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In This Issue . . .

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This *Water Operation and Maintenance Bulletin* is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Bureau of Reclamation personnel and water user groups in operating and maintaining project facilities.

The *Water Operation and Maintenance Bulletin* and subject index may be accessed on the Internet at: **www.usbr.gov/assetmanagement**.

Although every attempt is made to ensure high quality and accurate information, the Bureau of Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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***Cover photograph*:** Pumping plant located on a canal, looking upstream.

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DEVELOPMENT OF STAND-ALONE STANDING OPERATING PROCEDURES FOR A PUMPING PLANT/CANAL

by: Charlie Swanson, P.E., Bureau of Reclamation, Technical Service Center, Instrumentation and Inspections Group, 86-68360

According to the Bureau of Reclamation's (Reclamation) Standing Operating Procedures Guide for Dams, Reservoirs, and Power Facilities (SOP Guide), the contents of a pumping plant would normally be found in Chapter V, "Power Facility Operations." However, this article provides information about the organization and content of an SOP that was written as a stand-alone document for a pumping plant and an associated canal. Reclamation requires SOPs only for high- and significant-hazard dams. Developing an SOP for a pumping plant/canal is not required, but can be developed at the discretion of the Regional Director.

The following chapters were used for an SOP for one of Reclamation's pumping plants on a canal. The decision for including these particular chapters was made by Reclamation area and regional office personnel, the Technical Service Center (TSC), and operating entities, as applicable. This SOP was for a pumping plant with an associated canal, and there were seven chapters and related appendices as shown below.

Chapter I	General Information
Chapter II	General Operating Procedures
Chapter III	Unit Operating Instructions
Chapter IV	Major Equipment and Systems
Chapter V	Switchyard
Chapter VI	Pumping Plant Structure and Intake Channel
Chapter VII	Canal
Appendix A	Pumping Plant Supporting Material
Appendix B	Forms and Checklists
Appendix C	Reference Drawings

It should be noted that this article **excludes** the discussion of the Emergency Action Plan (EAP) and/or a Communications Directory, including related references and documentation.

The pumping plant/canal SOP should provide detailed information regarding operation and maintenance (O&M) procedures for the associated equipment and systems. Also, sufficient information should be included for all sections in each SOP chapter. The SOP is often used by many other offices, including area and regional offices, operating entities (as applicable), and the TSC.

Key operating personnel/supervisors and designated Reclamation offices are responsible for periodically reviewing the SOP, typically on an annual basis, to ensure all the information is current. Suggested changes to the SOP should be provided to the issuing (area/regional) office for revisions. Recommendations are sometimes made during onsite field examinations to revise the SOP, and these recommended revisions should be made in a timely manner.

The preliminary pages (usually found before the table of contents) to the SOP generally include the following headings:

- List of Acronyms/Abbreviations
- Revision Sheet
- Certification of SOP Review by Operating Personnel
- Annual Review of SOP by Operating Personnel
- Preface
- Items of Special Importance
- Arc Flash Requirements — Information about arc flash requirements for the owner/operating entity were included as part of this SOP

The heading entitled "Emergency Procedures for Pumping Plant/Canal" can be included as part of the preliminary pages in the SOP to aid the user(s) in actions to be taken during an emergency event/occurrence at the pumping plant or along the canal reach. An example of the headings/subheadings of this section is as follows:

Emergency Procedures for Pumping Plant/Canal

A. Purpose

B. Line of Communication and Minimum Procedures

1. Personnel Involved in Reporting Emergencies
2. Minimum Procedures

C. Reporting

D. Notifications

E. Pumping Plant Emergency Events

1. Pumping Unit Trips
2. Power Outages
3. Improper Check Gate Operations
4. Equipment not Available to Meet Water Delivery Requirements
5. Low Water in Inlet Canal
6. Flooding

Chapter I – General Information

The section headings (A. through O.) in this chapter are similar to those used for a dam SOP and were included in the stand-alone pumping plant and canal SOP. The section headings shown in this article are provided for your consideration when developing the pumping plant and canal stand-alone SOP. Three sections were added to this chapter: "Training," "Safety Procedures," and "Protective Coatings."

A. Purpose of the Project

A table similar to the one shown below can be useful to summarize the engineering data at the facility.

Table I-1. Engineering Data for ________ Pumping Plant and ______ Canal

Location	Approximately ___ miles (direction) of City, State Latitude: ___° _____' N Longitude: ___° _____' W
Water Supply:	__________________ Canal
Construction period	Original construction period and any modifications
Structure: Indoor type, with the footprint of the plant structure measuring ____ feet long and ____ feet wide. The substructure and immediate structure of the plant are constructed of reinforced concrete. The superstructure is constructed mostly of steel and brick siding.	
Pump units:	*<number>* ____, vertical-shaft centrifugal-type pumps, directly connected to a synchronous motor.
Pump capacity, each	_____ ft^3/s at _____ feet of head (720 RPM) _____ ft^3/s at _____ feet of head (450 RPM) _____ ft^3/s at _____ feet of head (360 RPM)
Total rated pump capacity	_____ ft^3/s at ____ feet of head (___ pumps)
Motor rating, each	_____ horsepower (720 RPM) _____ horsepower (450 RPM) _____ horsepower (360 RPM)
Intake channel: The inlet portion of the pumping plant is a reinforced, concrete-lined trapezoidal-shape, having a design capacity of _______ ft^3/s. The length of the intake channel is _____ feet.	
Discharge pipe: _____-foot-diameter _________ pipe conveys pumped water approximately ______-feet to an outlet structure.	
Inlet canal pool elevations:	______ to ______ feet
Outlet canal normal pool elevation:	_______ feet
Transformers: *<number>*____, ___-kV outdoor, _______-type	
Switchyard: *<number>* _____, _____-type breakers rated at ____ kV	

B. Location and Access to the Pumping Plant

C. Assignment of Responsibility

D. Attendance, Communications, and Warning Systems

1. Attendance
2. Communications
3. Warning Systems

E. Cooperation with Other Agencies

F. Data Reporting

G. Operating Log

H. Public Safety and Health

I. Restricted Areas

J. Emergency Management and Facility Security Plans

K. Distribution of Standing Operating Procedures

L. Revisions to Standing Operating Procedures

M. Supporting Documents

N. Reference Material

O. Training

P. Safety Procedures

1. General
2. Procedures for Confined Spaced Entry
3. Procedures for Hazardous Materials Management

Q. Protective Coatings

1. Inspection
2. Maintenance

Chapter II – General Operating Procedures

A. Entering and Leaving Pumping Plant

B. Water and Power Orders

C. Water Measurement

D. Inlet Water Surface Elevations

E. Inspections

1. Daily
2. Weekly
3. Monthly
4. Every 6 Months
5. Annually
6. Every 3 Years
7. As Necessary

F. Pumping Plant Operations Records

Chapter III – Unit Operating Instructions

A. Main Pumping Units' Motor Restarting Limits

B. Temperature and Electrical Limitations

1. Main Pumping Units
2. Main Power Transformers

C. Normal Operation

1. General
2. Preparation for Normal Starting
3. Local Starting and Shutdown
4. Automatic Pump Controller for Remote Starting of Units
5. Equipment Settings and Adjustments
6. Starting with Discharge Line Empty
7. Automatic Restarting after Power Failure

D. Emergency Shutdown

1. General
2. Abnormal Conditions

E. Supervisory Control

F. Switching Outline to Place Clearance on ____ Transformer

G. Switching Outline for Clearing _____ Transformer Bank

1. De-Energizing Procedures
2. Energizing Procedures

H. Switching Outline for Clearing the _____-Volt Busses to Install Emergency Bus Links

1. De-Energizing Procedures
2. Energizing Procedures

I. Switching Outline for Clearing the _____-Volt Busses to Remove Emergency Bus Links

1. De-Energizing Procedures
2. Energizing Procedures

J. Switching Outline to Clear Station Service Transformer Bank

1. De-Energizing Procedures
2. Energizing Procedures

K. Switching Outline to Restore Pumping Plant to Normal

L. Switching Outline for Bypassing PCB _____

1. De-Energizing Procedures
2. Energizing Procedures

Chapter IV – Major Equipment and Systems

A. Unit Equipment

1. Pumps
2. Motors
3. Motor Switchgears
4. Nonsegregated-Phase Bus
5. Main Power Transformers
6. Butterfly Valves and Operating System
7. Pump Suction Tube Bulkhead Gates
8. Steel Manifold (Discharge)
9. Discharge Line
10. Discharge Line Drain
11. Sleeve Valve
12. Surge Tank

B. Outlet Structure

1. Description
2. Operation
3. Maintenance
4. Unwatering Canal through Discharge Line

C. Water Systems

1. Unwatering System, General
2. Unwatering Pump Casing and Suction Tube
3. Unwatering Plant Discharge Line and Manifold
4. Refilling Suction Tube, Pump Casing, and Casing Extension
5. Unit Cooling Water Systems

    a. General
    b. Cooling Water Motor Air Coolers
    c. Cooling Water Unit Guide and Thrust Bearings
    d. Pump Shaft Stuffing Box Water Supply
    e. Unit Cooling Water Requirements

6. Domestic and Service Water Systems

    a. General
    b. Operation and Maintenance
    c. Chlorinating Station
    d. Special Operating Instructions
    e. Emergency Fire Water Pump
    f. Backwashing Domestic Water Filter Beds

D. Oil Systems

1. Motor and Pump Bearing Lubricating Oil System
2. Lubricating Oil Service System

E. Compressed Air System

F. Fire Extinguishing Systems

1. Fire Protection Water System
2. Fixed Carbon Dioxide Fire Extinguishing Systems

    a. General
    b. Operation

3. Portable Fire Extinguishing Equipment

G. Miscellaneous Systems

1. Gravity Drainage
   a. Description
   b. Operation
   c. Maintenance

2. Sanitary Waste Sewage System
   a. Description
   b. Maintenance

H. Heating, Ventilating, and Air-Conditioning Systems

1. Description
2. Operation
3. Maintenance

I. Auxiliary Mechanical Equipment

1. Monorail Hoist
   a. Description
   b. Operation
   c. Maintenance

2. Traveling Crane
   a. Description
   b. Operation
   c. Maintenance

3. Pumping Plant Flowmeter

4. Trashrack
   a. Description
   b. Operation
   c. Maintenance

5. Trashrake
   a. Description
   b. Operation
   c. Maintenance
   d. Safety

Chapter VI – Pumping Plant Structure and Intake Channel

A. Pumping Plant Structure

1. General
2. Loading Data
3. Floor Finish Protection
4. Joints and Seals
5. Roof
6. Field Reports of Cracks
7. Slope Protection
8. Structural Behavior Instrumentation

B. Turnout from _____ Canal

C. Intake Channel

1. Description
2. Lining
3. Berm Drain and Drain Inlets
4. Pressure Irrigation and Other Crossings
5. Intake Channel Stoplogs

D. Drainage Systems

E. Oil Containment Structure

1. Description
2. Operation

Chapter VII — Canal

A. General Description of Canal

1. Canal System Operations[1]
2. Safety Ladders
3. Safety Cables

B. Canal Maintenance and Inspection

1. Inspection and Maintenance
2. Inspections Following Earthquakes

[1] This should include procedures for water operations, canal drawdown requirements, etc.

C. Canal Bridges and Operating Roads

1. Bridges
2. Bridge Maintenance
3. Operating Roads

D. O&M Instructions for Check Structures

1. General Description/Location
2. Radial Gates, Hoists, and Controls
3. Control House
4. Level Monitor

E. O&M Instructions for Turnout Structures

1. General Description/Location
2. Operation and Maintenance

F. Cross Drainage Features

1. General
2. Maintenance

G. Irrigation Crossing Features

H. Oil Line, Gas Line, and Other Utility Crossings

I. Road Crossings

J. Auxiliary Equipment

1. Trashracks
2. Stoplogs
3. Roadway Gates

K. Electrical System and Equipment

1. Electrical Service
2. Power and Control Boards
3. Grounding System
4. Engine-Generator Sets
5. Propeller Fan Motors

Appendix A – Pumping Plant Supporting Material

This appendix should include discharge and rating tables/curves, pump rating tables, canal storage tables, calibration curves, canal structures list, and pertinent diagrams, figures, schematics associated with the pumping plant and canal, etc.

Appendix B – Forms and Checklists

This appendix should include common forms and checklists that are used for reporting information about operations/maintenance for the pumping plant and canal.

Forms in the SOP generally include, but are not limited to "Telephone Report of Water and Power Interruptions and Facility Failure," daily operations report forms, sample pages of the Operating Log, inspection checklists, switching order forms, other data reporting forms, etc.

Appendix C – Reference Drawings

Include drawings relating to the pumping plant, canal, and appurtenant features. There is no need to include all design and specification drawings, as this would make the SOP too large with extraneous drawings.

Additional appendices may be added to meet the needs of the operating agency. These appendices may include aerial maps, rodent control plans, preventive maintenance sheets for the mechanical and electrical equipment at the pumping plant and the canal, etc.

Summary

Information in this article may be helpful whether developing a new pumping plant SOP or updating an existing pumping plant SOP as a complete republished document.

The following points should be considered when developing/revising an SOP:

- The SOP author(s)/users should use their best judgment when organizing the contents in each chapter.

- If available, information from the Designers' Operating Criteria or other operating documentation should be incorporated into the SOP instead of making a reference.

- Digital photographs of the pumping plant, canal, and appurtenant features, equipment, and controls for equipment operations can be beneficial and should be included in the SOP. The decision for placement of photographs in the document should be made by the (Reclamation) office having jurisdiction of the plant. Consider having the photographs included within the SOP section where the feature is discussed in the text. This can be done with word processing software.

- Applicable drawings should be included in the SOP as a means of providing additional information to supplement the text. Drawings that are referenced in the text of the SOP should be included if available. Consider including drawings in Appendix C of the SOP. A complete set of the construction drawings should not be included, but rather only drawings that represent the key features, mechanical equipment, installation, general electrical drawings, etc. Note that any drawings provided in the SOP are not to be used for construction purposes.

- Computers and word processing software now make it possible to embed digital photographs and other digital (tiff or jpeg) images into the document. Word processing software also makes it easier to update and maintain an SOP.

References

Standing Operating Procedures Guide for Dams, Reservoirs, and Power Facilities, dated August 1996, revised reprint June 2001.

Water Operation and Maintenance Bulletin No. 231, "Development of Standing Operating Procedures for Dams," U.S. Department of the Interior, Bureau of Reclamation, dated December 2012.

Water Operation and Maintenance Bulletin No. 232, "Development of Standing Operating Procedures for Canals," U.S. Department of the Interior, Bureau of Reclamation, dated March 2013.

DEVELOPMENT OF STAND-ALONE STANDING OPERATING PROCEDURES FOR A PUMPING-GENERATING PLANT

by: Charlie Swanson, P.E., Bureau of Reclamation, Technical Service Center, Instrumentation and Inspections Group, 86-68360

According to the Bureau of Reclamation's (Reclamation) Standing Operating Procedures Guide for Dams, Reservoirs, and Power Facilities (SOP Guide), the contents of a pumping-generating plant would be found in Chapter V, "Power Facility Operations." However, this article provides information about the organization and content of an SOP that was written as a stand-alone document for a pumping-generating plant. Reclamation requires SOPs only for high- and significant-hazard dams. Developing an SOP for a pumping-generating plant is not required, but can be developed at the discretion of the Regional Director.

The following chapters were used for an SOP for one of Reclamation's pumping-generating plants. The decision for including these particular chapters was made by Reclamation area and regional office personnel, the Technical Service Center (TSC) and operating entities, as applicable. This SOP was for a pumping-generating plant, and there were five chapters and related appendices as shown below.

Chapter I	General Information
Chapter II	General Operating Procedures
Chapter III	Unit Operating Instructions
Chapter IV	Major Equipment and Systems
Chapter V	Switchyard
Appendix A	Pumping-Generating Plant Supporting Material
Appendix B	Forms and Checklists
Appendix C	Reference Drawings

It should be noted that this article **excludes** the discussion of the Emergency Action Plan (EAP) and/or a Communications Directory, including related references and documentation.

The pumping-generating plant SOP should provide detailed information regarding operation and maintenance procedures for the associated equipment and systems. Also, sufficient information should be included for all sections in each SOP chapter. The SOP is often used by many other offices, including area and regional offices, operating entities (as applicable), and the TSC.

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- Preface
- Items of Special Importance
- Arc Flash Requirements — Information about arc flash requirements for the owner/operating entity were included as part of this SOP

The heading entitled “Emergency Procedures for Pumping-Generating Plant” can be included as part of the preliminary pages in the SOP to aid the user(s) in actions to be taken during an emergency event/occurrence at the pumping-generating plant. An example of the headings/subheadings of this section is as follows:

Emergency Procedures for Pumping-Generating Plant

A. Purpose

B. Line of Communication and Minimum Procedures

1. Personnel Involved in Reporting Emergencies
2. Minimum Procedures

C. General

D. Emergency Events

1. Flooding
2. Severe Storms
3. Earthquakes
4. Plant Fires
5. Power Outage
6. Loss of Communication Service
7. Abnormal Pump-Turbine Readings
8. Hazardous Material Spill
9. Accidents
10. Plant Evacuations

Chapter I – General Information

The section headings (A. through O.) in this chapter are similar to those used for a dam SOP and were included in the stand-alone pumping-generating plant SOP. The section headings shown in this article are provided for your consideration when developing the pumping-generating plant stand-alone SOP. Three sections were added to this chapter: "Training," "Safety Procedures," and "Protective Coatings."

A. Purpose of the Project

A table similar to the one shown below can be useful to summarize the engineering data at the facility.

Table I-1. Engineering Data for _________ Pumping-Generating Plant

<table>
<tr><td>Location</td><td>Approximately ___ miles (direction) of City, State
Latitude: ___° _____’ N
Longitude: ___° _____’ W</td></tr>
<tr><td>Construction period</td><td>Original construction period and any modifications</td></tr>
<tr><td colspan="2">Structure: Indoor type, ____ feet-long and ____ feet-wide. The building also houses the ___________. The substructure and immediate structure of the plant are constructed of reinforced concrete. The superstructure is made of mostly steel and brick siding.</td></tr>
<tr><td>Units</td><td><<i>number</i>>___, vertical shaft dual purpose pump-generators, Francis-type 120, 150, and 156 revolutions per minute (RPM)</td></tr>
<tr><td>Pump capacity, each</td><td>_____ ft^3/s at _____ feet of head (120 RPM)
_____ ft^3/s at _____ feet of head (150 RPM)
_____ ft^3/s at _____ feet of head (156 RPM)</td></tr>
<tr><td>Generator rating, each</td><td>_____ ft^3/s at _____ feet of head (120 RPM)
_____ kilovolt-amperes (120 RPM)
_____ kilovolt-amperes (150/156 RPM)</td></tr>
<tr><td>Motor rating, each</td><td>_____ horsepower (120 RPM)
_____ horsepower (150/156 RPM)</td></tr>
<tr><td colspan="2">Motor-Generators: Francis-type, 120- and 150-RPM two speed pump-turbines. Vertical-shaft, 3-phase, 60-cycle, 2-speed synchronous generator/motor consists of two machines rated as follows:</td></tr>
<tr><td colspan="2">Generator at 150/156 RPM (Units __, __, __, __, __,)
_____ kilovolt-amperes, zero power factor, overexcited
_____ kilovolt-amperes, zero power factor, underexcited
Units __ and __ are 156 RPM, all others are 150 RPM</td></tr>
</table>

Table I-1. Engineering Data for _________ Pumping-Generating Plant

Generator at 120 RPM (Units 1 through __) _____ kilovolt-amperes, zero power factor, overexcited _____ kilovolt-amperes, zero power factor, underexcited
Tunnels and penstocks: <*number*> ____, ______-foot diameter _______ tunnels are steel lined beginning at Station _____. Each steel liner bifurcates approximately _____ feet downstream (generating) to serve _____ pumping-generating units.
Inlet/outlet gates: <*number*> ____- by _____-foot with hydraulic hoists located at the outlet/inlet structure.
Transformers: <*number*>____, ___-kV to ___-kV, forced oil, forced air with atom-seal, delta-wye connected.
Switchyard: <*number*> _____, _____-type breakers rated at ____ kV.

B. Location and Access to the Pumping-Generating Plant

C. Assignment of Responsibility

D. Attendance, Communications, and Warning Systems

1. Attendance
2. Communications
3. Warning Systems

E. Cooperation with Other Agencies

F. Data Reporting

G. Operating Log

H. Public Safety and Health

I. Restricted Areas

J. Emergency Management and Facility Security Plans

K. Distribution of Standing Operating Procedures

L. Revisions to Standing Operating Procedures

M. Supporting Documents

N. Reference Material

O. Training

P. Safety Procedures

1. General
2. Procedures for Confined Spaced Entry
3. Procedures for Hazardous Materials Management

Q. Protective Coatings

1. Inspection
2. Maintenance

Chapter II – General Operating Procedures

A. Contacting Personnel

B. Relay Trip on Operating Units

C. Forebay Water Surface Elevations

D. Daily Inspection of Units in Operation

E. Inspections

F. Work Orders

Chapter III – Unit Operating Instructions

A. General (Local Manual Mode)

1. Initial Conditions
2. Ready-To-Start Condition
3. Unit Auxiliary Logic
4. Master Start/Stop Sequencing
5. Unit Creeping Annunciation

B. Local Automatic Mode

1. Generate-Hydraulic Start
2. Pump, Full-Voltage, and Electric Start
3. Normal Unit Stop
4. Normal Unit Stop at Unit Control Board

C. Supervisory Mode (by others)

D. Emergency Operations

Chapter IV – Major Equipment and Systems

A. Unit Equipment

1. Pump-Turbines
2. Motor-Generators
3. Excitation System
4. Motor-Generator Switchgear
5. Power Transformers
6. Speed Selection Switches
7. Phase Reversal Switches
8. Penstocks and Suction-Draft Tubes
    a. Description
    b. Steel Penstock and Liner Filling Procedure
    c. Unwatering Procedure
    d. Maintenance
9. Butterfly Valves and Controls
    a. Description
    b. Operation
    c. Maintenance
    d. Testing
10. Bulkhead Gates
    a. Outlet/Inlet Structure Bulkhead Gate
    b. Suction-Draft Tube Bulkhead Gates

B. Inlet/Outlet Gates

1. Description
2. Operation
3. Maintenance
4. Testing

C. Water Systems

1. Unwatering System
    a. Description
    b. Operation
    c. Maintenance
2. Cooling Water Systems
    a. Description
    b. Operation
    c. Maintenance

3. Service Water System
    a. Description
    b. Operation
    c. Maintenance

4. Domestic Water System
    a. Description
    b. Operation
    c. Maintenance

D. Oil Systems

1. Lubricating Oil System
2. Transformer Insulating Oil System
3. Transformer Oil Spill Containment System
4. Sump Oil Removal System

E. Air Systems

1. Compressed Air Systems
    a. Description
    b. Operation
    c. Maintenance

2. Tail Water Depressing System

F. Fire Extinguishing Systems

1. Fire Extinguishing Systems
    a. Description
    b. Operation
    c. Maintenance

2. Fixed Carbon Dioxide Fire Extinguishing Systems
    a. Description
    b. Operation
    c. Maintenance

3. Portable Fire Extinguishing Equipment
    a. Description
    b. Operation
    c. Maintenance

G. Miscellaneous Systems

1. Gravity Drainage and Air Vent Systems

   a. Description
   b. Operation
   c. Maintenance

2. Sanitary Waste Sewage System

   a. Description
   b. Operation
   c. Maintenance

H. Heating, Ventilating, and Air-Conditioning Systems

1. Heating, Ventilating, and Air Conditioning Systems for Pumping-Generating Plant

   a. Description
   b. Operation
   c. Maintenance
   d. Inspection
   e. Isolation

I. Auxiliary Mechanical Equipment

1. Trashracks

   a. Description
   b. Operation
   c. Maintenance

2. Overhead Traveling Cranes

   a. Description
   b. Operation
   c. Maintenance

3. Gantry Cranes

   a. Description
   b. Operation
   c. Maintenance

4. Elevators

   a. Description
   b. Operation
   c. Maintenance
   d. Isolation

5. Engine Generator Set

   a. Description
   b. Operation
   c. Maintenance

6. Flowmeters

   a. Description
   b. Operation
   c. Maintenance

7. Machine Shop Equipment

   a. Description
   b. Operation
   c. Maintenance

8. Life Safety Equipment

   a. Description
   b. Operation
   c. Maintenance

J. Plant Control and Protection Systems

1. Unit Control System
2 Protective Relay Provisions
3. Annunciators and Sequential Recorder

K. Auxiliary Electrical Systems and Equipment

1. AC Station Service System
2. DC Station Service System
3. Plant Alarms
4. Lighting Systems
5. Reservoir Elevation Measurement System

Chapter V – Switchyard

A. General Description

B. Major Equipment and Auxiliary Systems

1. Power Circuit Breakers

   a. Description
   b. Designations and Ratings
   c. Alarms
   d. Testing and Maintenance

2. Disconnect Switches

   a. Description
   b. Designations
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

3. Disconnect Switches with Grounding Switches

   a. Description
   b. Designations and Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

4. Potential Transformers

   a. Description
   b. Designations and Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

5. Current Transformers

   a. Description
   b. Designations and Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

6. Lightning Arresters

   a. Description
   b. Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

7. Coupling Capacitor Voltage Transformers

   a. Description
   b. Designations and Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

8. Carrier Line Traps

   a. Description
   b. Designations and Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

9. Station Service Transformer

   a. Description
   b. Ratings
   c. Alarms
   d. Testing and Maintenance
   e. Clearance Procedures

10. Control Building Equipment

   a. Description
   b Equipment
   c. Heating and Ventilating Systems
   d. Alarms
   e. Testing and Maintenance
   f. Clearance Procedures

C. Control, Metering, Protection, and Annunciation Equipment

1. General Description

2. Control and Indication Equipment

   a. Control Equipment
   b. Lamps
   c. Alarms

3. Protective Relaying Systems

   a. Transmission Line and Transfer Breaker Protective Relaying
   b. Bus Differential Protective Relaying
   c. Transformer Circuits Protective Relaying
   d. Switchyard Backup Protective Relaying
   e. Testing and Maintenance
   f. References

4. Annunciation System

   a. Description
   b. Ratings
   c. Alarms
   d. Testing and Maintenance

D. Operations

1. Normal Operations
2. Emergency Operations
3. Maintenance

E. Inspections

1. Introduction

2. Inspection of Switchyard Control Building

   a. Transmission Line Carrier Test, Switchyard to Substation
   b. Inspection – Control Board ____, Front
   c. Inspection – Control Board ____, Rear
   d. Inspection – Control Board ____, Interior
   e. Inspection – Control Board ____
   f. Inspection – Transformer ______
   g. Inspection – Heating & Ventilating System

3. Inspection of Circuit Breakers

   a. Exterior
   b. Control Cabinet

4. Inspection of Line Potential Devices with Carrier Output and Main-Bus Potential Devices

5. Inspection of Disconnect Switches

6. Inspection of High-Line Fittings and Buswork

Appendix A – Pumping-Generating Plant Supporting Material

This appendix should include discharge and rating tables/curves, pumping/generating rating tables, tables of bus and switchyard relays, transformer relays, distribution boards and service gear relays, and pertinent diagrams, figures, and schematics associated with the pumping-generating plant, etc.

Appendix B – Forms and Checklists

This appendix should include common forms and checklists that are used for reporting information about operations/maintenance for the pumping-generating plant.

Forms in the SOP generally include, but are not limited to "Telephone Report of Water and Power Interruptions and Facility Failure," daily operations report forms, sample pages of the Operating Log, checklists, preventive maintenance summary reports, unit data log sheets, etc.

Appendix C – Reference Drawings

Include drawings relating to the pumping-generating plant and appurtenant features. There is no need to include all design and specification drawings, as this would make the SOP too large with extraneous drawings.

Additional appendices may be added to meet the needs of the operating agency. Additional appendices may include aerial maps, rodent control plans, unit rating tables, etc.

Summary

Information in this article may be helpful whether developing a new pumping-generating plant SOP or updating an existing pumping-generating plant SOP as a complete republished document.

The following points should be considered when developing/revising an SOP:

- The SOP author(s)/users should use their best judgment when organizing the contents in each chapter.

- If available, information from the Designers' Operating Criteria or other operating documentation should be incorporated into the SOP instead of making a reference.

- Digital photographs of the pumping-generating plant and appurtenant features, equipment, and controls for equipment operations can be beneficial and should be included in the SOP. The decision for placement of photographs in the document should be made by the (Reclamation) office having jurisdiction of the plant. Consider having the photographs included within the SOP section where the feature is discussed in the text. This can be done with word processing software.

- Applicable drawings should be included in the SOP as a means of providing additional information to supplement the text. Drawings that are referenced in the text of the SOP should be included if available. Consider including drawings in Appendix C of the SOP. A complete set of the construction drawings should not be included, but rather only drawings that represent the key features, mechanical equipment, installation, general electrical drawings, etc. Note that any drawings provided in the SOP are not to be used for construction purposes.

- Computers and word processing software now make it possible to embed digital photographs and other digital (tiff or jpeg) images into the document. Word processing software also makes it easier to update and maintain an SOP.

References

Standing Operating Procedures Guide for Dams, Reservoirs, and Power Facilities, dated August 1996, revised reprint June 2001.

SPILL PREVENTION AND COUNTERMEASURE – ARE YOU PREPARED?

by: Joseph Bullough, Mechanical Engineer, Bureau of Reclamation, Engineering Services Group, Salt Lake City, Utah, UC-214

Background

The Spill Prevention Control and Countermeasure (SPCC) program in the Upper Colorado Region is required by 40 CFR (Code of Federal Regulations) Part 112. This section of the CFR requires that all facilities that possess an aggregate aboveground storage capacity of at least 1,320 gallons of petroleum products, which could reasonably be expected to reach the navigable waters of the United States or adjoining shorelines, prepare and implement an SPCC plan at their facility. This section of the CFR is implemented by the United States Environmental Protection Agency.

The SPCC plan is a written document that describes the measures that must be taken to prevent, contain, and clean up oil spills. The term “oil” is comprehensive and includes gasoline, diesel, heating oil, and solvents. The SPCC definition of oil also includes nonpetroleum products such as vegetable and animal oils, but Bureau of Reclamation (Reclamation) facilities deal strictly with petroleum products. The term “oil” is used throughout this article to denote petroleum products covered by the SPCC plan. The SPCC plan must spell out operating procedures aimed at preventing oil spills, control measures in place to prevent a spill from affecting the surrounding environment, and a plan for cleaning up and restoring damage caused by a spill. The SPCC plan must be signed by a professional engineer (PE) who certifies that the plan meets all the requirements contained in 40 CFR Part 112.

Storage capacity includes the capacity of all containers such as tanks, portable tanks, transformers, 55-gallon drums, etc. The capacity of any empty containers that may be used to store oil and are not permanently taken out of service are also counted in a facility’s total storage capacity (i.e., storage tanks used during the transfer of oil). Regulations apply regardless of whether the tanks are full or nearly empty.

The SPCC plan can be created by management or staff of a facility, but the plan must be reviewed and approved by a PE. Fines for not complying with SPCC requirements may reach $25,000 per day, and violations can involve failure to provide proper training, failure to report a spill, or failure to draft a certified plan.

SPCC Program in the Upper Colorado Region

Reclamation's Upper Colorado Region includes eight facilities for which an SPCC plan is maintained: Fontenelle (Wyoming), Flaming Gorge and Deer Creek (Utah), Blue Mesa, Morrow Point, and Crystal (Colorado), Elephant Butte/Caballo (New Mexico), and Glen Canyon (Arizona). The plans are reviewed on a 5-year cycle.

Although there is no official format or template for an SPCC plan, all plans generally contain the same information: a description of the facility, a list of oil-containing equipment and quantities present, spill scenarios and containment/clean up procedures to be followed, contact information to be used for reporting the spill, and a list of equipment and supplies available for containment and cleanup.

Spill Containment

Containment around equipment containing oil varies with the type and location of the equipment. When equipment is located indoors, containment may be in the form of concrete berms (figure 1) or locating the equipment in a recessed location. Large oil storage tanks are commonly located at a lower level than the surrounding area.

Figure 1.—Secondary containment around oil-containing equipment at Deer Creek Powerplant, Utah.

When oil-containing equipment is located in an outdoor area, a variety of methods are used to prevent oil spills or to contain spilled oil. Areas of oil-containing equipment, such as transformers, may be located in a secured area (figure 2). When equipment is located near water, such as a transformer deck, a berm may be placed around the area (figure 3). The berm is sized such that it is sufficiently large enough to contain the largest quantity of oil contained in the area, plus additional volume to accommodate storm water, which may have accumulated.

Figure 2.—Power transformer pad at Crystal Powerplant, Colorado.

Oil-containing equipment, such as fuel storage tanks, may be located in a recessed area that does not contain any paths to water (figure 4). Fuel storage tanks may also be placed in containment bins (figure 5).

A spare transformer at the Curecanti Field Division in Colorado is contained within a concrete containment berm (figure 6). The berm includes a drain for storm water, which is filled with Imbiber Beads®, small plastic beads in the throat of the drain. The beads allow storm water to drain out of the containment area, but upon contact with oil, the beads swell and block the drain, preventing flow of oil out of the containment area.

Figure 3.—Containment area around transformers at Blue Mesa Powerplant, Colorado.

Figure 4.—Fuel storage tank for backup generator at Blue Mesa Powerplant, Colorado. The tank is located in a low area, which serves as secondary containment, away from any direct path to open water.

Figure 5.—Fuel storage tanks at Fontenelle Powerplant, Wyoming. The tanks are located away from any channels leading to water, and secondary containment is provided by the containment bins in which the tanks are placed.

Figure 6.—Spare transformer located at the Curecanti Field Division, Colorado. Secondary containment is provided by a concrete wall around the transformer. Imbiber Beads® allow drainage of storm water, but swell upon contact with oil and prevent flow of oil out of the containment area.

Various other berms may be used to contain oil in the event of a spill and prevent flow into surrounding areas. A containment berm in front of a doorway at Fontenelle Powerplant, Wyoming, is shown on figure 7.

Figure 7.—A containment berm at Fontenelle Powerplant, Wyoming. The berm provides containment of oil, which in the event of a spill would otherwise flow under the door.

Notification of an Oil Spill Incident

In the event of an oil spill incident, the SPCC plan lists the contacts that must be made and the corresponding phone numbers. These contacts include the National Response Center, the facility manager, the Regional Dam Safety Emergency 24-Hour Duty Officer, and the Regional Oil Spill Coordinator.

Materials and Equipment for Clean-up

In the event of a spill incident, the materials and equipment available for cleanup varies slightly depending on the facility, but in general includes the same items. Each SPCC plan includes a list of all materials and equipment available for cleanup of oil spills. Oil-absorbent booms and various types of trucks and boats are available at all powerplants.

OBERMEYER GATE INSTALLATION AT BOISE RIVER DIVERSION DAM

by: Ernest Bachman, P.E., Mechanical Engineer, Middle Snake Field Office, Boise, Idaho, MSFO-3108 and Brian Sauer, P.E., Water Operations Manager, Middle Snake Field Office, Boise, Idaho, MSFO-6200

Boise River Diversion Dam Operations

The Boise River Diversion Dam, on the Boise River about 7 miles southeast of Boise, Idaho, is a rubble-concrete, weir-type structure with a hydraulic height of 39 feet. The dam diverts up to 2,800 cubic feet per second (cfs) into the New York Canal through eight motor-operated slide gates. The ogee spillway crest is 216 feet (ft) long with a capacity of 40,000 cfs. The dam was also constructed with a 30-ft wide logway adjacent to the spillway, which is controlled by an 8 x 30-ft roller gate. The forebay elevation at the dam was designed to be regulated with 4-inch x 6-inch x 7-ft 6-inch flashboards supported by vertical steel supports on the top of the spillway. There are nine 23-ft bays separated by concrete piers, and each bay has three sections of flashboards separated by steel supports. The flashboards are manually installed and removed from the deck of the access bridge 15 feet above the spillway crest.

Figure 1.—Boise River Diversion Dam prior to installation of the pneumatic gates, showing the spillway and power house. New York Canal can be seen in the background.

Upstream of the Boise River Diversion Dam there are three storage reservoirs, including Anderson Ranch, Arrowrock, and Lucky Peak Dams, which are operated for both water supply and flood control. Late winter and spring releases can vary greatly depending upon reservoir contents and snowpack conditions. Flows passing the diversion dam can vary from as little as 250 cfs to over 7,000 cfs. Since the dam must provide sufficient water elevations upstream of the dam to maintain diversions into the New York Canal over the full range of flows that pass the dam, the flashboards can be added or removed from the dam crest to regulate upstream water levels.

The three original generators at the diversion dam produced a total output of 1,500 kilowatts. These units were used until 1982 when they were taken out of service due to high maintenance costs. In 2004, the units were replaced with three new 1-megawatt units and put back into regular use. These units operate primarily during the irrigation season, typically from April through mid-October, and during spring flood control operations. At the end of the irrigation season, riverflows are reduced to winter minimums of 250 cfs to begin storing water for the next season. These flows are insufficient to operate any of the generators, and flows are passed through sluice gates at the bottom of the dam.

Depending upon reservoir system contents and snowpack levels, flood control operations may begin as early as January, increasing riverflows. If flows are sufficient, generators at the dam may be operated. However, care must be taken not to install too many flashboards on the crest of the dam. If flood operations require flow increases, it is difficult and potentially dangerous to remove flashboards. And, if forebay levels increase too high, power production at the larger powerplant at Lucky Peak Dam, located 2.5 miles upstream, is affected. Even worse, if the diversion dam forebay elevations get too high, it can force water into the powerhouse.

Due to the difficulty of controlling the forebay elevations at the diversion dam with flashboards, the powerplant seldom ran at the highest efficiency levels during the winter and spring. Efficiency had to be sacrificed to ensure that floodflows could be moved safely past the dam.

Boise River Diversion Dam Modifications

In 2009, the Bureau of Reclamation (Reclamation) began plans to improve control of the diversion dam forebay elevations. Several factors were considered in the preliminary design phase:

- Boise River Diversion Dam is on the National Register of Historic Places, so modifications to the facility needed to be minimized.

- While better water level control would improve power production at the facility, funding for the project was limited because of the relatively small size of the facility and the limited generation period.

- Control gates would be 23 ft wide to fit the spaces between the concrete piers on the dam crest.

- The construction period needed to be limited to the period between the end of the irrigation season and the beginning of any flood control releases. Flows higher than the 250-cfs winter minimum would begin to limit construction access and create potential safety issues. Also, only about 1,500 cfs can pass through the sluice gates at the bottom of the dam without raising the upstream water levels to the spillway crest.

It was feasible to install standard radial gates between the piers. However, this would have required removal of the bridge over the spillway, which is also the primary pedestrian access to the powerhouse. Also, the right abutment of the dam is adjacent to the Boise River Greenbelt, a popular recreational corridor, and there were security concerns over potential vandalism of radial gate operators. After evaluating various options, Reclamation designers determined that the most cost-effective replacement for flashboards would be some type of pneumatic gate. Installation of these devices would not require a great deal of modification to the existing structure and could be installed during a relatively short time, and with pneumatic gates, most of the critical operating equipment could be installed inside the existing powerhouse building.

A cost/benefit analysis was made to determine how many gates would be affordable. The installation of five 23-ft gates would eliminate any future flashboard adjustments, while installing three gates would eliminate these manual adjustments approximately 90 percent of the time. Reclamation engineers looked for gates that would fit the existing bays, potential routes for air lines, where the air compressor and control components could be located inside the existing powerplant, and how to interface a gate control system with the Supervisory Control and Data Acquisition (SCADA) system already in place for the facility.

Additionally, designers evaluated how to best anchor inflatable gates on top of the existing spillway, ultimately deciding upon saw-cutting the top 8 inches of the original ogee crest to reach solid concrete and allow sufficient room for the installation. Also, designers looked at demolition of the existing steel flashboard support, construction access, and potential contingencies in the event that flood control releases would be required during the construction period. Because of historical considerations, the horizontal steel member of the flashboard support was to be left in place across the bays to be modified to preserve the downstream appearance of the dam as much as possible. In the end, funding constraints limited the project to installing three 23-ft Obermeyer pneumatic gates. Because of scheduling challenges, a decision was made to purchase the design and materials for the three gates directly from Obermeyer, and then do a Government supply of these materials to the installing contractor, a local company from the Boise area.

Onsite work on the project commenced on November 1, 2011, and was substantially completed before the end of February 2012. Prior to the start of construction, the contractor was required by the contract to design and build bulkheads that could be installed upstream of the work bays on a 3-day notice in the event that it was necessary to make releases from upstream reservoirs for flood control. These bulkheads were built, but fortunately, they were not required. Flood control releases did, however, begin shortly after the construction was completed.

Construction phases included:

- Mobilization, including reopening an existing roadway down into the riverbed upstream of the dam, placement of scaffolding, and fall protection around the construction site.

- Removal of existing vertical steel flashboard supports in the three bays.

- Saw-cutting and removal of 8 inches of concrete from the top of the dam crest in the three areas.

- Drilling and placement of air lines and conduit through the three bays.

- Forming and placing a new concrete crest and anchors for new gates in the three bays.

- Installing the new Obermeyer inflatable gates in each bay under the supervision of an Obermeyer installation engineer. Each gate consists of two steel panels, each approximately 11 feet long, and 5 feet elevation in the raised position, connected by a reinforced polyester inter panel seal, supported by two pneumatic bladders, and pivoting on rubber hinges bolted to the panels. The end seals consist of reinforced polyester flat seals, which contact stainless steel abutment plates.

- Placement of the air compressor and control box in the powerplant and routing of air lines from the gates into the plant.

- Initially testing of the gates in the dry condition.

- Demobilization of the construction site.

- Final testing of the gates under watered-up conditions.

The transfer inspection for the project took place on March 15, 2012, after the diversion dam forebay was filled to create a full head of water on the gates for final testing. See the figures below for illustrations of construction and installation.

Figure 2.—Boise River Diversion Dam during the Obermeyer gate installation. Wooden safety rail has been placed at the worksite. Workers are removing original steel flashboard guides where the gates will be placed. Installed flashboards can be seen at far left.

Figure 3.—Horizontal cable saw used to cut off the top of the original ogee spillway crest at Boise River Diversion Dam.

Figure 4.—Pre-placement of concrete crest, showing re-bar, stainless steel air lines, and forming slots for bladder restraining straps.

Figure 5.—Placement of concrete crest, imbedding the air lines.

Figure 6.—New crest in place and stainless steel abutment plate being grouted in at rear of photo.

Figure 7.—Gate panels in place. Note, from left to right, the anchor clamp castings, with two anchor bolts each, the rubber hinge, and two steel gate panels, connected by a reinforced polyester inter-panel seal, and the stainless steel abutment plate and polyester seal in the rear. Note also the vertical air lines behind abutment plate, which supply air to the gate bladders.

Rather than having automatic forebay control, the Obermeyer gates at the diversion dam are operated via remote control from Reclamation's Southern Idaho Control Center, which is staffed around the clock. This SCADA system already enabled operators to remotely operate the generators and other gates at the diversion dam. The SCADA local control system is tied directly to the pneumatic operator, and there are inclinometer position indicators on each gate, which provide a feedback signal to the SCADA, so the operators can track position as they make changes. Gate discharge curves have been developed to assist the operators, but the bottom line is to pass required flows while holding the target forebay elevation. The 8 x 30-ft roller gate is used as a bypass for the generator units if they trip off-line, and the Obermeyer gates pass any flows above the powerplant discharge.

Figure 8.—Pneumatic control system for the Obermeyer gates, including the compressor and air receiver in rear, control cabinet, and stainless steel air piping, which is connected to the air bladders under the gates.

The gates operated smoothly throughout the 2012 irrigation season. In April and May, hot weather and heavy rain in the Boise River Basin required large releases from upstream reservoirs, raising flows through Boise above the 7,000-cfs flood stage. Had this event happened prior to the installation of the new overshot gates, dam operators would have needed to manually remove flashboards under high flow conditions in order to avoid extreme forebay elevations, which could potentially force water into the powerplant, shutting it down. However, with the newly installed gates on the dam crest, sufficient water was released over the fully lowered gates, and the generators ran throughout the high-water event without removing any flashboards.

Based upon the power production during 2012, the improved control of the upstream water levels provided by the gates should help optimize powerplant operations. In the spring, when flows passing the dam exceed powerplant capacity, a more consistent head elevation can be maintained over a wide range of flows. Plant operators are now able to raise the forebay elevations to maximize power without concerns of having to remove flashboards should flow later increase. Also, when downstream irrigation demands change and lower flows pass over the dam, plant operators can easily raise the Obermeyer gates, wasting less water over the spillway and passing more through the hydro units. Additionally, the larger Lucky Peak Powerplant, 3 miles upstream, will be subjected to fewer tailwater fluctuations and fewer fluctuations in power production.

The performance of the gates has been very good, providing the control center operators push button control of the reservoir levels, helping stabilize the forebay upstream of the New York Canal and Boise Diversion Powerplant. The gates were relatively easy to install, required minimal changes to the structure of the dam and the overall historical appearance, and required just one off-season between irrigation seasons to install. The contractual process of purchasing the gates directly from Obermeyer and then supplying to the installation contractor worked well in this case because of the limited installation window. This allowed sufficient time to adapt the Obermeyer design to the facility and helped streamline the work once the installation award was made. So far, maintenance of the gates has been limited to one off season at the end of the 2012 irrigation season, but has been relatively straightforward. The primary maintenance activity was to check the torques on all fasteners, including anchors, hold down straps, and hinge and side seal fasteners, and to perform standard air equipment maintenance. The limited number of moving parts on the gates and operators is a real plus. The area office is pleased with the overall product and would recommend consideration of this type of system for other Reclamation or district projects.

Figure 9.—Back side of gates, showing the gate bladders and restraining straps. In this photo, Government crews are checking bolt torques during the first maintenance season.

Figure 10.—Boise River discharge over Obermeyer gates 2 and 3, with the gate at the far right in the fully raised position. When the gates are fully raised, the leakage past the seals is drop-tight. The installed flashboards can be seen on the far left in bay 4.

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The purpose of this bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful operation and maintenance ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin—let us hear from you soon!

Prospective articles should be submitted to one of the Bureau of Reclamation contacts listed below:

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