

# Performance-Related Outage Inspections

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**ASME POM 101-2013**

# **Performance- Related Outage Inspections**

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**AN AMERICAN NATIONAL STANDARD**



**The American Society of  
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# FOREWORD

POM 101, Performance Related Outage Inspections, is the first standard in a planned series of power plant performance operation and maintenance standards. Related to and initially sponsored and staffed by the Performance Test Code Standards Committee, these standards do not prescribe testing activities, but if followed will assist in the improvement of power plant performance and reliability.

In June 2007, the Performance Test Code Standards Committee approved the charter for the series of standards on operation and maintenance activities related to power plant performance. The ASME Board on Standardization and Testing approved this Standard on October 7, 2013. It was approved as an American National Standard by the ANSI Board of Standards Review on December 4, 2013.

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Secretary, PTC Standards Committee  
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Two Park Avenue  
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**Proposing Revisions.** Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

**Attending Committee Meetings.** The PTC Standards Committee and PTC Committees hold meetings or telephone conferences, which are open to the public. Persons wishing to attend any meeting or telephone conference should contact the Secretary of the PTC Standards Committee.

# INTRODUCTION

This Standard contains a series of sections, each pertaining to specific equipment and/or systems commonly found in power plants. Internal inspections covered in this document are intended to take place when the equipment is out of service. Each section of this Standard can be used independently and includes recommendations on what to look for during the inspection. For additional information on inspections that can be done when the unit is online, please consult ASME POM 102, Operating Walkdowns of Power Plants; it is the second standard in the planned series of POM standards and will be published soon.

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# PERFORMANCE-RELATED OUTAGE INSPECTIONS

## 1 OBJECT AND SCOPE

### 1.1 Object

This Standard provides guidelines for equipment inspections that are designed to ultimately improve the thermal performance or efficiency of the power plant. By following these guidelines, many issues identified during an inspection, upon resolution, will also improve the reliability of the plant.

### 1.2 Scope

This Standard provides guidelines for equipment inspections of power plants using fossil fuels during shutdown or outage periods. Some portions of this document may be applicable to other types of power plants.

## 2 ACRONYMS

The following acronyms are used in this Standard:

*AH*: Air Heater

*ESP*: ElectroStatic Precipitator

*FD*: Forced Draft

*GT*: Gas Turbine

*HP*: High Pressure

*HRSG*: Heat Recovery Steam Generator

*IP*: Intermediate Pressure

*LOI*: Loss On Ignition

*LOTO*: LockOut/TagOut

*LP*: Low Pressure

*NDT*: NonDestructive Testing

*OEM*: Original Equipment Manufacturer

*P&ID*: Process and Instrumentation Diagram

*PPE*: Personal Protective Equipment

*SCR*: Selective Catalytic Reduction system

*SNCR*: Selective NonCatalytic Reduction system

*UBC*: UnBurned Carbon

## 3 GUIDING PRINCIPLES

Equipment reliability and performance have parallels. Indications of poor performance are closely tied to those of reduced reliability. Abnormal wear patterns, poor cleanliness, increased corrosion and/or erosion, and

mechanical failures, no matter how small, have effects on both unit reliability and unit performance. Identifying the sources and root cause(s) are the first steps in improving the overall performance of a piece of equipment and the power generating unit of which it is a part. While these inspection guidelines are written to ultimately enhance the plant's performance, all observations should be noted and acted upon.

Nonmandatory Appendices A through J provide details on activities to be completed prior to starting an outage inspection.

### 3.1 Safety Considerations

All plant safety procedures should be reviewed prior to inspecting equipment and shall be followed.

Prior to inspecting or entering any equipment, it is important to identify all potential hazards that may be encountered. All energy sources must be removed from service or isolated to ensure, without failure, that no energy can be released into the area or component inspected. Nearby equipment supporting sister units may remain in service. In sites with multiple units, ensure one is inspecting the correct piece of equipment. Maintain a safe distance from rotating equipment and moving parts that are encountered near the inspection area.

Refer to Nonmandatory Appendix K for some of the safety considerations.

### 3.2 Preinspection Activities

Prior to any inspection, the following documents and information should be gathered and reviewed:

- (a) the last inspection report
- (b) recent operating data from control system historian and other available archives
- (c) recent operating history as recalled by current plant operations staff
- (d) actual versus expected performance for the component(s) of interest
- (e) as-built P&IDs and design specifications of the system(s) of interest

### 3.3 Inspection Plan

A plan or checklist for the inspection should be developed prior to starting the actual inspection, covering the objective of the inspection — whether this is a routine inspection or the specific details if a performance deficit has initiated the need for an extra inspection.

The plan should include a list of the equipment to be inspected and methods of accessing equipment where special PPE or confined spaces may be involved.

The plan for the inspection should be reviewed and discussed with plant operations staff for additional information on operating history prior to starting the inspection.

Equipment needed for the inspection should be organized prior to starting the inspection, e.g., cameras, flashlights, infrared temperature guns, and writing equipment. If necessary, arrangements should be made for temporary scaffolding or ladders.

### 3.4 Inspection Activities

During the inspection, the following activities are recommended:

(a) Inspect the unit or piece of equipment in a structured direction, e.g., from top to bottom, bottom to top, or front to back. This will help to provide complete coverage while minimizing time spent moving from one area to another.

(b) Record all information as observed; do not rely on mental notes. This is critical to ensure all findings will be included in the inspection report.

(c) Obey all site safety rules.

### 3.5 Postinspection Activities

The following items should be completed immediately following the inspection:

(a) Report the significant findings from the inspections to the responsible plant contacts.

(b) Report any safety issues found to correct and remove the hazards.

(c) Ensure all tools and materials taken on the inspection are returned to their proper storage locations and that nothing was left out in the field.

(d) Sign out on the appropriate forms, as needed (such as LOTO or confined space permits).

(e) Document all findings in a report that is retrievable in the future.

(f) Summarize all recommended actions and alert appropriate personnel as needed for implementation.

(g) Plan for a reinspection if recommended actions require it.

## 4 SPECIFIC EQUIPMENT CONSIDERATIONS

Additional documentation on specific equipment considerations is provided in the appendices.

## 5 INSTRUMENTS AND METHODS OF MEASUREMENT

The following is a list of some of the instrumentation available to support equipment inspections:

(a) digital/photographic camera

NOTE: Be sure to take notes with each picture — instrument ID, location, time, etc.

(b) ultrasonic depth meters for determining wall thickness of metal pieces

(c) rulers and tape measures

(d) magnifying glasses

## 6 REPORT OF RESULTS

When reporting the results of an outage inspection, the following information should be included:

(a) site information

(b) date and time of inspection

(c) names, positions, and affiliations of persons involved in inspection

(d) equipment included in inspection

(e) purpose of inspection

(f) instrumentation used during inspection

(g) analytical methods used, if applicable

(h) findings from inspection

(i) conclusions and/or recommendations

(j) uncertainty considerations — may be applicable to extrapolations of future expectations

(k) appendices for data collected in support of inspection, including

(1) raw data and measurements

(2) photos

(3) drawings or sketches

(4) P&IDs of selected systems, as appropriate

# NONMANDATORY APPENDIX A

## AIR HEATER (TUBULAR)

### A-1 GENERAL INSPECTION GUIDELINES

This is a general inspection procedure; not all areas or items will pertain to every air heater.

Equipment reliability and performance have parallels. Indications of poor performance are closely tied to those of reduced reliability. Abnormal wear patterns, poor cleanliness, increased corrosion, and mechanical failures, no matter how small, have effects on both unit reliability and unit performance. Identifying the root cause is the first step in improving the overall performance of a piece of equipment and the power generating unit it is a part of. While these inspection guidelines are written to ultimately enhance the plant's performance, all observations should be noted and acted upon.

#### A-1.1 Prior to the Outage

The following should be conducted prior to the outage:

- (a) Review the last inspection report.
- (b) Review recent operating history
  - air in-leakage
  - pressure drops, both air and flue gas sides
  - efficiency and x-factor
  - tube leak history and map
  - abnormal operating events
- (c) Contact plant operations for additional information on operating history.
- (d) Obtain the following drawings of the air heater prior to inspection to aid in the inspection and report/documentation:
  - elevation
  - penetrations
  - instrumentation
  - layout
- (e) It is recommended that thermography be used to locate hot or cold spots on the external casing of the air heater while it is in service. Any spot varying more than 10°F from the general area should be documented, as it may be caused by air in-leakage or loss of insulation.
- (f) Make a plan or checklist on the items and areas of interest that should be inspected. Identify which doors (manways) you plan to use to enter and exit the air heater.
- (g) Make a safety plan and conduct a briefing prior to entering the air heater. Ensure all participants are aware of their responsibilities, including looking out for

each other, obeying the outside safety watch person, and evacuation plans.

- (h) Gather personal safety equipment.
- (i) Gather cameras, flashlights, and writing equipment, and ensure sufficient lanyards are available for all equipment brought into the air heater.
- (j) If necessary, arrange for temporary scaffolding or ladders.

#### A-1.2 During the Inspection

The following should be conducted during the outage:

- (a) Record all information as observed; do not rely on mental notes. This is critical to ensure all findings will be included in the inspection report.
- (b) Obey all instructions from the outside safety watch person.

#### A-1.3 After the Inspection

The following should be conducted after the outage:

- (a) Report the significant findings from the inspections immediately to the responsible plant contacts. Safety issues require immediate reporting and correction to remove the hazards.
- (b) Ensure all material brought into the air heater as part of the inspection leaves with you.
- (c) Sign out on the appropriate forms.
- (d) Document all findings in a report that will be retrievable in the future.
- (e) Summarize all recommended actions.
- (f) Plan for a reinspection if recommended actions require it.

### A-2 PROCEDURES PRIOR TO EQUIPMENT SHUTDOWN

The procedures to be followed prior to shutdown are as follows:

- (a) The equipment to be inspected should be taken out of service. Equipment clearances or tagouts should be signed by appropriate personnel.
- (b) All energy sources, steam, soot blowers, fuels, and chemical injection equipment such as ammonia must be removed from service.
- (c) Consider double block and bleed-valve isolation for inspections if any connections exist to operating units.

(d) If other boiler back-pass maintenance activities (e.g., economizer, cleaning, or replacement) will be conducted during the outage, this inspection should be scheduled to avoid those times when work will be occurring directly overhead. Mechanical parts and tools are heavy and if dropped may present a serious threat to safety. If the ash hopper beneath the air heater has been removed, the open areas should be covered to prevent unanticipated ingress of tools and personnel.

(e) Inspecting an air heater involves heights, close spaces, hard metal, sharp edges, and fly ash. Inspectors should be physically fit and able to climb. They should not be bothered by feelings of claustrophobia.

### A-3 CONDUCTING THE INSPECTION

A tubular air heater inspection should be undertaken as a team effort. It is recommended that a minimum of three individuals participate. Utilizing inspection team members from maintenance, engineering, and operations will broaden the view and improve the findings. The participants may rotate as the outside safety watch or all three may enter simultaneously if the safety-watch function can be performed by another person. It is recommended that one person serve as scribe and another carry the camera or video-recording device. The notes/records may be recorded in writing or via sound recording to be transcribed immediately thereafter. Upon exiting the air heater, all notes, records, and photographs should be duplicated and stored separately to ensure preservation of this information.

This tube-leak check is a multipart inspection — first prior to any cleaning, then after cleaning, and even later if needed. The air side should not require cleaning; therefore, one internal inspection of that portion of the air heater is sufficient.

Many tubular air heaters are designed and built to contain two separate banks of tubes, located in series with respect to flue gas flow. Two separate banks of tubes means double of nearly everything, from tube sheets to instrumentation. Ensure all notes and recordings are accurately labeled for future reference to the correct bank of tubes, e.g., upper or lower.

#### A-3.1 Initial Inspection — Before Cleaning

The first inspection should be conducted prior to any cleaning activities in the air heater.

Check the insulation on the interior of the casing walls; ensure it is all in place and none has fallen. Check the interior casing walls for indications of air in-leakage. These may be manifested by discoloration or distinctive fouling.

Photograph or sketch the locations of any debris. Piles of ash may be significant; record their size and location. Look for wear patterns from soot blowers and look for cleaning patterns to identify any area missed. These are evidenced by shiny spots or defined fouling patterns.

Note any signs of debris, foreign material, and corrosion products. Material and tools may have been inadvertently dropped from activities in the ductwork above the air heater. Identifying the source of the foreign material will assist in preventing its recurrence. Large pieces of material may block the flow through a large number of tubes, degrading the heat transfer capability of the air heater. A localized concentration of corrosion products is typically the indication of a problem. A further investigation is warranted to determine the root cause and potentially prevent recurrence.

Check to ensure instruments and their connections are not buried, covered, or insulated by mounds of ash or other debris.

#### A-3.2 Second Inspection — After Cleaning

A second inspection should be conducted after the air heater is cleaned. This inspection will enable those entering the air heater to observe the actual mechanical condition of the components.

Again, look for wear patterns from soot blowers and look for cleaning patterns to identify any area missed. These are evidenced by shiny spots or areas with accelerated wear.

Note any signs of debris, foreign material, and corrosion products. Material and tools may have been inadvertently dropped from activities in the ductwork above the air heater. Identifying the source of the foreign material will assist in preventing its recurrence. A localized concentration of corrosion products is typically the indication of a problem. A further investigation is warranted to determine the root cause and potentially prevent recurrence.

#### A-3.3 Tube Sheets

The tube-to-tube-sheet seal should be inspected to ensure no leakage is occurring. Look for erosion or shiny wear spots. The tube sheet should be flat and not warped or uneven. If necessary, an ultrasonic depth gage can be used to determine any metal loss from the tube sheet. There should not be signs of any flow between the edges of the tube sheet and the sides of the air heater.

#### A-3.4 Tubes

The tubes should first be visually examined for damage, or the existence of foreign material, fouling, or scaling. This visual inspection may continue deeper into the tubes through the use of a video probe. If the tubes are not clean or clear, the source of the fouling or foreign material should be identified and the tubes should be cleaned; otherwise, performance will suffer and tube leaks may occur in the future.

The tube surfaces should be clean, free from debris, and unscarred. If a coating exists, a sample should be taken to later determine its content, source, and effect. Debris and foreign material should be gathered and removed, or arrangements should be made to ensure its

removal. If a scar is noticed on a tube or tubes, it should be inspected closely to determine if it is through the wall or may potentially progress, eventually compromising the tube's integrity prior to the next planned outage.

If tube leaks have occurred in the past, the map of plugged tubes should be used to ensure all plugs are intact. Ensure all plugs are secured and matched, i.e., each one on the inlet side is accompanied by one underneath, plugging the same tube. Quantitative tube-wall thickness measurements can be done with eddy-current testing.

There are several methods to determine which, if any, tubes are leaking. The most commonly used method is to "pressurize" the air side of this heat exchanger by starting a forced draft (FD) fan. Leaking tubes may then be identified by the airflow exiting from them. That airflow rate is typically very low and difficult to sense. Using a very lightweight and thin piece of paper or plastic sheet, cover a small number of tubes. If the sheet rises, a leak is present. Other methods include the use of sonic listening devices and the introduction of visible smoke.

### **A-3.5 Seals**

If visible, check the seals between the tube sheets and the sides of the air heater.

### **A-3.6 Instrumentation**

Examine the oxygen probes. Ensure they are undamaged and not heavily fouled with ash. If extractive, ensure the sampling holes are open and unobstructed. Verify the probes are fully inserted into the duct.

Ensure all thermowells are in place. These are commonly and incorrectly used as a step, and subject to erosion and other damage. Ensure they are undamaged and not heavily fouled with ash.

Check the penetrations used for pressure measurements and ensure they are open and unobstructed.

### **A-3.7 Soot Blowers**

The soot blowers should be checked for alignment. Their supports should be secure. The spray holes at the ends of the lances should be open and free from debris. Inspect the tube sheet and air heater internals directly in the path of the soot blower media for erosive damage.

### **A-3.8 Penetrations**

Examine the penetrations through the ductwork casing for signs of fatigue cracks, erosion, corrosion, or obstructions and pluggage. In advance of the inspection, inspectors should familiarize themselves with the location and purpose of these penetrations as identified on design drawings.

Check the gasket material and seals on the manways and other penetrations for potential air in-leakage sources.

## **A-4 AIR-SIDE INSPECTION**

The air side should be relatively clean. The existence of fly ash there is the sign of a leak and its source should be determined. Note any signs of debris, foreign material, and corrosion products. Identifying the source of the foreign material will assist in preventing its recurrence. A localized concentration of corrosion products is typically the indication of a problem. A further investigation is warranted to determine the root cause and potentially prevent recurrence.

### **A-4.1 Tubes**

Look between the tubes to identify any foreign material that may be caught therein. If a scar is noticed on a tube or tubes, it should be inspected closely to determine if it is through the wall or may potentially progress, eventually compromising the tube's integrity prior to the next planned outage.

### **A-4.2 Tube Support Sheets**

Examine all tube support sheets for structural soundness. These are installed to secure the tubes and prevent tube damage due to vibration, and to promote better heat transfer by routing the air across the tubes. The tube support sheets should be free of holes and firmly in place.

### **A-4.3 Seals**

If visible, check the seals between the tube sheets and the sides of the air heater.

### **A-4.4 Instrumentation**

Ensure all thermowells are in place. These are commonly and incorrectly used as a step and subject to physical damage.

Check the penetrations used for pressure measurements and ensure they are open and unobstructed.

### **A-4.5 Penetrations**

Examine the penetrations through the ductwork casing for signs of fatigue cracks, erosion, corrosion, or obstructions. In advance of the inspection, inspectors should familiarize themselves with the location and purpose of these penetrations as identified on design drawings.

Check the gasket material and seals on the manways and other penetrations for potential air leakage.

## NONMANDATORY APPENDIX B

### BLOWDOWN TANK

#### B-1 BLOWDOWN TANK INSPECTION GUIDELINES

This is a general inspection procedure; not all areas or items will pertain to every blowdown tank.

Equipment reliability and performance have parallels. Indications of poor performance are closely tied to those of reduced reliability. Abnormal wear patterns, poor cleanliness, increased corrosion, and mechanical failures, no matter how small, have effects on both unit reliability and unit performance. Identifying the root cause is the first step in improving the overall performance of a piece of equipment and the power generating unit it is a part of. While these inspection guidelines are written to ultimately enhance the plant's performance, all observations should be noted and acted upon.

#### B-2 OUTAGE

The following should be conducted prior to plant shutdown:

- (a) Review the last inspection report.
- (b) Review recent operating history.
- (c) Review feedwater chemistry.
- (d) Review blowdown flow rates.
- (e) Review steam turbine fouling.
- (f) Review steam turbine damage due to solid-particle erosion.
- (g) Contact plant operations for additional information on operating history.
- (h) Obtain the drawings and specifications of the blowdown tank prior to inspection, to aid in the inspection and report/documentation.
- (i) Make a plan or checklist on the items and areas of interest that should be inspected. The action plan should be justified and based on historic performance and maintenance.
- (j) Make a safety plan and conduct a briefing prior to the inspection.
- (k) Gather personal safety equipment.
- (l) Gather cameras, flashlights, and writing equipment, and ensure sufficient lanyards are available for all equipment that enters the feedwater heater.

- (m) If necessary, arrange for temporary scaffolding or ladders.

#### B-3 CONDUCTING THE INSPECTION

##### B-3.1 During Inspection

During inspection, the following shall be done:

- (a) Inspect the vessel systematically, from top to bottom or left to right, to ensure all internal areas receive adequate attention.
- (b) Record all information as observed; do not rely on mental notes. This is critical to ensure all findings will be included in the inspection report.

##### B-3.2 After Inspection

After inspection, the following shall be done:

- (a) Report the significant findings from the inspection immediately to the responsible plant contacts. Safety issues require immediate reporting and correction to remove the hazards.
- (b) Ensure all material brought into the blowdown tank as part of the inspection is withdrawn.
- (c) Document all findings in a report that will be retrievable in the future.
- (d) Summarize all recommended actions.
- (e) Plan for a reinspection if recommended actions require it.

#### B-4 PROCEDURES PRIOR TO EQUIPMENT SHUTDOWN

The procedures to be followed prior to shutdown are as follows:

- (a) The equipment to be inspected should be taken out of service. Equipment clearances or tagouts should be signed by appropriate personnel.
  - (b) All energy sources, steam, feedwater or recirculation pumps, layup, and chemical injection equipment such as those supplying a nitrogen blanket shall be removed from service.
  - (c) Consider double block and bleed-valve isolation for inspections if any connections exist to operating units.
- Inspecting a blowdown tank usually involves entering it through a manway with your head or upper body. It still presents many of the same hazards as those spaces in which your entire body enters the confined space.

## B-5 CONDUCTING THE INSPECTION

### B-5.1 General

A blowdown tank inspection should be justified and planned in advance. The frequency of inspection is dependent upon the history of chemistry-related problems on the steam side and feedwater portion of the plant. Scheduling when the tank will be open during an outage should incorporate any contingencies to ensure time exists to complete any required repairs. If wall thickness data or weld nondestructive testing (NDT) is desired, arrangements should be made to ensure personnel with those capabilities and the related instruments are available. The notes/records may be recorded in writing or via sound recording to be transcribed immediately thereafter. Upon completing the inspection of each blowdown tank, all notes, records, and photographs should be duplicated and stored separately to ensure preservation of this information.

### B-5.2 Internals

A visual inspection of the inside of a blowdown tank can be conducted with a video probe through an instrument connection. While it is not normal practice to conduct an internal inspection of the blowdown tank during each planned outage, occasional inspections can help identify the causes of chemistry problems and potential

solutions. There is not a lot of physical space inside the tank, though, and prior planning and very careful movements will help one conduct a safe internal inspection.

### B-5.3 Cleanliness/Debris/Corrosion

Note any signs of debris, foreign material, and corrosion products. Identifying the source of the foreign material will assist in preventing its recurrence. The foreign material should be removed prior to closing the vessel.

The site glasses, if installed, should be verified to be clean and clear, permitting a reasonable visual indication of level when the tank is in service.

### B-5.4 Penetrations

Examine all penetrations for structural soundness. In addition to a visual inspection, the welds may be checked via NDT methods.

### B-5.5 Wall Thickness

The wall thickness should be examined directly across from each high-energy penetration. Those have the potential to cause erosion of the opposite wall by impingement. The wall thickness of elbows on any lines transporting wet steam can be checked using NDT from the outside of the pipe.

## NONMANDATORY APPENDIX C

### CONDENSER STEAM SIDE

#### C-1 CONDENSER STEAM SPACE INSPECTION GUIDELINES

This is a general inspection procedure; not all areas or items will pertain to every steam condenser.

Equipment reliability and performance have parallels. Indications of poor performance are closely tied to those of reduced reliability. Abnormal wear patterns, poor cleanliness, increased corrosion, and mechanical failures, no matter how small, have effects on both unit reliability and unit performance. Identifying the root cause is the first step in improving the overall performance of a piece of equipment and the power generating unit it is a part of. While these inspection guidelines are written to ultimately enhance the plant's performance, all observations should be noted and acted upon.

##### C-1.1 Prior to the Outage

The following should be conducted prior to the outage:

- (a) Review the last inspection report.
- (b) Review recent operating history
  - air in-leakage/off-gas flow rates
  - dissolved oxygen in the condensate
  - actual versus expected backpressure
  - tube leak history and map
  - abnormal operating events
- (c) Contact plant operations for additional information on operating history.
- (d) Obtain the following drawings of the condenser prior to inspection, to aid in the inspection and report/documentation:
  - elevation
  - penetrations
  - instrumentation
  - layout
- (e) It is recommended to use thermography to locate hot or cold spots on the external casing of the LP turbine and condenser shell. Any spot varying more than 20°F from the norm should be documented.
- (f) Check the off-gas flow and dissolved oxygen in the hot well to determine if air in-leakage is higher than desired.
- (g) Make a plan or checklist on the items and areas of interest that should be inspected. Identify which doors (manways) you plan to use to enter and exit the condenser.

(h) Make a safety plan and conduct a briefing prior to entering the steam space. Ensure all participants are aware of their responsibilities, including looking out for each other, obeying the outside safety watch person, and evacuation plans.

(i) Gather personal safety equipment.

(j) Gather cameras, flashlights, and writing equipment, and ensure sufficient lanyards are available for all equipment brought into the condenser.

(k) If necessary, arrange for temporary scaffolding or ladders.

##### C-1.2 During Inspection

The following should be conducted during the outage:

(a) Inspect unit from top to bottom or vice-versa, as components are typically common across each horizontal plane.

(b) Record all information as observed; do not rely on mental notes. This is critical to ensure all findings will be included in the inspection report.

(c) Obey all instructions from the outside safety watch person.

(d) Avoid walking on the tubes. Utilize the tops of the support plates wherever possible.

##### C-1.3 After Inspection

The following should be conducted after the outage:

(a) Report the significant findings from the inspections immediately to the responsible plant contacts. Safety issues require immediate reporting and correction to remove the hazards.

(b) Ensure all material brought into the condenser as part of the inspection leaves with you.

(c) Sign out on the appropriate forms.

(d) Document all findings in a report that will be retrievable in the future.

(e) Summarize all recommended actions.

(f) Plan for a reinspection if recommended actions require it.

#### C-2 PROCEDURES PRIOR TO EQUIPMENT SHUTDOWN

The procedures to be followed prior to shutdown are as follows:

(a) The equipment to be inspected should be taken out of service. Equipment clearances or tagouts should be signed by appropriate personnel.

(b) Remove all energy sources, steam, feedwater or recirculation pumps, fuels, and chemical injection equipment such as the ammonia from service.

(c) Consider double block and bleed-valve isolation for inspections if any connections exist to operating units.

(d) If LP turbine maintenance is conducted during the outage, this inspection should be scheduled to avoid those times when work will be occurring directly overhead. Turbine parts and tools are heavy and if dropped may present a serious threat to safety. If the turbine casing has been removed, the open areas should be covered to prevent unanticipated ingress of tools and personnel.

(e) Inspecting a condenser steam space involves heights, close spaces, hard metal, and sharp edges. Inspectors should be physically fit and able to climb. They should not be bothered by feelings of claustrophobia.

### C-3 CONDUCTING THE INSPECTION

#### C-3.1 General

A steam-side condenser inspection should be undertaken as a team effort. It is recommended that a minimum of three individuals participate. Utilizing inspection team members from maintenance, engineering, and operations will broaden the view and improve the findings. Participants may rotate as the outside safety watch or all three may enter simultaneously if the safety-watch function can be performed by another person. It is recommended that one person serve as scribe and another carry the camera or video-recording device. The notes/records may be recorded in writing or via sound recording to be transcribed immediately thereafter. Upon exiting the condenser, all notes, records, and photographs should be duplicated and stored separately to ensure preservation of this information.

#### C-3.2 Cleanliness/Debris/Corrosion

Note any signs of debris, foreign material, and corrosion products. Material and tools may have been inadvertently dropped onto the tubes or into the hot well. Identifying the source of the foreign material will assist in preventing its recurrence.

#### C-3.3 Internal Piping

All piping should be inspected to ensure it is secure and contains no cracks or leaks. For feedwater heater extraction lines, refer to section C-9 below. In addition to the erosion caused by moisture impingement, corrosive elements and high cycle fatigue due to induced vibrations may be at work in this volume. The piping carrying the off-gas flow is susceptible to corrosion due to the nature of its contents. Many pipes are located around

the turbine bearings, which is in a high-velocity area. All supports should be checked. The bearing slop drains may run through the condenser steam space and eventually penetrate the condenser shell. If this pipe is breached, it becomes a source of air in-leakage that is difficult to identify during operation. A leak or crack in this pipe also may introduce oil into the condenser. Some designs of bearing slop drains contain flanged connections, which should be examined closely.

#### C-3.4 Supports

The support members ensure the condenser is structurally intact. These may experience erosion and corrosion. Ensure they are intact, stable, and able to bear load.

#### C-3.5 Instrumentation

Examine the sensor tubing used for extraction steam pressures. The tubing typically spans a portion of the steam space and if damaged will cause erroneous measurements of the extraction steam pressure. Some higher-pressure extraction steam pipes may also have instrument tubing containing the wires for temperature-measuring devices. A loss of integrity will degrade the instrument and yield a faulty, if any, signal.

The single most important parameter affecting power plant performance is that of condenser backpressure. These measurements are recorded by devices outside the condenser shell. To ensure the proper drainage of any condensate forming inside the sensor tubing, that tubing must slope continuously downward towards the process. With the very high exhaust steam velocities existing in the condenser steam space, basket tips or guide plates should be installed on the end of each backpressure sensor tube. Examine those velocity-reducing devices to ensure they are intact and continue to serve the purpose for which they were designed. Expect several sets of sensor tubing at each LP turbine exhaust.

There should be several sets of level taps used to monitor and control the condensate level in the hot well. Ensure all are open and free from debris.

All temperature probes should be encased in a thermowell. Temperature probes may be located on the LP turbine shell and in the hot well.

#### C-3.6 Baffle Plates

Examine all baffle plates for structural soundness. These are installed to prevent tube damage by absorbing or deflecting the high energy flow entering the condenser and are subject to wear and failure. If any baffle plates are found in the hot well, identify its source and ensure the penetration it was covering is covered with a replacement. Examine all unprotected penetrations for signs that a baffle was previously installed and may have torn loose.

### C-3.7 Spargers

Spargers permit the introduction of high-energy steam or water into the condenser and reduce its impact on the tubes and surrounding structures. They also enhance the deaeration of makeup water. The holes on spargers should be checked to ensure they are not enlarged or constricted; either would reduce their effectiveness. The sparger should be secured and not present a future danger to nearby tubes. Its end cap should be in place.

### C-3.8 Tubes

The tube surfaces should be clean, free from debris, and unscarred. If a coating exists, a sample should be taken to later determine its content, source, and effect. Debris and foreign material should be gathered and removed, or arrangements should be made to ensure their removal. An attempt should be made to determine the source of the debris and foreign material, and if it is from within the condenser steam space, that area should receive thorough inspection. Look between the tubes to both identify any foreign material that may be caught therein and the condition of staking. If a scar is noticed on a tube or tubes, it should be inspected closely to determine if it is through the wall or may potentially be through the wall soon.

### C-3.9 Hot Well

The hot well should be drained in advance of the inspection, permitting a view of the entire volume. It should be free of debris and foreign material. The source of debris and foreign material found should be identified to prevent recurrence. Actions should be initiated to remove any sludge. Examine the entire bottom, including any "false" floors. Look in low-flow areas, e.g., the corners, or around supports or seams. Holes or cracks permitting air in-leakage can sometimes be identified by discoloration or the buildup of corrosion products. Examine the screens on the sump(s) for hot well or condensate pumps. Ensure the screens are secure and unobstructed.

### C-3.10 Feedwater Heaters and Extraction Piping

Extraction steam piping routed from LP turbines to feedwater heaters is typically found in the condenser

steam space. Feedwater heaters are sometimes also located in the condenser steam space. If these components are covered with lagging type insulation, all sections should be examined to ensure the lagging is secure and in place. The extraction steam piping typically contains expansion joints, which have a life of 10 yr to 25 yr. The failure mode is usually catastrophic, so any signs of degradation of the corrugated bellows should be taken as a call to action for replacement. Many of those expansion joints are covered for protection. Those covers must be secure; otherwise they pose a threat to the tubes located beneath them. Some expansion joints contain stabilization bars or other devices to limit their movement; those should be examined. The specifications of those expansion joints should be reviewed in advance of the inspection, to ensure the bars installed for shipment are still not in place and viewed as normal devices but instead overly limit the ability of the expansion to function correctly.

### C-3.11 Penetrations

Examine the penetrations through the condenser shell for signs of fatigue cracks, erosion, or corrosion. In advance of the inspection, inspectors should familiarize themselves with the location and purpose of these penetrations as identified on design drawings.

### C-3.12 Turbine-Condenser Flange (Boot Seal)

On smaller units, the flanged joint between the turbine exhaust and the condenser may be metal to metal. On many units, that joint is comprised of a rubber, flexible boot seal, permitting some expansion and movement. That seal has a finite life and may catastrophically fail, causing a loss of vacuum and a unit trip. It may leak and be the source of air in-leakage and poor backpressure. Therefore, the entire length of the boot seal should be inspected. Any burnished, worn, frayed, or discolored spots should be examined closely and noted on the report. Some boot seals are covered by metal deflectors. The deflectors should be structurally sound and not loose. One may remove those deflectors for a better look at the boot seal.