

**FACILITIES INSTRUCTIONS,
STANDARDS, AND TECHNIQUES
VOLUME 1-12**

**ABNORMAL OPERATIONS
GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**



MARCH 2003



**UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION**

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suit 1204, Arlington VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Report (0704-0188), Washington DC 20503.				
1. AGENCY USE ONLY (Leave Blank)		2. REPORT DATE	3. REPORT TYPE AND DATES COVERED Final	
4. TITLE AND SUBTITLE FIST 1-12, Abnormal Operations Generic Technical Guidelines for Power Stations			5. FUNDING NUMBERS	
6. AUTHOR(S) Gary McDermott, Bill Parks, John Snead, Mitch Samuelian				
7. PERFORMING ORGANIZATIONS NAME(S) AND ADDRESS(ES) Bureau of Reclamation Denver Federal Center PO Box 25007 Denver CO 80225-0007			8. PERFORMING ORGANIZATION REPORT NUMBER FIST 1-12	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Power Resources Office Office of Policy Bureau of Reclamation Mail Code D-5400 PO Box 25007 Denver CO 80225			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Available from the National Technical Information Service, Operations Division, 5285 Port Royal Road, Springfield, VA 22161			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) FIST 1-12 has been prepared to provide a generic technical guideline for Reclamation facilities to develop a site-specific set of abnormal operating procedures, which will become a section in the facility Standing Operating Procedures. Sites will be required to use this manual as a template to develop their own Site-Specific Abnormal Operations procedures. Remotely operated facilities will be required to share copies of their procedures with their control center.				
14. SUBJECT TERMS			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UL	18. SECURITY CLASSIFICATION OF THIS PAGE UL	19. SECURITY CLASSIFICATION OF ABSTRACT UL	20. LIMITATION OF ABSTRACT UL	

**FACILITIES INSTRUCTIONS,
STANDARDS, AND TECHNIQUES
VOLUME 1-12**

**ANORMAL OPERATIONS
GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

**OFFICE OF POLICY
POWER RESOURCES OFFICE**

**UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION**

MARCH 2003

PREFACE

This document presents technical guidelines for the development of abnormal operating procedures for powerplants owned and operated by the Bureau of Reclamation. These technical guidelines are designed to assist Regional staff in the development of their own site-specific Abnormal Operating Procedures. These procedures will be a supplement to the Standing Operating Procedures for each facility.

These guidelines were developed by power maintenance, operations, and management personnel from Reclamation's Denver, Regional, and Area Offices.

For more information on these technical guidelines, please contact Mitchell Samuelian at the Power Resources Office, D-5400, 303-445-3712.

DISCLAIMER

This written matter consists of general information for internal Bureau of Reclamation operations and maintenance staff use. The information contained in this document regarding commercial products or firms may not be used for advertising or promotional purposes and is not to be construed as an endorsement of any product or firm by the Bureau of Reclamation.

CONTENTS

	<i>Page</i>
1.0 Introduction	1
1.1 Purpose and Scope	1
2.0 General Guidelines	2
2.1 Standing Operating Procedures	2
2.2 Safety of Personnel.....	2
2.3 Use of Equipment Under Abnormal Conditions	2
2.4 Reduction in Plant Capacity	3
2.5 Reduction in Plant Generation	3
2.6 Control Center Operations	4
2.7 Reporting Abnormal Conditions	4
3.0 Operator Training Program	5
3.1 Initial Training.....	5
3.2 Annual Refresher Discussion.....	5
3.3 Review of Training Program.....	6
3.4 Documentation of Training	6
4.0 Facility Abnormal Operations	6
4.1 Flooding in the Facility	6
4.2 Loss of Station Service.....	6
4.3 Loss of Plant DC Control and Protection.....	9
4.4 Loss of Plant Control AC/Uninterruptible Power Supply/Inverter.....	9
4.5 Loss of Air Systems	10
5.0 Abnormal Operations of Generator and Transformer Breakers.....	11
5.1 Generator and Transformer Breaker Abnormal Operations.....	11
6.0 Abnormal Operation of Main Generators	13
6.1 Plant Running Isolated (Not Connected to Grid)	13
6.2 Carbon Dioxide (CO ₂) Discharge	13
6.3 Differential or Ground Relay Operation	14
6.4 Overcurrent Relay Operation	14
6.5 Overvoltage Relay Operation.....	15
6.6 Loss of Generator Field.....	15
6.7 Abnormal Operation of the Voltage Regulator	15
6.8 Stator Winding High Temperature.....	16
6.9 Main Field Winding High Temperature (If Applicable).....	16
7.0 Abnormal Operations of Unit Auxiliary Equipment.....	17
7.1 Generator-Bearing Temperature Alarm or Shutdown Relay Operation.....	17
7.2 High or Low Thrust-Bearing Oil Level Alarm	18

CONTENTS (CONTINUED)

	<i>Page</i>
7.0 Abnormal Operations of Unit Auxiliary Equipment (continued)	
7.3 Generator Air-Cooling Water Alarm	19
7.4 Thrust-Bearing Cooling Water Alarm.....	19
7.5 Turbine-Bearing Temperature Alarm or Shutdown Relay Operation.....	20
7.6 Loss of Water Supply to Packing Gland	21
7.7 Loss of Turbine Seal Lubricating Water	21
7.8 Failure of Turbine/Generator-Bearing Oil Pumps	21
8.0 Abnormal Operation of Main Governor.....	22
8.1 Loss of Permanent Magnet Generator (PMG)/Speed Signal Generator (SSG).....	22
8.2 Abnormal Operation of Governor	23
8.3 Loss of the Restoring Cable (Mechanical Governor).....	24
8.4 Loss of Gate Position Indication (Digital Governor).....	25
8.5 Low Governor Oil Pressure Alarm and Shutdown Relay Operation.....	25
8.6 Overspeed or Runaway	26
9.0 Abnormal Operation of Main Turbine	27
9.1 Turbine Pit High Water	27
9.2 Failure of Gate Shear Pin	27
9.3 Unusual Mechanical Noise or Vibration.....	28
10.0 Abnormal Operation of Main Transformers	28
10.1 Transformer Differential-Relay Operation.....	28
10.2 Transformer High Temperature Alarm or Shutdown Relay Operation.....	29
10.3 Transformer Oil Flow Failure	29
10.4 Sudden Pressure Relay	30
10.5 Transformer Oil and Gas Alarm.....	31
10.6 Low Oil Pressure/Level for Transformers with Conservator Tank.....	31
11.0 Pre-Fire Plan.....	32
11.1 Purpose.....	32
11.2 Objective	32
11.3 Procedure.....	33

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

1.0 INTRODUCTION

1.1 Purpose and Scope

- A. Historically, Reclamation has had effective Emergency Operating Procedures (EOPs) to deal with facility emergencies. EOPs are normally developed to guide operations during large catastrophic events that pose a hazard to facility personnel and the public downstream from Reclamation facilities. In general, these EOPs were not intended to handle small, abnormal events. Incidents in the last few years have identified the need for procedures governing operations during abnormal events.
- B. Abnormal events are not emergencies by definition. However, the consequences of not dealing with these events in a systematic manner could further complicate the event, cause damage to plant equipment, loss of generation, and possible plant personnel injury.
- C. Facilities Instructions, Standards, and Techniques (FIST) 1-12 has been prepared to provide a generic technical guideline for Reclamation facilities to use in developing a site-specific set of abnormal operating procedures. These procedures will become a section in the facility Standard Operating Procedures (SOPs).
- D. The manual is broken into three parts:
 - 1) General guidelines
 - 2) Operator training
 - 3) Generic technical guidelines for operating under abnormal conditions
- E. In this manual, the term *Operator* is used to describe all personnel with operational duties at the associated facility.
- F. This manual additionally identifies Operator initial and refresher training for abnormal events. The manual contains the required educational program for training operating personnel to function more effectively during abnormal operating conditions. Abnormal conditions usually occur without advance warning, and, typically, remedial action must be taken. A continuing educational program provides Operators with the knowledge to act promptly and effectively when the unexpected occurs and decisions have to be made as to what should be done.
- G. The purpose of the educational program is to develop a more capable and alert operating organization that can function effectively under abnormal or emergency conditions with minimum delay and with the expectation that correct remedial action will be taken.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- H. While these operating procedures have been developed for the information and guidance of operating personnel in handling abnormal conditions, they do not cover all abnormal conditions or combinations of conditions that may occur. A thorough understanding of the function and operation of all powerplant equipment by operating personnel will be especially valuable when emergencies occur without established SOPs.

2.0 GENERAL GUIDELINES

2.1 Standing Operating Procedures

- A. Detailed operating procedures for most abnormal conditions associated with powerplant generating and transmission equipment are contained in the abnormal operations generic technical guidelines section of this manual.
- B. However, there are a number of basic principles governing the steps to be taken that apply to all abnormal operating conditions. These principles, outlined in the following paragraphs, should be thoroughly understood by all operating personnel.

2.2 Safety of Personnel

- A. Abnormal operating conditions do not usually involve hazards to plant personnel unless inspection or maintenance work is performed on operating equipment. The Operator must always be informed when such work is being done. If an abnormal or emergency condition develops while performing work on the equipment, the Operator must be sure that all personnel are in the clear before taking any action toward restoring the equipment to normal. If correction of the abnormal condition requires work performed by maintenance personnel, the Operator must be sure that the equipment is safe to work on and any necessary clearance issued before beginning. Where abnormal operating conditions involve hazards to personnel, their safety must receive top priority in any remedial action taken by the Operator.

2.3 Use of Equipment Under Abnormal Conditions

- A. Occasionally, abnormal conditions of a minor nature may develop in operating equipment and necessitate its removal from service.
- B. If alternate equipment is available, the abnormal equipment should be shut down until the conditions can be corrected. If alternate equipment is not available and if continued operation is essential to meet load schedules or contractual obligations, the abnormal equipment may be used, provided no damage would result.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- C. If possible, approval of the Facility Manager or Operations Head should be obtained before equipment is used under abnormal conditions.

2.4 Reduction in Plant Capacity

- A. One of the chief advantages of hydro generating units is their ability to make fast load changes. Hydro units can be loaded to full capacity within minutes even when they are shut down. For this reason, units on standby provide valuable reserve capacity to meet system emergencies caused by loss of generating units at other plants.
- B. To make full use of this ability to pick up load quickly, the full plant capacity must be available for immediate use at all times, except during maintenance outages. Abnormal conditions, which reduce the plant capacity even if the capacity is not being used or scheduled, should be corrected to restore the plant to full capacity as soon as possible.

2.5 Reduction in Plant Generation

- A. Hydropower plants are expected to supply their part of the system load as scheduled by the system dispatcher. Availability of system loads often cannot be accurately forecast to meet unexpected load demands. Any failure of the plant to meet its load demand or schedule may disrupt the system and result in unexpected load demands on other system units.
- B. When relatively large blocks of generation are suddenly lost, as when a loaded unit is tripped by relay action, abnormal conditions are created in the system that may upset tie line load schedules and overload transmission lines or other generators.
- C. If generation loss is greater than the system can absorb without overloading other units, it may be necessary for the plant to restore the lost generation immediately. On the other hand, if ample reserve capacity is available, generation loss may involve only plant generation and tie line schedules disruption.
- D. When an abnormal condition involving loss of generation occurs, the plant Operator will not usually know whether generation must be immediately restored to normal. The Operator should therefore take whatever action is required to restore generation to normal by the fastest available means. Before picking up much load, the Operator shall contact the power system dispatcher to determine how fast to pick up the required load. Restoration of plant generation to normal may be accomplished by any of the following methods, and the quickest one normally should be used:
 - 1) If capacity is available, pick up load on units that are online.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- 2) If sufficient capacity is not available online, start and load standby units.
- 3) In cases where the tripped unit is immediately available, put it back online and load it.
- 4) Where capacity is not available, immediately notify the dispatcher so that he can make other arrangements for the required generation.
- 5) If generation dropping scheme is initiated or called upon to initiate (site-specific), the Operator should ensure that the dropping scheme responded appropriately.

2.6 Control Center Operations

- A. Control Centers shall have copies of the abnormal operating procedures for all plants they remotely operate.
- B. The Control Center Operators must understand the differences between each plant. Review these differences annually.
- C. Trouble alarms may often be initiated by many points. Control Center Operators should use all available indications to assess the problem.
- D. Control Centers should consider the development of alarm response procedures that list all incoming alarm points for different trouble alarms and the required actions.

2.7 Reporting Abnormal Conditions

- A. An important part of the program for handling abnormal conditions is the prompt reporting either in writing or verbally, of essential information to all those who need to know. Properly informed plant, system operating, and maintenance personnel can usually correct abnormal conditions in less time and with less chance of making mistakes than if they were not properly informed. However, reporting abnormal conditions to others should not be allowed to interfere with or delay restoring conditions to normal where the Operator can do this without outside delay.
- B. The load dispatcher or hydrosystem controller should be informed immediately of any abnormal condition that affects system operation, especially if corrective action is needed. However, informing the dispatcher/controller should not delay restoring normal service. Even if the abnormal condition affects equipment in a standby condition, the dispatcher should still be informed promptly because it is assumed that all equipment is ready for immediate service.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- C. Inform the Facility Manager or Operations Head by appropriate means to site-specific conditions of all abnormal operating conditions. When abnormal conditions are expected to be of short duration, routine and corrective actions are completed according to SOPs, inform the Facility Manager or Operations Head through regular established reporting procedures, such as the control room log or by interruption reports, as required. However, in those cases where the abnormal condition is unusual or where investigation or corrective action by the plant maintenance personnel is required, immediately inform the Facility Manager or Operations Head to prevent delay in starting repairs or other corrective action.
- D. Enter all essential information concerning abnormal conditions in the control room log. The log entries should be brief and concise but should contain sufficient information to clearly indicate the nature of the abnormal condition and its status. This is particularly important when the condition is not corrected during the shift on which it occurs or when abnormal equipment is continued in operation with use limitations. In some cases, it may be necessary to supplement the information in the logbook with verbal information or written notes to ensure that Operators on other shifts are fully informed.

3.0 OPERATOR TRAINING PROGRAM

Coordinate the abnormal operations training program for Operators, established by this manual, with existing training programs. The training plan, administered and supervised by the Facility Manager or Operations Head, is outlined in the following subparagraphs.

3.1 Initial Training

- A. The Facility Manager or Operations Head shall ensure that new Operators and Apprentices receive training on abnormal operations before assuming operational duties. Document this training in the control room logbook.

3.2 Annual Refresher Discussion

- A. An important feature of the training plan is the annual refresher discussion in abnormal operating conditions conducted by the Facility Manager, Operations Head, or other qualified personnel.
- B. The discussion should be tailored to fit the needs of the plant personnel and should, therefore, include discussions of abnormal conditions which have occurred at the facility and other Reclamation

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

facilities during the past year, along with a discussion of operating problems encountered during a major system disturbance.

- C. The remainder of the material for the refresher discussion may be taken from the facility SOP.

3.3 Review of Training Program

- A. To keep the program current, the Facility Manager or Operations Head should review the training annually. The Facility Manager or Operations Head should then recommend any changes or improvements considered desirable, based on the past year's experience.

3.4 Documentation of Training

- A. All Operators shall receive abnormal operations training before assuming duties and on an annual basis. Training will be documented in the control room log and signed by each Operator.

4.0 FACILITY ABNORMAL OPERATIONS

4.1 Flooding in the Facility

- A. A failure of a penstock, scroll case door/gasket, draft tube door/gasket, or head cover would cause catastrophic damage to the facility.
- B. If a failure of a penstock, scroll case door/gasket, draft tube door/gasket, or head cover has occurred:
 - 1) Sound the plant evacuation alarm.
 - 2) If the failed penstock or head gate is identified, close the specific unit penstock gate in accordance with (IAW) local facility instructions.
 - 3) If it is not known which one failed, close all penstock gates to protect the facility IAW local facility instructions.
- C. If a failure of the sump pumps occurs, usage of (site-specific educator or temporary sump pump) is required.

4.2 Loss of Station Service

- A. The loss of Station Service can cause many significant problems in a facility including:

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- 1) Loss of generator auxiliaries, including cooling water, lube oil pumps, and governor oil pumps
- 2) Flooding from loss of sump pumps
- 3) Loss of power to emergency equipment (site-specific, fire pumps, alarms, etc.)
- 4) Loss of the ability to bypass water
- 5) Loss of station air systems
- 6) Loss of transformer cooling
- 7) Loss of battery chargers (site-specific plant battery, Supervisory Control and Data Acquisition [SCADA] battery, Uninterruptible Power Supply [UPS] battery)
- 8) Loss of power to restore penstock intake gates
- 9) Loss of Oil Pressure Systems
- 10) Exit issues including elevator failures
- 11) Loss of facility services including water, wastewater, lighting, and heating, ventilation, and air conditioning (HVAC)

NOTE:

A loss of station service may cause a loss of Main Unit Auxiliaries. This could cause overheating of the generator windings and lube oil system and may cause bearing damage. If you have designated Main Units to provide station service, you may want to continue to operate them to allow the re-energization of station service.

- B. For blackstart plants, initiate blackstart procedures.
- C. Stop any unit-unwatering operations to conserve sump capacity.
- D. For a complete failure of station service from a major fault or fire, perform the following:
 - 1) Shutdown Main Units to prevent damage caused by a loss of auxiliaries.
 - 2) Close the intake gates.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- 3) Drain the unit penstocks by cracking open the unit wicket gates. This will prevent unit creep once station service air pressure is lost and will limit inflow to plant sumps.
 - 4) Leave wicket gates slightly open to drain off intake gate leakage.
 - 5) Manually block the unit brakes.
- E. If the units trip, verify that the units shut down completely.

CAUTION:

A loss of power may prevent the operation of plant educators if they are operated or water is supplied from the penstock. Facility should consider alternative means to remove water on a loss of power.

- F. If you have manually operated educators (site-specific), operate them to control sump levels.
- G. Ensure (site-specific) that emergency generators have started. Ensure that critical loads are being fed, and monitor generator for proper operation.
- H. If a Main Unit is left on to assist with restoring station service:
- 1) Operate the unit at minimum load, but not condensing.
 - 2) Take unit off automatic generation control (AGC).
 - 3) Minimize load changes to conserve governor pressure.
 - 4) Monitor battery and reduce direct current (DC) loads to conserve energy.
 - 5) Monitor bearing metal/oil and generator air temperatures. Reduce load or shut down the unit, as necessary, to reduce temperature rise.
 - 6) Monitor transformer temperatures and reduce loading as necessary to minimize temperature rise.
- I. Verify that personnel are not stuck in elevators.
- J. Implement facility procedures to maintain downstream flows.
- K. Conserve station air system by securing maintenance operations that consume air.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

4.3 Loss of Plant DC Control and Protection

- A. A loss of the DC system will cause a loss of control and protection circuits.
- B. Check that the units have tripped and are shutting down.

CAUTION (Site-Specific):

Manually opening a large switchgear breaker may be hazardous. Facilities should develop site-specific procedures to respond to a generator breaker trip failure.

- C. Ensure that generator breakers are open. Manually trip breakers that have not opened.
- D. Ensure that transformer breakers are open. Manually trip breakers that have not opened.
- E. Secure the Main Units as follows:
 - 1) Close the intake gates.
 - 2) Drain the unit penstocks by cracking open the unit wicket gates.
 - 3) Leave wicket gates slightly open to drain off intake gate leakage.
 - 4) Manually block the unit brakes.
- F. Investigate loss of DC system.

4.4 Loss of Plant Control Alternating Current (AC)/Uninterruptible Power Supply/Inverter

- A. The loss of the Plant Control AC system may cause the loss of the following (site-specific) systems:
 - 1) SCADA
 - 2) Instrumentation/metering
 - 3) Digital governors
 - 4) Fire alarms/detection
 - 5) Power system stabilizer (PSS)

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- B. If all control room indication of units is lost (metering and SCADA), dispatch personnel to locally monitor and/or operate units (site-specific or Continuity of Operations [COO] Plan).
- C. If units are SCADA operated and UPS power to SCADA is lost, initiate procedures to take manual operation of units.
- D. If the generation is not essential, consider shutting the units down.
- E. If generators must remain operational, minimize load changes.
- F. Investigate loss of AC plant control.

4.5 Loss of Air Systems

NOTE:

Some facilities have separate systems for governors, breakers, and station air.

- A. If a major failure occurs in the station air system piping:
 - 1) Secure station air compressors.
 - 2) Secure condensing operations.
 - 3) Shut down units beginning to creep and ensure penstock gate closure and thrust pump starting.
 - 4) Isolate the air leak and restore the air system.
- B. If air compressors have failed:
 - 1) Implement air system cross-connect procedures or emergency air supply. (site-specific).
 - 2) Investigate the failure of the air compressors and restore system.
 - 3) Take manual control of all air operated cooling water control valves until station air system is restored.
- C. If a loss of unit governor air occurs, minimize load changes to conserve governor pressure. The main units will trip, and the intake gate will close at a low governor pressure of (site-specific).

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- D. If a major failure occurs in the governor air system piping:
 - 1) Secure governor air compressor(s).
 - 2) Isolate piping failure and restore system.
- E. If governor air compressor(s) have failed, perform the following:
 - 1) Implement governor air system cross-connect procedures or emergency air supply (site-specific).
 - 2) Investigate the failure of air compressor(s) and restore system.

NOTE:

A loss of generator breaker operating air may cause the breaker to lock out, open, or close breaker (site-specific).

- F. If Unit Breaker's operating air is lost, minimize breaker operations to conserve operating air.
- G. If a major failure occurs in Unit Breaker air system piping:
 - 1) Secure breaker air compressor(s).
 - 2) Isolate piping failure and restore system.
- H. If Unit Breaker air compressor(s) have failed, perform the following:
 - 1) Implement governor air system cross-connect procedures or emergency air supply procedure (site-specific).
 - 2) Investigate the failure of breaker air compressor(s) and restore system.

5.0 ABNORMAL OPERATIONS OF GENERATOR AND TRANSFORMER BREAKERS

5.1 Generator and Transformer Breaker Abnormal Operations

- A. A breaker failure relay (BFR) will indicate a failed breaker to the Operator (site-specific).
- B. The BFR should operate appropriate breakers to isolate the failed breaker.
- C. If the breaker fails to open or to be isolated, open the switchyard breaker or manually open the breaker (site-specific).

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

CAUTION:

Do not open breakers manually with low sulfur hexafluoride (SF₆), air, or oil pressures. This could cause catastrophic breaker failure and personal injury.

CAUTION (Site-Specific):

Manually opening a large switchgear breaker may be hazardous. Facilities should develop site-specific procedures to respond to a generator breaker trip failure.

NOTE:

Breakers should have a breaker failure scheme.

- D. If breaker fails to operate:
- 1) Check whether the red and green lights on breakers are operational. This verifies continuity through the closing and tripping circuits.
 - 2) Check oil/air/SF₆ pressure.
 - 3) Check synchronizing circuit, local/remote switch (site-specific).
 - 4) Check that control power is available.
- E. If a loss of SF₆ occurs, refer to *FIST 5-9, Safe Handling Procedures for SF₆ Equipment*.
- F. Low breaker operating pressure will prevent the operation of air blast breakers. The low pressure alarm operates at (site-specific).
- G. For low breaker air pressure, the Operator will do the following:
- 1) Attempt to locate and isolate the leak.
 - 2) Check the breaker air compressor status, including the power supply and fuses.
 - 3) Implement air system cross-connect procedures or emergency air supply. (site-specific).

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

6.0 ABNORMAL OPERATION OF MAIN GENERATORS

6.1 Plant Running Isolated (Not Connected to Grid)

- A. In this condition, the facility is a step closer to a blackout condition.
- B. Immediately maintain station service voltage and frequency. Failure to do so can cause electrical equipment failures.
- C. Plant staff should minimize the use of non-essential electrical equipment (compressors, cranes, pumps, etc.).
- D. Initiate recovery procedures with Power Marketing Agency (site-specific).

6.2 Carbon Dioxide (CO₂) Discharge

CAUTION:

Do not enter lower areas of the facility where CO₂ could collect. Time should be allowed for CO₂ to dissipate. Areas shall not be entered without a self-contained breathing apparatus (SCBA) and air monitor.

NOTE:

Reset the initiating devices or relays prior to resetting the CO₂ system (site-specific).

- A. Verify operating unit shutdown.
- B. If the plant is manned, operating personnel should monitor the generator for signs of a fire. If fire is present, additional CO₂ should be discharged.
- C. Plant personnel should be warned of the danger of concentrations of CO₂ in low places and should evacuate lower elevations of the facility for at least 30 minutes.
- D. Entries into these areas shall be IAW established Job Hazard Analysis (JHA). Anyone entering these areas should carry a SCBA and an air monitor.
- E. Evacuate the facility or lower areas of the plant (site-specific).

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

6.3 Differential or Ground Relay Operation

- A. When a unit is shut down by operation of the differential or ground relays, the Operator should take the following action:

CAUTION:

DO NOT restart the unit until the problem has been identified and corrected. Failure to identify and correct the problem could cause permanent damage to the windings and core.

- 1) Always ensure that the unit has come to a complete stop.
- 2) Ensure that CO₂ has discharged (site-specific details) and determine if additional discharges are required.
- 3) Refer to section 6.2 for CO₂ discharges.
- 4) Notify the Facility Manager or Operations Head.
- 5) The unit should not be restarted until the cause of the shutdown has been investigated and repaired, if necessary.

6.4 Overcurrent Relay Operation

- A. Overcurrent relays are not likely to operate on overload, unless the overload is accompanied by a very high reactive load.
- B. The relay protects the generator against sustained excessive currents and against external faults, which do not clear, such as switchyard bus faults or line faults.
- C. If a unit overcurrent relay operates, ensure that unit 86-lockout and unit shutdown occurs.
- D. When a single unit trips on overcurrent, the Operator should check for trouble in the excitation system.
- E. When several units trip simultaneously on overcurrent, the Operator should check for the possibility of a switchyard bus fault or a line fault that failed to clear.
- F. The unit may go back online as soon as the problem is corrected.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

6.5 Overvoltage Relay Operation

- A. The generator overvoltage relay provides protection against dangerously high generator voltages.
- B. If a unit overvoltage relay operates, ensure that unit 86-lockout and unit shutdown occurs.
- C. If the unit was tied to the grid and supplying a significant voltage support, a grid disturbance could have caused the relay actuation.
- D. The excitation system should be inspected to determine the problem.

6.6 Loss of Generator Field

- A. When loss of the generator field occurs with the unit connected to the system, leading reactive flows into the machine to help maintain the generator terminal voltage.
- B. If a unit loss of field relay operates, ensure unit 86-lockout and unit shutdown occurs.
- C. The following should be inspected to determine the loss of field.
 - 1) Excitation system
 - 2) Field breaker
 - 3) Collector ring
 - 4) Brush assembly
 - 5) Associated bus work

6.7 Abnormal Operation of the Voltage Regulator

CAUTION:

Voltage regulators should not be operated in manual or current mode without an Operator present or for extended periods of time. Western Energy Coordinating Council (WECC) or the Local Control Area shall be notified of all units that are being operated with the voltage regulator in manual.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- A. When abnormal conditions occur in the voltage regulator or the excitation system, the voltage regulator should be taken out of service by shutting the unit down.
- B. The voltage regulator may automatically swap to the manual mode on a failure of the automatic voltage regulator.
- C. The voltage regulator and excitation system should be inspected and the problem corrected before restarting the unit.

6.8 Stator Winding High Temperature

- A. The stator winding temperature high limit is monitored by embedded temperature detectors and are set at (site-specific) degrees Celsius.
- B. Remotely operated units at facilities that are currently unmanned should be unloaded first to reduce temperatures to a safe operating limit. If load reduction does not reduce high temperatures, shut down the unit.
- C. While high stator temperatures should not occur except at rated load and above, Operators should watch for higher than normal temperatures at lower loads.
- D. When abnormal temperatures occur, Operators should check for:
 - 1) Proper generator air-cooling water flow (site-specific)
 - 2) Hot spots
 - 3) Air-locked coolers
 - 4) High field current or temperature
- E. If the temperature exceeds the maximum of (site-specific) degrees Celsius, the load and/or reactive should be reduced to bring the temperature back to the limit. Raising the generator voltage slightly to reduce armature current may be helpful, especially if the reactive is on the leading side.
- F. If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

6.9 Main Field Winding High Temperature (If Applicable)

- A. The main field winding temperature may be calculated from rotor current (facility specific).
- B. Remotely operated units whose facility is also currently unmanned should have the field current reduced to bring temperatures to

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

a safe operating limit. If lowering the field current does not reduce high temperatures, shut down the unit.

- C. When the indicated field temperature reaches (site-specific) degrees Celsius, the Operator should take the following action:
- 1) Check the stator temperature and the field current.
 - 2) If the stator temperature is below its limit of (site-specific) degrees Celsius and the field current is below its limit (site-specific), it is unlikely that the field temperature is too high.
 - 3) If the field current is above the limit or if the stator temperature is too high, reduce the generator reactive and megawatt load.
 - 4) High temperature may be an indication of an increase in the resistance of the winding as a result of the development of high resistance joints in the connections between coils. If this is suspected, the Facility Manager or Operations Head should be notified.

7.0 ABNORMAL OPERATIONS OF UNIT AUXILIARY EQUIPMENT

7.1 Generator-Bearing Temperature Alarm or Shutdown Relay Operation

- A. The generator-bearing high temperature alarm actuates at (facility specific) and will cause a unit shutdown at (facility specific).
- B. If the unit receives a trip actuation, verify that the unit is shutting down normally. If it isn't, initiate a normal unit shutdown.

CAUTION:

Do not use emergency shutdown (SCADA or control switch). This will open the generator breaker before the gates are closed, causing an increase in speed, which might do further damage to the bearing.

- C. Remotely operated units at facilities that are currently unmanned should be immediately shutdown.
- D. An immediate inspection should be made including a check on bearing temperatures, oil flows and levels, and cooling water flow. The Operator should also check for any unusual noises or vibration of the unit.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- E. If the bearing temperature shows a fast temperature rise of (site-specific) degrees Celcius or more above normal with other temperatures near normal, the unit should be shut down immediately.
- F. If the temperature recorder shows a rather slow temperature rise, check to make sure that cooling water flow and oil level is normal and reduce unit load.
- G. If temperatures continue to rise, the unit should be shut down using normal procedures.
- H. For a slow rise in temperature, the Operator should be alert for indicator failures. When the bearing temperatures actually rise, the change is likely to show up on several indicators, rather than on only one.
- I. SCADA or other temperature indicators may be used to validate the high temperature.
- J. If a high temperature relay operates, ensure the unit 86-lockout and a unit shutdown occurs.
- K. If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

7.2 High or Low Thrust-Bearing Oil Level Alarm

- A. The generator high oil level alarm actuates at (facility specific) and the low level alarm actuates (facility specific).
- B. If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.
- C. Remotely operated units at facilities that are currently unmanned should be immediately shut down.
- D. If the oil level is high:
 - 1) Check for an oil cooler leak.
 - 2) Check the sight glass for milky appearance and take an oil sample from the bottom of the bearing sump.
- E. If there is considerable water in the oil, the unit should be unloaded and shut down using normal procedures.
- F. If the oil level is low:
 - 1) The thrust-bearing temperatures should be monitored.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- 2) Check for leaks.
 - 3) If a large leak is discovered, unload the unit and shut it down until the condition can be corrected.
 - 4) If there is no indication of a leak, oil should be added.
- G. In cases of abnormal oil levels, all supply and drain valves should be checked to be sure they are not leaking.
- H. If the cause of the high/low oil level is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

7.3 Generator Air-Cooling Water Alarm

- A. The air-cooling water alarm is energized by:
- 1) Low cooling water flow (site-specific)
 - 2) Low pressure (site-specific)
 - 3) High discharge air thermometers (site-specific)
- B. When the alarm is energized, the Operator should check cooling water flow and discharge air temperatures.
- C. If the cooling water flow is below normal, check that all supply and discharge valves are open.
- D. Check that water supply pressure is greater than (site-specific). If supply pressure is low, check pumps and strainers.
- E. A single high discharge air temperature greater than (site-specific) is an indication of an air-locked cooler or a closed isolation valve.
- F. If the stator temperature gets too high, it may be necessary to reduce load in order to keep the temperature within limits.
- G. If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

7.4 Thrust-Bearing Cooling Water Alarm

- A. Thrust-bearing cooling water alarm actuates at (site-specific).
- B. Remotely operated units at facilities that are currently unmanned should be immediately shutdown.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- C. An immediate inspection should be made to check cooling water flow greater than (site-specific). The Operator should also check for any unusual noises or vibration of the unit.
- D. Ensure that all supply and discharge valves are open and header pressure is greater than (site-specific).
- E. If cooling water flow cannot be restored, the unit should be unloaded and shut down until the condition can be corrected.

7.5 Turbine-Bearing Temperature Alarm or Shutdown Relay Operation

- A. The turbine-bearing temperature alarm will be energized by any of the following:
 - 1) Bearing temperature recorder (site-specific)
 - 2) Bearing metal temperature indicating thermometer (site-specific)
 - 3) Bearing oil temperature indicating thermometer (site-specific)
- B. If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.
- C. Remotely operated units at facilities that are currently unmanned should be immediately shut down.
- D. When the alarm is energized, the Operator should check bearing temperatures.
- E. If any temperatures are found to be above normal, inspect the bearing cooling water and the oil supply system to determine the cause of the high temperature.
- F. The turbine-bearing can be operated temporarily without cooling water if the bearing temperature does not exceed (site-specific).
- G. If the cooling water supply is normal, the Operator should check the shaft runout. The Operator should also check for any unusual noise or a vibration that might increase the bearing friction.
- H. If the cause of the high temperature is not found and corrected, the unit should be unloaded and shut down until the condition can be corrected.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

7.6 Loss of Water Supply to Packing Gland

- A. The shaft packing requires a small amount of cooling water to help lubricate the packing and to prevent heating and seizing of the packing. The low flow alarm actuates at (site-specific).
- B. Remotely operated units at facilities that are currently unmanned should be immediately shut down.
- C. The Operator should check the flow of gland water on each inspection.
- D. If the cooling water fails and the packing gets hot, the Operator should first try to restore the cooling water flow. If this cannot be done, the unit should be unloaded and shut down to prevent possible damage to the shaft sleeve.

7.7 Loss of Turbine Seal Lubricating Water

- A. Some generators use seal water only during motoring/condensing. If the seal water fails and cannot be restored on a motoring/condensing unit, the unit could be operated until the problem is corrected.
- B. The seal-water pressure and flow should be checked between (site-specific) on each unit inspection.
- C. The low seal pressure alarm actuates at (site-specific).
- D. Remotely operated units at facilities that are currently unmanned should be immediately shut down.
- E. If the seal water fails on a generating, that requires constant seal water and cannot be restored, the unit should be unit shut down until the problem can be corrected.

7.8 Failure of Turbine/Generator-Bearing Oil Pumps

NOTE:

The DC oil pump is a backup to the AC oil pump. In some cases it may be acceptable to operate the unit with the DC oil pump for short periods of time. However, the unit will not have a backup oil supply. Consideration should be given (especially at remote facilities) to shutting down the unit and starting an alternate unit.

- A. The DC pump provides a continuous supply of oil to the turbine/generator bearings in case the AC pump or station service fails.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- B. The DC pump starts on a low pressure of (site-specific).
- C. If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.
- D. Remotely operated units at facilities that are currently unmanned should be immediately shut down.
- E. When any abnormal condition occurs in the turbine/generator-bearing oil system, the Operator should first determine if the bearing is receiving adequate lubrication. If it is not, the unit should be unloaded and shut down immediately.
- F. When the bearing oil alarm is energized, the Operator should:
 - 1) Check that the bearing oil supply pressure is greater than (site-specific).
 - 2) Check that turbine/generator-bearing temperatures are less than (site-specific).
 - 3) Check the AC oil pump status. If the pump is not operating, check the AC pump supply breaker.
 - 4) Verify operation of the DC pump (site-specific).
 - 5) Check for oil leaks in the system that may be causing a low pressure.
- G. If the cause of the AC pump failure is not found and corrected and the DC oil pump is not supplying proper pressure and flow, the unit should be unloaded and shut down until the condition can be corrected.
- H. For a failure of the thrust bearing oil pump:
 - 1) Ensure that the brakes come on and the unit is shut down quickly.
 - 2) At slow speeds, the thrust bearing may not have an adequate oil film.
 - 3) Do not restart the unit until the thrust bearing pump is repaired.

8.0 ABNORMAL OPERATION OF MAIN GOVERNOR

8.1 Loss of Permanent Magnet Generator (PMG)/Speed Signal Generator (SSG)

- A. When a loss of a PMG occurs, the unit will go to gate limit setting, and you will have no speed indication on the unit.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- B. If the SSG fails and a generator field is not present, the speed signal will be lost, and a main unit lockout and shutdown will occur. The SSG is a backup to the generator potential transformer (PT) speed signal.
- C. SSG and/or PT feeds speed information to electronic governors to operate speed switches (brake application, thrust pump application, etc.) and speed indicating meters.
- D. If local plant Operators are available, some of the following actions need to be taken based on the governor type (site-specific):
 - 1) Take the brakes off auto to prevent brake damage.
 - 2) Lower the gate limit to unload the generator speed to no load.
 - 3) Manually, start thrust bearing oil pump.
 - 4) When the generator load is at minimum, open the generator breaker and shut down the unit.

CAUTION:

Do not shut down the unit without placing brakes in manual. Failure to do so will damage brakes.

- E. If the governor is a digital governor, the unit will lock out. Depending on how the governor failed, the brakes may actuate, and the thrust bearing pump may not start.
- F. For electronic or mechanical governors, lower the gate limit to unload the generator.
- G. When generator reaches (site-specific) revolutions per minute (rpm), manually apply the brakes.

8.2 Abnormal Operation of Governor

NOTE:

Hunting or surging could be an indication of a serious problem in the governor.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- A. The most common abnormal conditions affecting governors are lack of sensitivity and hunting or surging. The Operator usually will not be able to correct either of these conditions.
- B. For governor control problems, the unit should be taken off AGC. If this fails to correct the problem, the governor should be block loaded and the unit shut down as soon as possible.
- C. If the speed-adjusting motor fails to operate from the control room, the Operator may be able to control the unit from SCADA using the gate limit. Additionally, the speed adjustment may be operated temporarily at the governor, but load changes should be kept to a minimum.
- D. A loss of control power to the governor most likely will cause a unit shutdown or, at least, wicket gate closure.
- E. Operation of a unit governor in the “auxiliary” valve mode is normally done during maintenance. When the auxiliary valve is being used during an emergency, there are several things to remember:
 - 1) The unit transfer switch may have to be turned to “manual” to prevent the automatic operation of the gate limit motor.
 - 2) Turbine speed is under the complete control of the gate limit control knob.
 - 3) There is no speed sensing by the governor, and the servomotor timing will be slower.
 - 4) The governor should never be left unattended. The automatic shutdown devices are inoperative and will not shut down the generator in an emergency.

8.3 Loss of the Restoring Cable (Mechanical Governor)

- A. If the restoring cable breaks between the gate servomotor and the sheaves, perform the following:
 - 1) If the generator is online, the indications of a broken restoring cable will be: (1) the gate position indicator is at full open and (2) the unit will be motoring when the gate position indicates it should be producing power.
 - 2) Open the Unit Breaker under a small motoring load and take the unit offline to repair.
 - 3) If the generator is offline or operating isolated, the gate position indicator again will show full open, but the gates will close and shut down the unit.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- B. If the restoring cable breaks between the sheaves and the restoring cable weight, what do you look for and what should you do?
- 1) Regardless if the wicket gates are going open or closed during a load change, the generator will operate at maximum load with the gates full open, but the gate position indicator stays at the previous load setting.
 - 2) The Operator should use the gate limit control knob to shut down the generator.

CAUTION:

Under no circumstances should the unit be tripped if it is online. Tripping a unit with no restoring cable and the wicket gates full open would result in a runaway generator.

- C. If the pilot valve sticks in the open position and the gate limit control will not push down the pilot valve, what can you do to stop the unit?
- 1) The Operator should cut off oil pressure to the pilot valve, only allowing the valve servomotor plunger to fall of its own weight. This will open oil flow to the closing side of the servomotor and close the wicket gates.

CAUTION:

Under no circumstances should the unit be tripped if it is online. Tripping a unit with the pilot valve stuck in the open position would result in a runaway generator.

8.4 Loss of Gate Position Indication (Digital Governor)

- A. A failure of the gate positioning indicating device will cause a governor shutdown.
- B. The unit will receive a lockout.
- C. Verify that the unit is shutting down and the unit breaker is open.

8.5 Low Governor Oil Pressure Alarm and Shutdown Relay Operation

- A. If the low oil pressure alarm is energized, the control room Operator should stop any load changes on the unit. If the governor is hunting, block the gates with the gate limit.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- B. If the unit receives a trip actuation, verify the unit is shutting down normally. If it is not, initiate a normal unit shutdown.
- C. If the alarm does not clear and the plant is unmanned, the Operator should shut down the unit.
- D. If personnel are available, check that the governor oil pumps are running with proper discharge pressure (site-specific information), check the oil level in the pressure tank (site-specific information), and check that the governor sump level is normal (site-specific information).
- E. Check the starting and stopping pressures of both pumps (site-specific).
- F. If there is trouble with the lead pump, the lag pump should be put on lead. If there is complete failure of both pumps, the unit will have to be shut down.
- G. If the low oil pressure shutdown relay operates, the unit will be automatically shut down and must be left down until the cause of the low oil pressure is found and corrected. This may cause penstock gate closure.

8.6 Overspeed or Runaway

- A. There are two types of actuations for overspeed: instantaneous and sustained. The overspeed alarm and shutdown relay are set to operate at (site-specific speed and time).
- B. If the unit receives a trip actuation, verify that the unit is shutting down normally. If it is not, initiate a normal unit shutdown.
- C. The Operator should monitor the unit rpm to ensure that the governor is taking control of the unit or that the unit is shutting down.
- D. If an overspeed shutdown occurs, the entire governor system should be inspected before restarting the unit.
- E. If the governor is acting abnormally, DO NOT open the generator breaker until the generator load is zeroed using the gate limit.
- F. In case of a runaway condition where the wicket gates fail to close, the Operator should close the penstock gate.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

9.0 ABNORMAL OPERATION OF MAIN TURBINE

9.1 Turbine Pit High Water

- A. A turbine pit high water alarm actuates at (site-specific). A turbine pit high water pit alarm could be caused by the following:
 - 1) Head cover seal failure
 - 2) Cooling water line failure
 - 3) Turbine packing failure
 - 4) Plugged drain lines
 - 5) Head cover pump failure
 - 6) Wicket gate seal failure
- B. Remotely operated units, whose facility is also currently unmanned, should be immediately shut down.
- C. The high level alarm should be investigated to determine the cause of the high water alarm.
- D. The unit operation may continue if the leak can be isolated or if the leak is small and can be repaired during a scheduled outage.
- E. For large leaks, the unit should be unloaded, shut down, and the penstock gate closed until the condition can be corrected. If the leak is below the tail race water elevation, the tail race stop logs may have to be installed also.

9.2 Failure of Gate Shear Pin

- A. For a load rejection with shear pin failure, close the penstock gate.
- B. The wicket gate operating linkage for each gate is provided with a safety shear pin to prevent damage to gates in case they are blocked by foreign material getting between them.
- C. While shear pins usually fail when the gates are closed with foreign material between them, they also occasionally fail when the unit is on load.
- D. When a shear pin fails, the Operator may notice unusual noise and vibration of the turbine or elevated turbine bearing temperatures, especially while the gate is closing.
- E. Operators should be alert for this and should check for broken shear pins when the turbine is unusually noisy.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- F. If a broken shear pin is found, the unit should be unloaded, if possible, and operated at minimum load until the broken shear pin can be replaced.

9.3 Unusual Mechanical Noise or Vibration

- A. The Operator should investigate any unusual mechanical noise or vibration. Check shaft runout and generator/turbine bearing temperatures. Make an inspection for broken shear pins or for foreign material lodged in the gates or wheel.
- B. If the abnormal condition is such that continued operation of the unit might do further damage, or if there is evidence of foreign material in the gates or wheel, shut down the unit immediately.
- C. If severe vibration and noise develops, shut down the unit immediately.

10.0 ABNORMAL OPERATION OF MAIN TRANSFORMERS

10.1 Transformer Differential-Relay Operation

- A. When the transformer differential relay operates, the Operator should take the following action:
 - 1) Ensure that the associated generator and switchyard breakers are open.

CAUTION:

Care should be taken not to de-energize transformer oil pumps of operating transformers.

- 2) Stop the transformer oil pumps (site-specific).
- 3) Ensure that the transformer deluge system is activated if fire is present at transformer.
- 4) If no fire is present, ensure that the transformer deluge system is not operating.
- 5) If a fire has occurred, initiate the Pre-Fire Plan, section 11.0.
- 6) Ensure that the associated generators are shut down.
- 7) Do not restart units until the cause of the relay action has been investigated and corrected.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

10.2 Transformer High Temperature Alarm or Shutdown Relay Operation

- A. Transformers usually have cooling oil circulating pumps with fans and/or heat exchangers for heat removal. The high temperature alarm actuates at (site-specific).
- B. If the alarm does not clear and the plant is unmanned, the Operator should unload the transformer.
- C. The Operator should perform the following:
 - 1) Ensure transformer loading is within the limits (site-specific).
 - 2) Ensure both oil pumps are operating. If they are not, perform section 10.3.
 - 3) Check that the transformer oil level is normal (site-specific).
 - 4) Check that the cooling water pressure or flow is normal (site-specific). If they are not, check the cooling water supply valves and strainer.
 - 5) Check that the cooling fans are operating (site-specific).
- D. If the transformer temperature continues to rise, it may be necessary to unload the transformer.

10.3 Transformer Oil Flow Failure

- A. Each transformer is provided with two oil pumps that circulate the oil through water-cooled heat exchangers for cooling purposes. A continuous flow of oil is, therefore, necessary to provide adequate cooling.
- B. If the alarm does not clear and the plant is unmanned, the Operator should unload the transformer.
- C. Each pump is provided with a no-flow/low-flow device that energizes the Transformer Oil Flow alarm. This may start a timer that will deenergize the transformer in (site-specific).
- D. When transformer oil flow failure is indicated by the alarm, Operators should take the following action:
 - 1) Check the transformer temperatures.
 - 2) Check the operation of oil pumps.
 - 3) Check the oil supply valves to make certain they are 100 percent open.
 - 4) Check the oil pump power supply circuits for tripped breakers or overloads.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- 5) Although transformers can be operated for some time without oil circulation, it should be remembered that the winding temperature detectors may not read correctly (local temperature indication) when there is no oil flow. The actual temperatures are likely to be higher than indicated on the recorder, and transformers carrying rated generator load should not be operated with no oil circulation at temperatures above (site-specific).
- 6) The hot spot detector (site-specific) is a better choice for monitoring transformer temperature. The transformer temperature is obtained from embedded resistance temperature detector (RTD) and current/load on the transformer, and this is the one usually fed to the recorder/SCADA.
- 7) If normal oil flow cannot be restored, the associated units should be unloaded, shut down, and the transformers should then be de-energized.

10.4 Sudden Pressure Relay

- A. The operation of a sudden pressure relay is an indication of a large internal fault in the transformer.
- B. When the sudden pressure relay operates, it should trip the transformer differential lockout relay, and the Operator should take the following action:
 - 1) Ensure the associated generator and switch yard breakers are open.
 - 2) Ensure the lockout tripped and properly operated by verifying appropriate circuit breakers opened, fire water deluge system activated, etc. (site-specific).

CAUTION:

Care should be taken not to de-energize the transformer oil pumps on operating transformers.

- 3) Stop the transformer oil pumps (if accessible).
- 4) Check for fire at the transformer and turn on the water spray, if necessary.
- 5) If a fire has occurred, initiate the Pre-Fire Plan, section 11.0.
- 6) Ensure the associated generators are shut down.
- 7) Units should not be restarted until the cause of the relay action has been investigated and corrected.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

10.5 Transformer Oil and Gas Alarm

- A. The transformer oil and gas alarm will be energized by any of the following abnormal conditions:
 - 1) Low oil level
 - 2) Low cylinder gas pressure
 - 3) High or low transformer gas pressure
 - 4) Relief valve failure
- B. When the alarm is energized, the Operator should first try to determine which abnormal condition caused the alarm.
- C. If the oil level gauge indicates low oil level, the Operator should check for oil leakage at the following:
 - 1) Transformers
 - 2) Heat exchangers
 - 3) Connecting piping
- D. Low Cylinder Gas Pressure is energized at (site-specific) and indicates that it is time to replace the nitrogen cylinder with a new one. The cylinder can normally be left until maintenance personnel can replace it.
- E. The nitrogen gas pressure in the transformer is self-regulating in that gas is added from the cylinder when the pressure is too low (site-specific) and is vented to the atmosphere by a pressure relief valve when the pressure gets too high (site-specific).
- F. If the pressure is low, the Operator should check that gage is reading correctly and that the automatic regulating system is functioning to add gas to the transformer.
- G. If the pressure is high, check that the relief valve is operating. If it is not, slowly open the sampling or vent valve to release enough gas to clear the alarm.

10.6 Low Oil Pressure/Level for Transformers with Conservator Tank

- A. Some transformers are equipped with a constant oil pressure system. The system consists of a conservator tank, a urethane or rubber bladder, a pressure-vacuum bleeder and gauge, and an oil level indicator.

ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES FOR POWER STATIONS

- B. As oil expands and contracts following loading levels and ambient temperature, the bladder expels air to the atmosphere or allows air into the bladder from the atmosphere. These systems are designed to regulate the reservoir pressure between (site-specific) and will alarm outside those settings.
- 1) Check the pressure gauge for an accurate reading.
 - 2) Check the oil level indicator. If the bladder is damaged or ruptured, a low indication should be present, but the conservator tank will still be functional. Some conservator tanks have a bladder failure relay (site-specific) .
 - 3) Check for oil leaks at the main tank, conservator, and piping.
 - 4) Monitor transformer temperatures and loading until such time that the transformer can be removed from service for repair.

11.0 PRE-FIRE PLAN

11.1 Purpose

- A. A Pre-Fire Plan is essential to define procedures to respond to fires in Reclamation facilities. A Pre-Fire Plan establishes procedures and guidelines to safeguard personnel, public facilities, equipment, buildings, and grounds.

11.2 Objective

- A. The main objective of this fire plan is to:
- 1) Inform and protect employees and visitors.
 - 2) Minimize fire damage.
 - 3) Minimize interruption of operation.
 - 4) Coordinate outside assistance.
- B. The plan should establish:
- 1) Lines of authority
 - 2) Evacuation routes, assembly points, and the accountability of plant personnel
 - 3) Methods to contain, minimize, or extinguish facility fires
 - 4) Methods to minimize the effects of a fire on plant operations

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- 5) Coordination with off-site emergency response personnel
 - 6) The amount and location of all flammable materials on the facility
 - 7) The location and operation of all fire protection/detection equipment and systems
- C. Fire Protection Zones
- 1) Defining fire protection zones in a facility will segregate different areas of the facility for fire protection strategies.
 - 2) Each zone should:
 - a) Have a drawing showing the layout of the zone.
 - b) List the quantity and types flammable materials stored in the zone.
 - c) List the types of fire suppression equipment available.
 - d) List strategies for dealing with fires in the different areas of the zone.
 - e) List all large electrical panels/switchgear (200 volts and greater) in the protection zone or that supply major equipment that contain flammable materials.

11.3 Procedure

- A. All employees in all areas of the project are authorized to report fires and to perform firefighting procedures for which they are trained.
- B. Report a fire as follows:
 - 1) Call (site-specific) and report the fire to the Control Room.
 - 2) When reporting a fire, give the location, the nature of the fire (electrical, oil, trash, etc.), the telephone number from where you are calling, and your name. Do not hang up until you are released.
 - 3) After the fire has been reported, clear and isolate the area as much as possible and administer appropriate firefighting techniques to control the fire until assistance arrives.
 - 4) These techniques are to be ones the employee is trained on.
 - 5) If the discoverer of a fire is not trained in firefighting procedures, report the fire and evacuate the area.
 - 6) Project employees are not to attempt to control major fires; only small fires are within their capability.

**ABNORMAL OPERATIONS GENERIC TECHNICAL GUIDELINES
FOR POWER STATIONS**

- 7) Other employees at the site who are trained in firefighting procedures shall assist in extinguishing the fire. If they are not required to handle extinguishers or fire hoses, they should shut off apparatus using electricity or gas and salvage valuable material, if possible.
- 8) The discoverer of the fire, if so qualified, shall direct operations until relieved by a project supervisor or the chief of the fire department.

Acronyms and Abbreviations

AC	alternating current
AGC	automatic generation control
BFR	breaker failure relay
COO	Continuity of Operations
CO₂	carbon dioxide
DC	direct current
EOPs	Emergency Operating Procedures
FIST	Facilities Instructions, Standards, and Techniques
HVAC	heating, ventilation, and air conditioning
IAW	in accordance with
JHA	job hazard analysis
PMG	permanent magnet generator
PSS	power system stabilizer
PT	potential transformer
rpm	revolutions per minute
RTD	Resistance Temperature Detector
SCADA	Supervisory Control and Data Acquisition
SCBA	self-contained breathing apparatus
SF₆	sulfur hexafluoride
SOPs	Standing Operating Procedures
SSG	speed signal generator
UPS	Uninterruptible Power Supply
WECC	Western Energy Coordinating Council