging mechanism is used to secure the gate at that height. The hoist mechanism is then reversed to unwind the chain or rope on the drum, so that the hoist unit can move on to the next gate.

Design Limitations

The operation of traveling hoist units is sometimes limited by the following design factors:

- A hoist can only lift one gate at a time.
- Excess lifting chain or rope must be wound up and unwound at each lifting station.

Problem Areas

The deficiencies most commonly associated with traveling hoist units are:

- Chain or rope corrosion and damage.
- Corrosion of the components.

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

Visual Inspection

Your visual inspection of a traveling hoist unit should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Overall Unit	✓	Check for corrosion or other surface deterioration.
	✓	Make sure the motors and controls are in good condition.
	✓	Check for loose or missing hardware.
	✓	Look for oil leakage, especially at the oil seals.
	✓	Inspect the following for proper lubrication and/or excessive wear: . Chain drums . Bearings . Gears and pinions . Brake linings
Hoist Rope	✓	Make sure that the rope is laying properly on the drum.
Trolley Wheels And Rails	✓	Examine for wear and misalignment.
Oil Sumps	✓	Check for condensation in the oil sumps, and drain any water that is found. This must be done before the unit is operated or the water will be mixed with the oil. Record the amount of water and determine whether it is significant or merely reflects normal condensation.
Dogging Mechanism	✓	Check for lubrication and wear.

Test Operation

You should observe the hoist unit in operation. While the unit is lifting a gate, listen for unusual noises and look for binding, misalignment, and proper operation of the dogging mechanism.

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

FIXED HOIST

A fixed hoist is a hoist that has been permanently installed for use with a particular gate. The hoist consists of one or two rotating drums, reducing gears, rotating shafts, and a power unit. Wire rope or chain is wound onto the drum(s) to raise the gate, and the gate is lowered by winding the rope or chain off of the drum(s). A fixed gate hoist typically is powered by an electric motor, but in some instances hydraulic, air, or direct mechanical means such as a manually operated handcrank are used.

Problem Areas

The deficiencies most commonly associated with fixed hoists are:

- Corrosion of components.
- Loosening of couplings.
- Binding of misaligned parts.
- Unraveling of and broken strands in wire ropes.
- Broken chain links.
- Gear teeth not meshing properly.
- Collection of wind-generated and animal debris.

Visual Inspection

Your visual inspection of a fixed hoist should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Surfaces And Coatings	✓	Make sure that all surfaces and coatings are free of cracks, corrosion, and other damage.
Structural Members	✓	Check that structural members are not corroded, out of alignment, loose, or damaged.
Base Plate Mounts	✓	Ensure that mounting nuts and bolts are tight.
Couplings	✓	Check that nuts and bolts are tight and moving parts are lubricated.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: HOISTS AND OPERATORS

Visual Inspection (Continued)

ITEM		WHAT TO LOOK FOR
Reducing Gears	✓	Make sure that there is a metal enclosure surrounding the gears, and that the gears are well lubricated.
Drums	✓	Check for debris and corrosion.
Hoist Rope	✓	Inspect for broken strands, splices, and proper lubrication. Make sure that the rope is laying properly on the drum, and that there are at least two full wraps on the drum when the gate is in the lowered position.
Hoist Chain	✓	Spot-check for cracked, deformed, or severely corroded links. Check that the chain is lubricated properly.
Gear Reducers	✓	Open the drain and check for any accumulated condensation.
Oil Sump	✓	Check for condensation in the oil sump, and drain any water that is found. This must be done before the hoist is operated or the water will be mixed with the oil. Record the amount of water and determine whether it is significant or merely reflects normal condensation.
Limit Switches	✓	Ensure that switches are set for proper operation of the gate.

Test Operation

You should observe the hoist unit in operation. While the unit is lifting a gate, listen for unusual noises and look for binding or misalignment. In addition, you should verify the accuracy of the gate position indicator and the correct operation of the limit switches.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

SUMP PUMP

A sump pump is a pump used to dewater sumps, which are pits or basins that collect drainage water throughout the dam. Water drains into a sump, and at a preset level the pump is energized by a water level control device. Sump pumps are important because they:

- Remove excess water to allow personnel access.
- Help relieve pressure from foundation drains.

Problem Areas

The deficiencies most commonly associated with sump pumps are:

- Corrosion of pumps and waterlines
- Silt and trash, which plug the pump intake and restrict output
- Improper sizing of the pump motor
- Leakage
- The check valve not operating correctly
- The sump control device (float switch) inoperative or improperly set

Visual Inspection

Your visual inspection of a sump pump should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Pipe Valves	✓	Make sure that all valves are operable.
Surface And Coating Condition	✓	Ensure that the surface and coating are free of cracks, corrosion, or other damage.
Lubrication	✓	Check to see that the pump oiler is working (if required).
Pump Screens	✓	Make sure that the pump screens are free of trash.
Sumps	✓	Check to see if the sumps are clean.
Inlet Pipe	✓	Inspect the inlet pipe for holes and restrictions.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

Test Operation

To test the sump pump, check the level control devices to determine if they operate without binding, and start and stop the pumps at the proper water levels. Also, confirm that the pump is capable of pumping the required maximum capacity and that all alarm circuits and control switches are working properly.

During the test operation, inspect for the following potential problem areas:

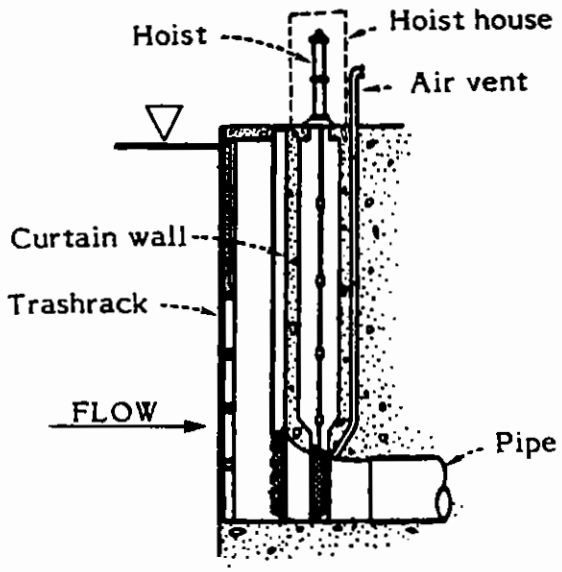
- Leakage in exposed piping and valves.
- Bearing noise in the pump and motor.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

AIR VENTS

Air vents, which generally are connected to the downstream sides of emergency gates and regulating gates, are usually constructed of steel or are formed in the concrete. The intake either can be open to the atmosphere or have an air vacuum-air release valve (sometimes an isolating valve is used in series with the air release valve). An example of an air vent system is shown in Figure III-31 below.

FIGURE III-31. AIR VENT



Air vents can be found in intake towers that house emergency gates and in outlet control buildings that house both emergency and regulating gates. The only moving part of the system is the air vacuum-air release valve, which may be located at the inlet of the vent. Air vents supply the air necessary to prevent the development of high negative or positive pressures, which could cause cavitation damage, collapse of downstream pipes, or water column separation. They are also used to vent air when filling a conduit. In this situation, not venting the air could result in a destructive pressure wave and the collapse of downstream pipes.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

Problem Areas

The deficiencies most commonly associated with air vents are:

- Blocked vent at the inlet or the outlet.
- Corrosion at the waterline.
- Ruptured or collapsed pipes, which could be the result of an undersized or blocked vent.
- Added maintenance needed for air vacuum-air release valves.
- Detached pipe anchors.
- Improper sizing. Size should be checked by an experienced and qualified engineer.

Visual Inspection

Your visual inspection of an air vent should include the following checkpoints:

ITEM	WHAT TO LOOK FOR	
Metal Pipe	✓	Look for corrosion of the pipe or couplings. Check for missing bolts or flanges.
Anchors	✓	Ensure that the anchors are not corroded or broken.
	✓	Make sure the anchors are the correct size for the installation.
Intake	✓	Inspect for material restricting the air passage.
Exhaust	✓	Check the safety screen and ensure that the exhaust is in a safe location.

Test Operation

Test the air vents during the operational closure of a gate or valve, and listen for the movement of air at the inlet vent.

During the test operation, inspect for the following potential problem areas:

- Make sure that the air vacuum-air release valve is functioning correctly.
- Listen for abnormal noise from the inlet vent.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

HEATING ELEMENTS

Heating elements are attached to a gate or valve, or embedded in the adjacent metalwork. They work by electrical current being supplied to the system and are used to prevent equipment from becoming inoperable when temperatures are below freezing.

Design Limitations

The operation of heating elements is sometimes limited by the following design factors:

- Difficulty of attaching the system directly to the gate or valve.
- Inaccessibility of heating elements that are embedded and burn out.

Visual Inspection

Your visual inspection of heating elements should include the following checkpoints:

ITEM	WHAT TO LOOK FOR
Heating Element	✓ Inspect for charred or broken connections.
	✓ Make sure there are no missing elements.

Test Operation

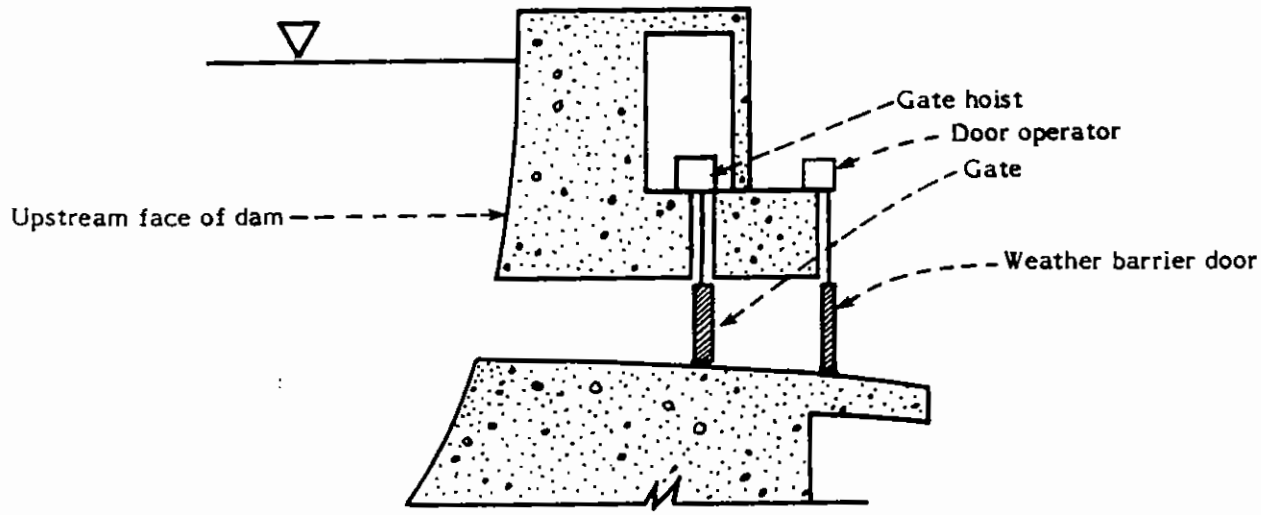
Perform the test operation when the gate or valve is accessible. Check to see that heat is being transferred to the gate or valve by touching the heated surface.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

WEATHER BARRIER DOORS

Weather barrier doors are doors with insulation and weathertight seals that act as an insulator between cold air and a gate. Weather barrier doors can be electrically operated, with switches located remote from the gate, or they can be hand operated. An example of a weather barrier door is shown in Figure III-32 below.

FIGURE III-32. WEATHER BARRIER DOOR



Weather barrier doors are located on the downstream side of spillways or outlet gates, and are used to prevent equipment from becoming inoperable when temperatures are below freezing.

Design Limitations

The operation of weather barrier doors is sometimes limited by the following design factors:

- In the open position, the door should not be in the fluidway discharge path.
- Malfunction of the electrical system will disable electrically controlled doors.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

Visual Inspection

Your visual inspection of a weather barrier door should include the following checkpoints:

ITEM	WHAT TO LOOK FOR
Door	✓ Check for damage to the door structure and for insulation seal damage.
Operator	✓ Check hoist and wire ropes for damage.

Test Operation

Open the weather barrier doors with the gate closed, and observe their operation.

During the test operation, inspect for the following potential problem areas:

- Doors not opening and closing correctly
- Trash or other obstructions that would hinder the operation of the gate
- Damaged seals

Insulation in the control buildings and vaults keeps the equipment inside these areas from freezing and protects it from the effects of condensation (rusting, etc.). Check that the insulation is still in place.

III. SPECIFIC INSPECTION GUIDELINES: MISCELLANEOUS EQUIPMENT

AIR BUBBLER SYSTEM

An air bubbler system consists of an electric-motor-driven air compressor, usually located in an enclosure on top of the dam near the gates, that supplies compressed air through pipes to headers located below the water surface at a depth where ice never forms. The exit portion of the pipe normally is referred to as the nozzle. The air bubbles rising from the nozzles circulate the lower warmer water to the surface to prevent the formation of ice at the freezing zone in the reservoir. Air bubbler systems are located on the upstream side of the dam, below the equipment being protected, and are used to prevent equipment such as gates, valves, trashracks, etc., from becoming inoperable when temperatures are below freezing.

Design Limitation

The main design limitation of an air bubbler system is that it cannot be used in conditions where there is less than 10 feet of water above the nozzles.

Problem Areas

The deficiencies most commonly associated with air bubbler systems are:

- The piping and headers are embedded in the concrete mass of the dam and often are inaccessible for maintenance or replacement.
- Nozzles, pipes, and headers can become plugged with silt, rust, or other debris.
- The air compressor and electrical control system must be maintained properly to ensure operability when needed.

Visual Inspection

Your visual inspection of an air bubbler system should include the following checkpoints:

ITEM		WHAT TO LOOK FOR
Nozzles And Piping	✓	Ensure that they are not clogged. Since the nozzles and piping are normally submerged, divers may be needed.
Air Compressor	✓	Look for damaged or broken parts and corroded or dirty contacts, frayed wiring, or broken components on electrical devices and controls.

Test Operation

Operate the system, and observe the water surface adjacent to the protected equipment. Look for agitation of the water surface that would indicate no major blockages of the system.

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE

INSTRUCTIONS: Use the information presented in this unit to answer the following questions. When you have completed all of the questions, check your answers against those presented in the answer key. The answer key can be found immediately following this exercise.

1. List two of the three types of systems that are used to protect mechanical equipment from freezing.

   - _____
   - _____

2. Place checkmarks (✓) next to the gates that are designed to serve exclusively as emergency gates.

   _____ Ring-Follower Gate

   _____ Spillway Radial Gate

   _____ Crest Gate

   _____ Paradox Gate

   _____ Slide Gate

3. Place a checkmark (✓) next to the item that is **NOT** a type of auxiliary power system.

   _____ Manually Operated System

   _____ Compressed-Air System

   _____ Sump Pump

   _____ Emergency Engine-Driven Electrical Generator

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE

4. Write the letter of each type of gate listed below next to the matching description.

GATES		DESCRIPTIONS	
a.	Wheel-Mounted Gate	_____	This gate is a long, buoyant vessel made of structural steel.
b.	Flap Gate	_____	The moveable portion of this gate resembles a barrel, with no top or bottom, and is reinforced to withstand external pressure.
c.	Cylinder Gate	_____	This gate is usually hinged along the top edge and is designed to allow flows in only one direction.
d.	Drum Gate	_____	This gate has a flat structural-steel stiffened gate leaf with steel wheels.

5. The fixed-cone valve is more commonly know as the: (check one)

_____ Triangle Valve

_____ Howell-Bunger Valve

_____ Gate Valve

_____ Cylinder Valve

6. Before starting an inspection, the inspector should go over the "red tag" and lockout procedures with project personnel. Why are these procedures important?

_____

_____

_____

7. Typically, engaging the manually operated auxiliary system will simultaneously disengage the primary power system.

☐ True ☐ False

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE

8. You are checking the operation of a gate that is equipped with an electrically powered operator. With the gate in the closed position, you discover that the gate will not open.

   How might you determine whether the problem is electrical or mechanical?

   _____

   _____

   _____

   _____

9. Draw a line from the gate or valve in Column A to the gate or valve in Column B that is most similar.

COLUMN A	COLUMN B
Slide Gate	Needle Valve
Hollow-Jet Valve	Paradox Gate
Sphere Valve	High-Pressure Gate
Ring-Follower Gate	Plug Valve

10. Place a checkmark (✓) next to the gate that is **NOT** a type of roller-mounted gate.

    _____ Stoney Gate

    _____ Caterpillar Gate

    _____ Wheel-Mounted Gate

    _____ Tractor Gate

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE

11. Write the letter of each item listed below next to the matching description.

MECHANICAL EQUIPMENT		DESCRIPTIONS	
a.	Manual Primary Operator	_____	A gasoline-powered hydraulic unit used to lift gates.
b.	Gantry Crane	_____	A traveling superstructure that moves on permanent rails set in the crest of the dam.
c.	Fixed Hoist	_____	Typically a handwheel or crank on a threaded stem that is attached to a gate or valve.
d.	Portable Auxiliary Power Unit	_____	Installed permanently for use with a particular gate.

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE — ANSWER KEY

INSTRUCTIONS: Compare your answers to the answers given below to see how well you learned the information presented in this unit.

1. List two of the three types of systems that are used to protect mechanical equipment from freezing.

   Any two of the following:

   - **Heating Elements**
   - **Air Bubbler System**
   - **Weather Barrier Doors**

2. Place checkmarks (✓) next to the gates that are designed to serve exclusively as emergency gates.

   ___✓___ **Ring-Follower Gate**

   _____ Spillway Radial Gate

   _____ Crest Gate

   ___✓___ **Paradox Gate**

   _____ Slide Gate

3. Place a checkmark (✓) next to the item that is **NOT** a type of auxiliary power system.

   _____ Manually Operated System

   _____ Compressed-Air System

   ___✓___ **Sump Pump**

   _____ Emergency Engine-Driven Electrical Generator

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE — ANSWER KEY

4. Write the letter of each type of gate listed below next to the matching description.

GATES		DESCRIPTIONS	
a.	Wheel-Mounted Gate	__d__	This gate is a long, buoyant vessel made of structural steel.
b.	Flap Gate	__c__	The moveable portion of this gate resembles a barrel, with no top or bottom, and is reinforced to withstand external pressure.
c.	Cylinder Gate	__b__	This gate is usually hinged along the top edge and is designed to allow flows in only one direction.
d.	Drum Gate	__a__	This gate has a flat structural-steel stiffened gate leaf with steel wheels.

5. The fixed-cone valve is more commonly know as the: (check one)

_____ Triangle Valve

__✓__ **Howell-Bunger Valve**

_____ Gate Valve

_____ Cylinder Valve

6. Before starting an inspection, the inspector should go over the "red tag" and lockout procedures with project personnel. Why are these procedures important?

The "red tag" and lockout procedures are designed to ensure that no gate, valve, or electrical circuit can be moved or energized without proper safety procedures being observed.

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE -- ANSWER KEY

7. Typically, engaging the manually operated auxiliary system will simultaneously disengage the primary power system.

   ☑ **True** ☐ False

   Engaging the manually operated auxiliary system will disengage the primary system automatically. This simultaneous disengagement is designed to prevent injuries that could occur if the primary system suddenly re-engaged itself.

8. You are checking the operation of a gate that is equipped with an electrically powered operator. With the gate in the closed position, you discover that the gate will not open.

   How might you determine whether the problem is electrical or mechanical?

   Use the applicable auxiliary operator. If the gate will open using the auxiliary operator, the problem is probably electrical. However, if the gate does not open, the problem is probably mechanical (e.g., the gate assembly or the gears of the operator).

9. Draw a line from the gate or valve in Column A to the gate or valve in Column B that is most similar.

COLUMN A	COLUMN B
Slide Gate	High-Pressure Gate
Hollow-Jet Valve	Needle Valve
Sphere Valve	Plug Valve
Ring-Follower Gate	Paradox Gate

10. Place a checkmark (✓) next to the gate that is **NOT** a type of roller-mounted gate.

    ____ Stoney Gate

    ____ Caterpillar Gate

    ✓ **Wheel-Mounted Gate**

    ____ Tractor Gate

Continued . . .

III. SPECIFIC INSPECTION GUIDELINES: UNIT EXERCISE — ANSWER KEY

11. Write the letter of each item listed below next to the matching description.

MECHANICAL EQUIPMENT		DESCRIPTIONS	
a.	Manual Primary Operator	**d**	A gasoline-powered hydraulic unit used to lift gates.
b.	Gantry Crane	**b**	A traveling superstructure that moves on permanent rails set in the crest of the dam.
c.	Fixed Hoist	**a**	Typically a handwheel or crank on a threaded stem that is attached to a gate or valve.
d.	Portable Auxiliary Power Unit	**c**	Installed permanently for use with a particular gate.

FINAL REVIEW EXERCISE

INSPECTION AND TESTING OF GATES, VALVES, AND OTHER MECHANICAL SYSTEMS

FINAL REVIEW EXERCISE

INSTRUCTIONS: Several situations are described below. After reviewing each situation, answer the question asked using the information presented in this module.

When you have completed all of the questions, check your answers against those presented in the answer key. The answer key can be found immediately following the last page of this exercise.

---

1. An inspector has reached the point in the inspection where a slide gate is to be tested. The inspector finds the gate control panel and pushes a button to operate the gate. After operating the gate through a full cycle, the inspector is satisfied that the condition of the gate is adequate. The inspector departs to find the dam personnel and inform them that the gate has been tested and that it was found to be satisfactory.

   What is wrong with the inspector's actions?

   _____

   _____

   _____

   _____

   _____

2. You are performing an operational test of a spillway radial gate. Suddenly the gate begins to vibrate violently.

   What should you do?

   _____

   _____

   _____

   _____

   _____

Continued . . .

FINAL REVIEW EXERCISE

3. During an inspection, you realize that, due to circumstances beyond your control, you will not be able to test operate the gates and valves.

   What should you do?

4. While checking the as-built drawings against the actual features at the dam site, you notice a gate that does not appear on the as-built drawings.

   What should you do?

5. You are about to go into a conduit to inspect a valve.

   What safety concerns should be taken into account before descending into the conduit?

Continued . . .

FINAL REVIEW EXERCISE

6. During the course of an inspection, you notice that a fence that guards the entrance to a spillway is in need of repair.

   Since a broken fence does not affect dam safety, should you report this finding in your dam safety inspection report? ☐ Yes ☐ No

   Explain your answer: _____

   _____

   _____

7. Cavitation damage is found: (check one)

   _____ At an offset or obstruction in a fluidway.

   _____ Upstream of an offset or obstruction in a fluidway.

   _____ On the spillway deck near a gate operator.

   _____ Downstream of an offset or obstruction in a fluidway.

8. Are the security requirements for all dams the same?

   ☐ Yes ☐ No

   Explain your answer: _____

   _____

   _____

Continued . . .

FINAL REVIEW EXERCISE

9. The test operation of the emergency engine-driven electrical generator at a dam cannot be conducted due to a dead starting battery.

   What should you do?

10. The recommended procedure for testing a ring-follower gate is that it be tested under balanced, no-flow conditions.

    How is it determined whether the gate is under balanced, no-flow conditions?

FINAL REVIEW EXERCISE

ANSWER KEY

FINAL REVIEW EXERCISE — ANSWER KEY

INSTRUCTIONS: Compare your answers to those given below. For more information review the referenced text pages.

	REFERENCES
1. An inspector has reached the point in the inspection where a slide gate is to be tested. The inspector finds the gate control panel and pushes a button to operate the gate. After operating the gate through a full cycle, the inspector is satisfied that the condition of the gate is adequate. The inspector departs to find the dam personnel and inform them that the gate has been tested and that it was found to be satisfactory. What is wrong with the inspector's actions? **The inspector should never reach into open control panels or push buttons or switches. Also, the "red tag" and lockout procedures should be followed before conducting any equipment tests.**	Text Page: II-5
2. You are performing an operational test of a spillway radial gate. Suddenly the gate begins to vibrate violently. What should you do? . **Stop the gate.** . **Note the gate position at which the gate began vibrating.** . **Note the elevation of both the reservoir and the downstream pool, to help in the evaluation of the problem by an experienced and qualified engineer.** . **Check for trash and debris.** . **Inspect the seals and seats for binding and damage.** . **Check for loose mounting bolts.** . **Check for misalignment of parts.** . **Check the equipment's lubrication.** . **Document the problem using "SMPL."**	Text Page: II-13

Continued . . .

FINAL REVIEW EXERCISE — ANSWER KEY

	REFERENCES
3. During an inspection, you realize that, due to circumstances beyond your control, you will not be able to test operate the gates and valves. What should you do? **Review the logbooks to determine if the gates and valves have been operated since the last inspection. Check to see if the logbooks note any problems. If problems were noted, talk to operating personnel who are at the dam site to gather additional information.**	Text Page: II-12
4. While checking the as-built drawings against the actual features at the dam site, you notice a gate that does not appear on the as-built drawings. What should you do? **Inspect the gate. Record the condition of the gate and its location in your dam safety inspection report. Remember, illegally or improperly used gates and valves may decrease the capacity of spillways or pressurize a conduit not meant to be pressurized.**	Text Page: II-10
5. You are about to go into a conduit to inspect a valve. What safety concerns should be taken into account before descending into the conduit? **"Red tag," lock out, or personally padlock the operators of all related gates and valves. Make sure there is adequate ventilation before entering the conduit. Wear a safety belt, and take extra care on ladders that may be wet or slippery. It's also a good idea to notify someone that you are going into the conduit and tell them when you plan to exit the conduit. If you don't come out at that time, they should go in and look for you.**	Text Pages: II-4 - II-5

Continued . . .

FINAL REVIEW EXERCISE — ANSWER KEY

	REFERENCES
6. During the course of an inspection, you notice that a fence that guards the entrance to a spillway is in need of repair. Since a broken fence does not affect dam safety, should you report this finding in your dam safety inspection report? ☑ Yes ☐ No Explain your answer: **Although a broken fence does not affect dam safety, it is a finding that should be reported in your dam safety inspection report as an operation and maintenance concern. A broken fence near the spillway entrance can be a safety hazard and should be fixed by the dam owner or operator. Also, a broken fence provides no protection against vandals.**	Text Page: II-11
7. Cavitation damage is found: (check one) _____ At an offset or obstruction in a fluidway. _____ Upstream of an offset or obstruction in a fluidway. _____ On the spillway deck near a gate operator. ✓ **Downstream of an offset or obstruction in a fluidway.**	Text Page: II-7
8. Are the security requirements for all dams the same? ☐ Yes ☑ **No** Explain your answer: **The security required at a dam is dependent on the consequences of illegal or unauthorized operation of the dam outlet equipment.**	Text Page: II-11

Continued . . .

FINAL REVIEW EXERCISE — ANSWER KEY

	REFERENCES
9. The test operation of the emergency engine-driven electrical generator at a dam cannot be conducted due to a dead starting battery. What should you do? **Review the dam logbooks to determine when the generator was last operated. Check to see whether the logbooks note any problems, and mention the dead battery to the dam personnel at the exit meeting.**	Text Page: II-12
10. The recommended procedure for testing a ring-follower gate is that it be tested under balanced, no-flow conditions. How is it determined whether the gate is under balanced, no-flow conditions? **A gate is under balanced, no-flow conditions when the head, or pressure, on both sides of the gate is equal. If the gate's upstream face is subject to the reservoir head, then the head downstream of the gate must also equal the reservoir head.**	Text Page: II-13

APPENDIX A

GLOSSARY

GLOSSARY

AS-BUILT DRAWINGS - Updated construction drawings that reflect the actual physical installation, including any changes that had to be made to the original plans.

CAVITATION - A process that damages concrete or metal by the formation of bubbles in a water flow, created when offsets or irregularities exist on a flow surface exposed to high velocities.

CAVITATION DAMAGE - Damage to a concrete or metal surface caused by shock waves from the collapse of bubbles in a high-velocity water flow.

CONTROL EQUIPMENT - A general term for the system of gates and valves with which flows through an outlet works are regulated.

CONTROL GATE (OR VALVE) - A gate (or valve) that is used to regulate water flows, and therefore can be used fully open, fully closed, or at any setting in between.

DAM - A barrier constructed across a watercourse for the purpose of storage, control, or diversion of water.

EMERGENCY GATE - A standby or reserve gate that is used only when the normal means of water control is not available.

GALVANIC CORROSION - The result of electrical/chemical reactions between two dissimilar metals.

GATE (OR VALVE) CYCLE - The movement of a gate (or valve) from fully closed to fully open to fully closed.

GATE - An adjustable device used to control or stop the flow of water in a waterway. A gate consists of a leaf or member which is moved across the waterway from an external position.

MAINTENANCE GATE (OR VALVE) - A gate (or valve) that is used upstream of a control device, to stop the flow of water so that the device downstream can be serviced.

MEGGER - An instrument used to measure high resistances, utilizing magnetos (magnetoelectric generators) to produce high test voltages (usually in the 500-1000 volt range). Megohmmeters can be either hand-cranked or battery-operated, depending on the model. The meters calibrate resistance values directly in megohms.

OUTLET WORKS - A system of dam components that regulates or releases water impounded by a dam. Components of an outlet works include an entrance channel, intake structure, conduit, gate or valve housing, energy dissipators, and return channel.

REGULATING GATE (OR VALVE) - See **CONTROL GATE (OR VALVE).**

GLOSSARY

RESERVOIR - The body of water impounded by a dam.

SPILLWAY - A structure over or through which flood flows are discharged. If the flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control, it is considered an uncontrolled spillway.

VALVE - An adjustable device used to control or stop the flow of water in a waterway. A valve is fixed permanently within the waterway, and has a closure member that is either rotated or moved transversely or longitudinally in the waterway in order to control or stop the flow.

WET WELL - A vertical pipe or shaft used to access a gate or valve controlling flow in the conduit that takes water away from the well. Generally, another conduit brings water from the reservoir to the well. If this conduit is ungated, or is in the open position if gated, then the water level in the well will be approximately the same as the water level in the reservoir.

APPENDIX B

REFERENCES

REFERENCES

Dam Safety Manual. State Engineer's Office, State of Colorado, June 1983.

Guidelines for Safety Evaluation of Mechanical Equipment. U.S. Department of the Interior, Bureau of Reclamation, June 1987.

Safety of Existing Dams: Evaluation and Improvement. National Research Council, National Academy Press, 1983.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1988—000-000