Performance-Related Outage Inspections

AN AMERICAN NATIONAL STANDARD

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ASME POM 101-2013

Performance-Related Outage Inspections

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers
Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: January 17, 2014

The next edition of this Standard is scheduled for publication in 2019. There will be no written interpretations of the requirements of this Standard issued to this edition.

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The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

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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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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.

NONMANDATORY APPENDIX D CONDENSER WATER BOX AND TUBE-SIDE INSPECTION GUIDELINES

D-1 CONDENSER WATER BOX 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.

D-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

- actual versus expected cooling-water temperature rise
- 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 water box elevation drawings and tube map prior to inspection, to aid in the inspection and report/documentation.

(e) 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 each water box.

(f) 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.

(g) Gather personal safety equipment.

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

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

D-1.2 During Inspection

The following should be conducted during the outage:

(a) Inspect water box from top to bottom or vice-versa. Also, at each level consistently move in the same direction horizontally to ensure full coverage.

(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-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 water box as part of the inspection leaves with you.

(c) Sign out on the appropriate forms.

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

(e) Summarize all recommended actions.

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

D-2 CONDUCTING THE INSPECTION

D-2.1 General

A condenser water box inspection should be undertaken as a team effort. It is recommended that a minimum of two 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 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 condenser water boxes, all notes, records, and photographs should be duplicated and stored separately to ensure preservation of this information. Most power plants contain two or more water boxes and all notes should be properly labeled to ensure they refer to the correct water box.

D-2.2 Cleanliness, Corrosion, and Cleaning

D-2.2.1 Initial Inspection. The initial inspection should occur prior to any cleaning activities. The initial inspection of the tube sheets shall verify surface cleanliness. Debris, biogrowth, and sediment should be removed prior to any cleaning or testing of the individual tubes. Any loose debris and all debris lying within the first few inches of the tubes should be removed. If the debris on the surface of the tube sheet is significant, high-pressure water cleaning should be performed.

D-2.2.2 Inspection After Cleaning. After cleaning the tube sheet, a general inspection shall be conducted to verify its condition. Any pitting, erosion, separation, or other defects should be noted and plant personnel informed.

Inspection of the tube-to-tube-sheet joints is required to determine potential problems and/or current issues that have not been discovered. The inspection should look for separation between the tube and tube sheet, cracking, or general corrosion.

If the tube sheet has an existing coating, the coating should be inspected for cracks, air pockets, chips, and/or any major loss of the coating that will leave the tube sheet exposed.

D-2.2.3 Inspection for Fouling. Individual tubes should be inspected for fouling. Conduct a visual inspection of the tubes by scanning the entire tube sheet, looking down the inside diameter of the tubes for visual comparison to determine if all areas are similar in cleanliness or if some areas, such as the top or bottom sections of the tube sheet, have different levels of fouling.

This visual inspection should be conducted on both the inlet and outlet ends of the tubes. In many cases, one end of the tube may be significantly more fouled than the other, as a result of water temperature and/or flow conditions.

Note the findings for reference as you proceed with the remainder of the inspection.

D-2.2.4 Mechanical Cleaners. To verify the amount or the presence of down-tube fouling, it is suggested that mechanical tube cleaners, such as metal scraper or brush-type cleaners, be shot through sample tubes and that the deposits being removed by these cleaning tools be captured in a container for qualitative and quantitative analysis.

(a) This captured sample can be strained and filtered, leaving only the fouling material in the sample.

(b) The fouling can then be analyzed for its quantitative and qualitative content.

(c) Samples should be gathered from various sections of the condenser, in order to determine if the fouling material is consistent.

(d) It is recommended that a second sample be taken of these sampled tubes to determine if all removable fouling has been successfully removed.

(e) If there is considerable fouling found in the second-pass or even third-pass cleaning sample, it may be determined that multiple cleaning passes are required. If the tube debris is such that a cleaner cannot be shot, or becomes lodged and unable to be removed, the suitable tube plug should be installed into both the inlet and outlet ends of the tube.

(f) There are multiple tube-cleaning tool designs available; therefore, it would be beneficial to evaluate different-style cleaning tools in this same way to determine which tool is most effective.

D-2.2.5 Borescope/Videoscope. To further qualify the extent of tube cleanliness, an inspection can be done by inserting a borescope or videoscope into individual tubes.

In this type of inspection, it is recommended to inspect prior to and after sample-tube cleaning. It is also recommended to inspect from both the inlet and outlet ends of the tube and as far down the tube length as possible, depending on the length of scope or probe being used.

The results of the borescope inspection, combined with the comparison of the tube deposits gathered during sample tube cleaning, are excellent ways to determine condenser cleanliness and the effectiveness of the chosen cleaning method.

The video inspection also provides a means of determining the condition of the tubes and whether an eddy-current test is needed. Some tube damage can be observed visually and through the use of the videoscope.

Identifying the source of the foreign material will assist in preventing its recurrence. Most cooling water systems contain one or more methods of excluding foreign material (e.g., screens, debris filters, etc.). Depending upon the material found, the component can be identified that failed or is unable to preclude its entrance into the condenser.

While in the water box, an inspection of any sacrificial anodes should be conducted to verify condition.

D-2.3 Eddy-Current Testing

Eddy-current testing on a sample of tubes provides information to determine the general condition of the condenser tubes.

If considerable tube wall loss or tube pitting is noted, it is recommended that you expand this testing to analyze the extent of the problem.

Plugging of tubes should be completed on those tubes that exceed the standards set by the plant.

D-2.4 Expansion Joints

Flexible expansion joints may be located between the cooling water piping and the water boxes to accommodate different thermal growth rates of those components during startup, operation, and shutdown. They should be inspected to ensure no cracking, tears, or damage is visible that may progress and create a leak or catastrophic failure during operation prior to the next planned outage.

D-2.5 Instrumentation

There may be several sets of level taps used to monitor and control the level in each water box. Ensure all are open and free from debris.

All temperature probes should be encased in a thermowell. Temperature probes may be located in the cooling water piping upstream/downstream of the water boxes. The thermowells should be free of debris and undamaged.

D-2.6 Penetrations

Examine the penetrations through the water box 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.

D-2.7 Valves

In addition to inlet and outlet isolation valves, the water boxes may contain large valves used for backwashing. Examine the seats and disks of all visible valves to ensure they are free from obstructions and they provide a seal.

D-3 PROCEDURES PRIOR TO EQUIPMENT SHUTDOWN

Prior to entry into the condenser, the following should be addressed:

(a) Identify and resolve hazards, thus eliminating potential accidents.

(b) Verify the need for confined-space permitting and complete appropriate training and record keeping.

(c) Perform an air quality test.

(d) There should be proper lighting, adequate to inspect the water boxes and associated piping.

(e) Floor openings should be noted and proper coverings should be installed to allow for safe maneuverability throughout both water boxes.

(f) Verify the plant lockout/tagout procedures and the implementation of those procedures.

(g) Valves should be inspected to verify full shut-off capability.

(h) The equipment to be inspected should be taken out of service. Equipment clearances or tagouts should be signed by appropriate personnel. The cooling water pumps shall be out of service. The cooling water system shall be isolated; all inlet and outlet valves shall be shut and verified to be closed and not leaking.

(i) Water-box drains should be inspected to assure they are in proper working condition and no obstructions exist. Obstructions should be removed and/or plant personnel notified to ensure that water will drain. Once that is verified, grating or plywood should be installed over the drains to prevent damage to the drain and for the safety of the crews.

(j) All energy or fluid sources (e.g., chemical injection, spongy ball injection equipment) must be removed from service.

(k) Inspecting condenser water boxes may involve 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.

(l) Prior to any inspection or cleaning process, it should be determined if scaffolding is required to reach all areas of the tube sheet.

NONMANDATORY APPENDIX E
COOLING TOWER OUTAGE INSPECTION GUIDELINES

E-1 INSPECTION GUIDELINES

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

E-1.1 General Inspection Considerations

(a) Tower. Understand the tower operation and construction, as they will influence the inspection process. Some examples include

- natural draft, forced draft, crossflow, etc.
- materials of construction
- fill type: high efficiency, splash, etc.

(b) Tower Integrity. Plant operations can greatly affect the integrity of the cooling tower. For instance, if the yearly capacity of the plant is 30%, then we can assume the tower is sitting idle for extended periods of time. It is important to understand the consequences of this type of operation. An example is an increase in biological activity or an increase in corrosion rates, both of which affect the integrity of the piping and fill.

(c) Drawings. P&IDs/drawings will improve the quality of the inspection by

(1) improving the ability to communicate inspection findings and any corrective actions that need to take place.

(2) helping to determine the root cause of any failures identified during the inspection. For instance, if iron fouling is found in the fill, understanding the entire system may help determine the origin of the iron fouling and how to prevent the recurrence.

(3) identifying heat exchangers supplied by the cooling tower for subsequent inspections.

If P&IDs are not available, hand sketches are acceptable.

(d) Makeup of the Water Source. Understanding the chemistry of the makeup source can also help guide the inspection. For example, if a particular makeup source is high in silica, there may be an increased potential for amorphous silica; therefore, cooling-tower fill would be an extremely critical portion of the inspection. Understanding if the makeup source varies will also help to understand any failures identified during the inspection.

(e) Review of Operating Chemistry. Upsets in tower chemistry can lead to many problems seen during the inspection. A good understanding of the operating chemistry, and all upsets experienced, can improve the ability to identify root causes during the inspection.

(f) Digital Photographs. Digital photographs are critical for any inspection. It is one thing to describe what was seen; it is another to show what was seen. Digital photographs help when sharing ideas with, as well as asking for assistance from, others. They are relatively easy to share. Digital photographs also help to determine year-over-year conditions and allow for determination of improvement or worsening of any existing conditions.

(g) Analyses. Analyses are critical in understanding what may be causing a particular issue. They can help identify root causes, as opposed to chasing down symptoms. Examples of pertinent analyses are

(1) water analyses — particularly makeup source; tower water if still some available

(2) biological analyses — any biofilms or sludge collected during the inspection; particularly fill slime or basin sludge

(3) deposit analyses — any scaling seen in the fill, fill fouling, and strainer fouling

(h) Equipment Inspection. When inspecting equipment, ensure that all measurements or recordings are in accordance with the manufacturers' specifications. For instance, belt tension, oil levels, blade pitch, and many others need to all be within manufacturers' specifications. Some may change setpoints in accordance with their previous experience with similar, although not the same, types of equipment; this rarely ends up being a positive change for the plant operations.

E-1.2 Fan Inspection Guidelines

The following should be considered:

(a) fan deck support condition

(b) loose tension rods, staves, panels, bands, and bracing

(c) missing air seals

E-1.2.1 Blades. Determine the following:

(a) Has there been a change in blade clearance from the fan cylinder?

(b) Is there any corrosion and fouling of the fan blades?

(c) Is there any cracking in the fan blades, which is sometimes brought on by abnormal obstructions?

(d) Is there improper pitch on fan blades?

(1) Is the tower operating with the proper L:G ratio? All towers are designed for a certain L:G ratio. These ratios are set by the manufacturer, and the blade pitch is adjusted to achieve the desired L:G. Changing the pitch will change the L:G.

(2) Has the amp draw on fan motors changed recently?

(3) Many plants will re-pitch in order to decrease the amp draw on the motors. While this may save on electricity use to operate the fan, the change in tower efficiency will negate this savings.

(e) Are all blades set at the same pitch?

(f) Is the blade tip level in accordance with the design?

E-1.2.2 Gear Driven. Check gear-driven fans as follows:

(a) Drive shaft and coupling alignment should be checked.

(b) Check for misalignment in the fan drive mechanism from broken motor mounts, fungus, and iron rot in wooden support members, and corrosion in steel support members.

(c) Ensure proper lubrication of bearings and gears, and check for leaky gearboxes.

(d) Gearbox oil level and quality should be checked and maintained according to the manufacturer's specifications.

E-1.2.3 Belt Drive. Belt tension systems and drive alignment should be checked on a monthly basis.

E-1.2.4 Drive Shaft. The following applies to the drive shaft:

(a) Bearings should be lubricated every 2,000 hr or every 3 mo.

(b) Check for corroded drive shaft, oil lines, drive shaft guard, and gearbox, often causing improper oil level in the gearbox.

(c) Vibration cutout switch (VCOS) must be operational and maintained.

E-1.3 Water Distribution

E-1.3.1 Headers. The following apply to headers:

(a) If possible, visually inspect all headers for obstruction. This is particularly critical in systems that operate with high-turbidity waters. Typically, when turbidity levels are high, a large amount of debris can collect in the ends of the headers, which will greatly affect proper water distribution.

(b) Is there any scale and debris accumulation in the water distribution system piping and nozzles?

(c) Is distribution piping corroded or broken?

(d) Is there failure of fasteners and/or wood deterioration causing distribution trough leaks, spreading of troughs, and unlevel troughs?

(e) Is there drying out of the tower during downtime, causing cracks in the distribution system and consequent leaks?

E-1.3.2 Distribution Nozzles. The following apply to distribution nozzles:

(a) For spray nozzles, are there missing splash plates or deteriorated splash boards?

(b) Are all nozzles intact?

(c) Are all nozzles present?

(d) Are nozzles obstructed with scale or debris?

Nozzles are critical to ensure proper water distribution and prevent channeling. Channeling can cause drying in areas of the fill, which can lead to scale formation. Channeling can also lead to large amounts of water falling across a small section of the fill, thus impeding evaporation. Both events decrease tower performance. Improper water flow will affect L:G and degrade cooling tower performance.

E-1.3.3 Strainers. Check the following for strainers:

(a) Installed?

(b) Free of obstruction?

(c) Any corrosion taking place?

(d) How often are they being cleaned?

(e) Any tower related issues due to lack of a PM for cleaning strainers?

E-1.3.4 Tower Decks. Some towers have water distribution decks instead of a network of distribution piping. The following apply:

(a) The deck should have a uniform water level, and the gravity distribution holes, which feed the distribution nozzles, should be free of obstruction. If the water level is not level, it is typically related to a riser valve synchronization issue. Is the water overflowing over the deck weirs? This can be an indication of imbalanced flow control or obstruction of distribution holes.

(b) Algae is of particular concern with systems where the decks are not closed and are exposed to sunlight.

(c) Because this area typically sees the hottest bulk water temperatures, scaling and fouling typically occur in the tower-deck section. This can be scale such as calcium carbonate, as well as iron or other metals fouling.

Even in field-erected towers that employ the use of a lateral system, the tower decks may be uncovered, which can lead to algae growth in the drift eliminators and fill below. It is always advised that the decks be covered and shielded from sunlight.

E-1.4 Fill

Consider the following:

(a) Is any chemical attack observed?

(b) Is there a biological surface attack causing fill sagging?

(c) Is there deposition between fill sheets?

(d) If biological attack and scale are found, which came first? Again, it is important to find the root cause, not the symptom. Understanding the chemistry during normal operation will help determine this.

(e) Is the tower located near a field or other industry, such as concrete plants? Because towers act as very good scrubbers, outside influences can cause fouling of the fill, which can in turn cause physical damage. Debris accumulation on the fill can cause airflow disturbances, which can then alter the performance of the tower during normal operation.

(f) The top section of the fill is most prone to deposition, due to the natural effects of the evaporation profile across the fill.

(g) Are fill slats out of position?

(h) Is there fill damage by ice, particularly in forced draft towers?

(i) Is there mud, oil, or scale accumulation?

(j) Are there air and water leaks in casing walls? Casing wall leaks can cause short-circuiting of air and water, thus degrading cooling tower performance.

E-1.5 Basin

Consider the following:

(a) When was the basin last cleaned?

(b) Are there any water leaks?

(1) Does the conductivity of the bulk water fluctuate greatly, particularly during downtime? This can indicate a leak, since you are losing concentrated water and replacing it with dilute makeup.

(2) If a leak is suspected, ensure there is not a basin level control issue causing an overflow, which may be assumed to be a leak.

(c) Check the basin sludge level. Sludge can cause problems in heat exchangers as well as tower fill. If a large amount of sludge is present, is there a large amount of biological growth underneath? This is typically associated with a black sludge and foul odor. Bioactivity can be detrimental to the basin, regardless of the material of construction. Anaerobic bacteria secrete acids that corrode metals and can cause deterioration of concrete basins.

(1) Is the sludge located near circulating water pumps?

(2) Is the sludge at the ends of the basin?

(3) Is the sludge due to low flow areas?

(d) Is there visible deterioration or corrosion of the basin? If so, is it being caused by

(1) high sulfates or chlorides? Sulfates are aggressive to both galvanized and concrete basins; chlorides are aggressive to both galvanized and stainless basins.

(2) cracks?

(3) concrete damage due to excess sulfates, cracks, and/or deformation?

(e) Check the presence and condition of screens ahead of circulating water pumps.

(1) Are screens obstructed with debris? Where did it come from? How do we prevent it from recurring?

(2) Is there corrosion of screens?

(f) Are there corrosion and fouling of pumps?

E-1.6 Louvers

Consider the following:

(a) Is there an obstruction? Check for

- algae
- debris
- scale
- mud

(b) Are there sagging louver boards? If applicable, is there wood deterioration?

(c) Are there missing louvers?

(d) Is there corrosion of connection hardware?

E-1.7 Plenum

This is defined as the enclosed space between the drift eliminators and the fan in the induced draft towers, or the enclosed space between the fan and the fill in forced draft towers. Broken or missing drift-eliminator slats and sections caused by deterioration of wooden or metal holders can cause bypass of air, drift loss, and improper air distribution.

E-1.8 Chemical Injection

E-1.8.1 Inhibitor Feed. Check line integrity. Does the location provide adequate mixing?

E-1.8.2 Acid Feed. The following apply:

(a) Check for proper dilution

- Fed to side stream for motive/dilution water?
- Acid dilution box?

(b) Is there concrete or metallurgy damage near the injection point?

Acid will be aggressive to all basin materials of construction. The key is to ensure the feed system is set up properly.

E-1.8.3 Bleach Feed. Check the following:

(a) Is bleach distributed evenly across the backside of the tower?

(b) Is piping free of obstruction and crystallized bleach?

(c) For a wood tower, is bleach attacking the wood? See wood inspection in para. E-1.10.

E-1.9 Piping and Valving

E-1.9.1 Blowdown. Answer the following:

(a) What is the method of blowdown?

(b) In reviewing the chemistry logs, have the cycles of concentration been controlled consistently? If not, this could indicate a blowdown control issue, such as uncontrolled blowdown via leaks in the piping, basin, etc.

(c) Is the blowdown taken from the basin, riser, or other? It should be off the return to where hot water is blown down.

(d) Is the control system manual or automated? Are there any issues experienced with the control system?

(e) Where does the discharge go?

(1) How does it affect the plant and is further inspection of downstream equipment needed?

(2) Has the blowdown control caused any issues with discharge permit limits?

E-1.9.2 Makeup. Answer the following:

(a) How is makeup controlled?

(1) Is it based on a level sensor? If so, how well does the system work? Excessive foaming in a cooling tower can have adverse effects on many level sensors.

(2) What is the source of the makeup water? Is it high in metals or turbidity? Both can cause fouling in other tower components such as fill.

(3) Has the tower experienced overflow incidents, indicating poor level control and uncontrolled blowdown? This not only affects the chemical program, but affects the program costs, both chemical and in water usage.

E-1.9.3 Risers. Answer the following:

(a) Is piping intact?

(b) Is water-distribution balance achieved during normal operation?

(c) Are control valves operating as needed?

(d) If a gravity-fed distribution system is being used, are the riser valves able to maintain the appropriate water level throughout the distribution deck?

E-1.10 Support Structure

E-1.10.1 Wood. The following outlines the mechanisms by which a wood structure can be compromised.

E-1.10.1.1 Chemical Attack: Delignification Due to Removal of Lignin. Lignin is the component that binds to the cellulose fibers, providing strength and hardening of the cell walls. Excessive chlorination, less than 1.0 ppm for extended periods, or improper location of bleach feed can cause delignification. This typically affects a thin layer on the external surface but it can be much deeper under prolonged conditions; it is most prevalent in the flooded sections of the tower.

E-1.10.1.2 Biological Surface Attack. This is commonly called *soft rot.* It

(a) is caused by fungi that attack the cellulose of damp wood and primarily leave lignin.

(b) has a dark appearance on the wood surface. Active growth of wood-destroying fungi is typically confined to the surface layers unless the wood is allowed to dry frequently.

E-1.10.1.3 Biological Internal Attack. This occurs below the surface of the wood and goes undetected until the infection spreads widely. The decay can be white rot, attacking both cellulose and lignin and leaving a spongy, stringy mass; or brown rot, attacking the cellulose and leaving a brown cubelike pattern. This type of attack is more apt to occur in warm, moist, but unflooded portions of the tower.

E-1.10.1.4 Iron Rot. This is a chemical attack caused by the formation of iron salts around corroding ferrous parts that are in contact with wood. The wood has a charred appearance and may be more susceptible to fungi attack.

E-1.10.2 Galvanized. Galvanized components are very susceptible to white rust, which can be due to high pH, i.e., above 8.3. White rust can appear as either a very tenacious or very soft white, chalky formation. Low hardness levels can also promote white rust formation.

Low pH can also cause a loss of the zinc coating, thus promoting corrosion.

Elevated chloride and sulfate levels can promote corrosion of galvanized parts, particularly wet/dry areas and areas where tower drift may come in contact.

Consult the manufacturers' operational manuals for recommended water chemistry limits.

E-1.10.3 Structural Inspection. Consider the following:

(a) Are there bowing columns?

(b) Are there sagging braces?

(c) Is there loss of any pieces of structure?

(d) For bolts and bracing,

(1) loose?

(2) deteriorating?

(3) stainless bolt corrosion due to high chloride concentrations in the bulk water?

(4) galvanized hardware may be used and is susceptible to corrosion under high pH extremes, as well as chloride and sulfate concentrations

(e) What is the appearance of the wood, and the depth at which the loose material could be scraped off with a dull instrument?

(f) The breaking strength and brittleness of fill, splash boards, and drift eliminators can be tested by hand.

(g) When the surface of the wood material is touched, is it soft, stringy, spongy, or intact and solid?

(h) When inspecting for internal rot, an icepick or screwdriver can be used for probing. How deep does the probe penetrate the wood? How easily does it penetrate? A penetration of greater than $\frac{1}{4}$ in. could be an indication of internal rot. If the probe penetrates and feels like when a stud is missing on a Sheetrock wall, this is also an indication of internal rot.

(i) Striking a wood member with a hammer should give good resonance if the wood is sound. If the sound is a dull thud or hollow, internal rot may be present.

E-1.11 Ladders and Walkways

Consider the following:

(a) Are they stable and intact?

(b) Some are manufactured using galvanized parts and are susceptible to corrosion as outlined in the section above.

(c) Is all the connecting hardware present?

NONMANDATORY APPENDIX F
ELECTROSTATIC PRECIPITATOR

F-1 PROCEDURES PRIOR TO OUTAGE

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

The following review should be conducted prior to the outage:

(a) Review the last inspection report.

(b) Review recent operating history[1]

(1) actual versus grain loading

(2) actual versus electrical readings

(3) maintenance work orders related to rappers, wires and plates, and shorts or field trips

(4) abnormal operating events

(c) Contact plant operations for additional information on the operating history.

(d) Obtain the ESP elevation drawings prior to inspection, to aid in the inspection and report/documentation.

(e) 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.

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

(g) Follow proper lockout/tagout procedure, including grounding actions.

(h) Gather personal safety equipment.

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

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

F-2 INSPECTION PROCEDURES

F-2.1 During Inspection

The following should be conducted during the outage:

(a) Don appropriate Personal Protection Equipment before inspection.

(b) Inspect ESP boxes from top to bottom or vice-versa. Also, at each level consistently move in the same direction horizontally to ensure full coverage.

(c) 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.

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

F-2.2 After Inspection

The following should be documented after the outage:

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

(b) Safety issues require immediate reporting and correction to remove the hazards.

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

(d) Sign out on the appropriate forms.

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

(f) Summarize all recommended actions.

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

F-3 SPECIFIC INSPECTION GUIDELINES

F-3.1 General

Inspection should comprise a multidisciplinary team — operators, mechanical and I&E maintenance staff, specialist/engineer, and OEM (consultants) if required. All findings should be recorded and properly documented in inspection data sheets with pictures. This, together with previous reports, will serve as the maintenance plan for the current outage. The main objective is to improve ESP performance, lower the outlet

[1] In addition to the ESP operating history, other boiler and air heater (AH) operating history, and recent test results (boiler gas flow, boiler casing air in-leakage, fly ash unburned carbon (UBC)/loss on ignition (LOI), AH air in-leakage and gas outlet temperatures, SO_2 and SO_3 concentration, induced draft fan and/or booster fan amp and power history, etc., will be useful as documentation and for root cause analysis. If flue gas conditioning is used, then operating history (flow, ppm) should be collected as documentation and for root cause analysis.

grain loading to downstream equipment, and lower the gas flow/draft losses/fan power.

F-3.2 Inspection Categories

Due to different vintages and rapping devices, the inspection is broadly categorized as follows.

F-3.2.1 Mechanical. General appearance and ash deposition before maintenance cleaning — ductwork and expansion joints, cracks, wires or discharge electrodes (DE) and plates or collecting electrodes (CE), flow conditioning devices, any in-leakages, wet appearances, and unusual buildup.

(a) Check for proper alignment and clearances of DE and CE, and tolerance allowed.

(b) Plate and wires (slacked and broken wires, bowed plates, corrosion, and erosion).

(c) Condition of frames — plate assembly and rigid DE.

(d) Insulators including rapper/shaft/vibrators and stand-off insulators of DE frame.

(e) Rappers (hammers, pneumatic, vibrators, electromagnetic, electric, etc.), roof and side wall penetrations, and rapper/shock bar.

(f) If chronic buildup exists and rapping energy/G-force is a suspect, could conduct certain rapping intensity test for inadequacy of G-force.

(g) Inlet gas conditioning devices — turning vanes, straightening devices, perforated plates, and rapping system if equipped.

(h) Outlet gas conditioning devices — turning vanes, perforated plates, and rapping system if equipped.

(i) Hoppers (plate and ESP proper interface and air in-leakage condition, ash bridging, deposition, rat hole), vibrators/fluidizing devices, level detectors, and heaters.

(j) Bypass – anti-sneakage plates/devices, ash hopper.

(k) If applicable, check condition and operating history with respect to the ESP flue gas inlet.

(l) Flue gas conditioning system – SO_3 and ammonia — skid, metering, injection system, and nozzles.

(m) Check SNCR – skid, metering, dilution/injection system and injection nozzles, setpoint versus actual, and ammonia slip.

(n) SCR operating history – ammonia slip and (total) SO_3.

F-3.2.2 Instrumentation and Electrical. Inspect

(a) grounding and ground cables (doors, frame, etc.)

(b) TR sets – access area with insulators (tracking, appearances), ducts and cables, and associated cable trays

(c) rappers and rapper controls

(d) controllers/automatic voltage control – check settings and parameters after maintenance or replacement

(e) ESP flue gas pressure drop – check condition of sensing lines and transmitters

(f) particulate or opacity monitors (if equipped) — check condition

F-3.2.3 Wet Electrostatic Precipitator (WESP). For WESP applications, the attention to detail is the same as dry ESP, with similar mechanical and electrical inspection of field alignment, DE and CE conditions, and electrical equipment. The exception is the lack of a rapping system; however, there is the wet or water side. Since WESP is usually the last emissions control equipment and most are designed to collect acid mist and minor carryover from scrubbers, attention should focus on wet and acidic corrosion as mentioned below.

F-3.3 Additional Subsystems

Inspect the following:

(a) wash water system, head tanks, and valves and pumps

(b) purge and/or acid recycle and conductivity control, and makeup water subsystems

(c) internal to each field (upflow stage): wash headers, nozzles, weirs, and troughs

(d) deposition along wet/dry zones, water coverage/distribution, and coloration on CE (if fiberglass, look for smoothness, peeling, uneven wet zones, etc.)

(e) DE insulator boxes — cleanliness/puddling/tracking; purge air annulus from insulator box (dry side) to internal (wet side)

(f) purge air system — condition of heaters, dampers and operators, headers and branches

NONMANDATORY APPENDIX G
FEEDWATER HEATERS AND DEAERATORS

G-1 GENERAL INSPECTION GUIDELINES

This is a general inspection procedure; not all areas or items will pertain to every feedwater heater. While it is not normal practice to conduct an internal inspection of each feedwater heater during each planned outage, occasional inspections of misperforming heaters can help identify the causes and potential solutions. An inspection may be for only a portion of the items following in this document, just pertaining to the problem experienced from the previous operating data analysis.

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.

G-1.1 Prior to the Outage

The following review should be conducted prior to the outage:

(a) Review the last inspection report.

(b) Review recent operating history

- terminal difference
- feedwater temperature rise
- drain cooler approach (where applicable)
- feedwater pressure drop
- tube leak history and map
- abnormal operating events

(c) Contact plant operations for additional information on operating history.

(d) Obtain the drawings and specifications of each feedwater heater prior to inspection, to aid in the inspection and report/documentation.

(e) Make a plan or checklist on the items and areas of interest that should be inspected. This plan of which feedwater heaters should be opened and inspected should be justified based on historic performance and maintenance.

(f) Make a safety plan and conduct a briefing prior to the inspection.

(g) Gather personal safety equipment.

(h) Gather cameras, flashlights, and writing equipment, and ensure sufficient lanyards are available for all equipment that enters the feedwater heater.

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

G-1.2 During the Inspection

The following should be conducted during the outage:

(a) Inspect the heat exchanger systematically, from top to bottom or left to right, to ensure all tubes and other 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.

G-1.3 After the Inspection

The following should be documented 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 feedwater heater 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.

G-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, feedwater or recirculation pumps, and layup and chemical injection equipment such as those supplying a nitrogen blanket must be removed from service.

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

Inspecting a feedwater heater usually involves entering the end bell of the heat exchanger with your head or upper body. While not a typical confined space since egress is much easier, it still presents many of the same hazards as those spaces in which your entire body enters the confined space.

G-3 CONDUCTING THE INSPECTION

A feedwater heater inspection should be justified and planned in advance. The frequency of inspection is dependent upon the history of operation, performance, and maintenance of the heater. Scheduling when the heater will be open during an outage should incorporate any contingencies to ensure time exists to complete any required repairs. If eddy-current testing of the tubes or other wall thickness data 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 feedwater heater, all notes, records, and photographs should be duplicated and stored separately to ensure preservation of this information.

For those feedwater heaters located in the condenser neck, refer to the section on condenser steam space inspection. The next four sections pertain to shell and tube heat exchangers; the following section pertains to deaerating heaters, and the last section pertains to both types of heaters.

G-4 CLEANLINESS, DEBRIS, AND CORROSION

Note any signs of debris, foreign material, and corrosion products. Identifying the source of the foreign material will assist in preventing its recurrence.

G-4.1 Partition Plate

Leakage of cold feedwater to the heater outlet can be avoided if the partition plate and the associated hardware are intact. The partition plate should be visually inspected for any signs of wear or erosion. If signs of wear or erosion are evident, the wall thickness of the plate should be determined and compared to design. Check the hardware, gaskets, or other materials that keep the partition plate in place and maintain the seal between the feedwater inlet and outlet. Again, signs of erosion, bolt-hole enlargement, or other signs of unintended flow paths should be identified.

G-4.2 Tube Sheet

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 heater shell. Inspect the seal between tube to tube sheet, independently if it is welded or compression fit.

G-4.3 Tube ID

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 or performance will suffer and tube leaks may occur in the future.

If tube leaks have occurred in the past, the map of plugged tubes should be used to ensure all plugs are intact. Quantitative tube wall thickness measurements can be done with eddy-current testing.

G-4.4 Shell Side

A visual inspection of the shell side can be conducted with a video probe through an instrument connection.

G-4.5 Tube Support Sheets

The tube support plates should be secure and parallel to each other, perpendicular to the tubes. The holes should not be enlarged or uneven.

G-4.6 Baffle Plates

Examine all baffle plates for structural soundness. These are installed to prevent tube damage by absorbing or deflecting the high energy flows entering the heater and are subject to wear and failure. If any unattached baffle plate is found in the belly of the heater, 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.

G-4.7 Drain Cooler Section (Where Applicable)

Inspect the "can" surrounding the drain cooler section for cracks, holes, or other openings. It should contain the final pass of tubes.

G-4.8 Tubes

The external surfaces of the tubes should be clean and undamaged. If fouling or scaling is identified, a sample should be acquired to determine its composition and source to prevent further buildup. Those surfaces should be clean for maximum performance. If the tubes experienced excessive vibration, fretting or wear may be evident at some of the support sheets.

G-5 DEAERATORS AND THEIR DRAIN/STORAGE TANKS

Deaerators are usually larger vessels than shell and tube feedwater heaters, and can permit human entry. However, there is not a lot of space, and prior planning and very careful movements will help one conduct a safe internal inspection. Once inside the heater, a video probe can assist the inspection.

G-5.1 Cleanliness, Debris, and Corrosion

Note any signs of debris, foreign material, and corrosion products. Identifying the source of the foreign material will assist in preventing its recurrence. Due to the potentially corrosive atmosphere that may exist in a deaerator while in service, check for signs of flow-accelerated corrosion (FAC) or other wear in all metal components.

G-5.2 Trays

The trays should be secure and undamaged. They should be checked for signs of wear.

G-5.3 Drain Tank

The internal supports should be examined to ensure structural integrity. In addition to a visual inspection, the welds may be checked via nondestructive testing (NDT) methods.

G-6 EXTRACTION STEAM PIPING

The inside of extraction steam piping can be viewed using a flexible video probe as accessed through an instrument connection, high-point vent, or low-point drain. The nonreturn check valve should be checked to ensure it is in place and fully functional. (The wall thickness of elbows on wet extraction steam lines can be checked using NDT from the outside of the pipe.)

NONMANDATORY APPENDIX H
HEAT RECOVERY STEAM GENERATORS

H-1 INTRODUCTION

This is a general inspection procedure; not all areas or items will pertain to every HRSG. If HRSGs contain upper and lower dead air spaces, both should be inspected to properly complete the procedure.

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.

H-2 PROCEDURES PRIOR TO EQUIPMENT SHUTDOWN

Prior to inspection, check the following:

(a) the last inspection report

(b) if the unit is scheduled for SCR catalyst sample/coupon testing

(c) the unit from front to rear, stack being the rear of the unit

Obtain a side elevation drawing of the unit prior to inspection to aid in documentation.

Access doors are numbered from front to rear. The number one (1) access door is located in the CT's outlet ductwork just before the high-pressure superheater.

Before the unit is shut down for inspection, it is recommended to use thermography to locate hotspots on the external casing. The location(s) of any hotspot greater than 130°F should be documented.

Record all information and findings on the inspection report.

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

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

All energy sources, steam, feedwater or recirculation pumps, fuels, and chemical injection equipment such as the ammonia must be removed from service.

Consider double block and bleed valve isolation for drum inspections when two or more HRSGs are tied to a common steam turbine. Then confirm no leak-through of the root valves on common systems, HP, IP, or LP.

H-3 DUCTWORK

Any part of the HRSG exterior that contains flue gas and HRSG tubes is considered ductwork. Ductwork configuration varies with each vendor but typically consists of insulation between liner plates (HRSG interior) that are held to an external casing by anchor pins. The HRSG gas-tight exterior casing is typically made from carbon steel, and liner plates are generally made from stainless steel in high-temperature areas and carbon steel in low-temperature areas.

H-3.1 Offline Visual Inspection

Inspect and record the overall condition of the HRSG exterior casing and interior (liner plates). Check for missing or damaged sections, loose or missing fasteners, corrosion, and deposits on the interior of liner plates. Inspect all locations where pressure parts penetrate the external casing.

H-3.1.1 HRSG Exterior. Inspect and record the overall condition of the HRSG ductwork for

(a) hotspots on exterior ductwork. Areas where the ductwork paint has stripped off and there is metal discoloration may be due to hotspots. They can also be found prior to shutdown using a thermographic camera.

(b) any openings (or cracks) in ductwork that allow flue gas to escape. Leaks can often be identified during an offline inspection by the discolored smear flue gas on the ductwork.

(c) water collection points. These points are susceptible to corrosion and may develop weep holes.

H-3.1.2 HRSG Interior. Inspect and record the general condition of the liner plates (HRSG interior).

(a) Check for cracks, physical damage, and deformation in liner plates.

(b) Check welds for cracks.

(c) Record any missing sections.

(d) Check for loose or missing fasteners.

(e) Check tack welds on washers. These tack welds prevent spinning and wear.

(f) Check for deposits on liner plates, especially in sections downstream in the HRSG. Collect samples for testing.

(g) Check deposit distribution, if any. This gives an indication of the types of operational/distribution conditions that exist.

H-3.1.3 GT Outlet (Gas Inlet to HRSG). This area is extremely turbulent. Liner attachments are usually on closer spacing with batten channels installed for additional support.

(a) Inspect cover plates for misalignment, bending, or warpage.

(b) Liner plates at the area of open duct, especially from the turbine exhaust to the first bank of tubes which is exposed to the highest velocity of GT exhaust, must be inspected thoroughly.

(c) Check liner plates for deformation such as warping and buckling due to binding and high-temperature ramp rates.

(d) Inspect studs for gouging due to rapid movement of liner plates.

(e) Tack welds and nuts must be inspected for erosion.

(f) Check for damaged or missing batten channels (it may be difficult to identify missing sections). If any missing sections are identified, debris may be located downstream of the HRSG.

H-3.1.4 Penetrations. Inspect penetrations and record misaligned tubes. Check for physical damage of HRSG exterior ductwork and liner plates (and tubes) from tubes due to vibration.

H-3.1.5 Supports, Guides, and Expansion Joints. Inspect supports, guides, and expansion joints.

H-3.1.6 Bypass Stack. The following apply to the bypass stack:

(a) Inspect the damper, guides, and ductwork interior.

(b) Ensure that all inside skin casings are intact.

(c) Check inside skin casings for

- misalignment
- missing sections
- binding
- warpage
- missing hold-down clips

(d) Inspect the damper for missing components, worn guides, or binding.

(e) Check that insulation is intact; pay particular attention to the expansion joints and the blanking plate.

(f) Inspect the gas shields around the expansion joints for damage.

If the bypass stack silencer and upper portions need inspection, an outside contractor will be needed to install rigging. An NDE contractor will be needed to perform thickness testing of the stack walls. Still visually inspect and record any physical damage that is visible from base level.

Inspection frequencies are dependent upon plant operational schedule and resource availability, and are not recommended herein.

H-3.2 Ductwork Notes: Hotspots and Leaks

Hotspots usually occur in areas where there are missing liner plates and the insulation has broken down due to exposure to flue gas. There are also areas where the liner plates are intact (possibly warped) but there is insulation breakdown. In this case, the breakdown of insulation may have been caused by moisture degradation of the insulation.

Hotspots can best be found with the thermographic camera before shutdown.

H-4 HP SECONDARY SUPERHEATER

H-4.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom; some are bottom-supported with expansion guides located at the top.

(b) Tubes are finned tubes.

(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.

(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

H-4.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.

(b) damaged fins on tube elements.

(c) deformed tubes.

(d) deposits on tube elements and fins. Collect samples for testing where possible.

(e) deposits or debris on roof and floor of HRSG.

(f) corrosion.

H-4.2.1 Tube Elements. Inspect tubes for physical damage and check for

(a) damaged fins on tube elements.

(b) warped or deformed tubes.

(c) misaligned tube elements.

(d) tube bundle misalignment.

(e) deposits, corrosion, and debris. Collect samples for testing where possible.

(f) deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube-support problems or thermal-expansion issues.

H-4.2.2 Pole Baffles. Thorough inspection of the existing baffles is very important at this location.

(a) Inspect baffles for warping.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged guide vanes on baffles.
(d) Inspect guide-vane welds for cracks.
(e) Inspect baffle penetrations.

H-4.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the HP secondary superheater since they are in the direct path of the GT exhaust gas.

(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-4.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities. Check for

(a) warpage of tube sheets.
(b) cracks in welds or in tube-sheet material.
(c) damaged or missing sections.
(d) misalignment. Misalignment may cause damage to tube fins.

H-4.2.5 Lower Shield. Inspect shield for

(a) warpage
(b) cracks in welds or in shield material
(c) damaged or missing sections
(d) guide misalignment and missing bolts and fasteners

H-5 SECONDARY REHEATER

H-5.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom; some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

Care should be taken when entering this area, since the Pyro-Bloc insulation may be installed and is damaged easily. The Pyro-Bloc insulation is a ceramic fiber with a coating of inorganic hardening agent and is susceptible to trampling. Plywood should be installed prior to entering this section, to protect insulation.

H-5.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-5.2.1 Tube Elements. Inspect tubes for

(a) physical damage.
(b) damaged fins on tube elements.
(c) warped or deformed tubes.
(d) misaligned tube elements.
(e) tube bundle misalignment.
(f) deposits, corrosion, and debris. Collect samples for testing where possible.
(g) deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-5.2.2 Center Baffle. Inspect center baffle for

(a) warpage
(b) cracks in welds
(c) missing or damaged sections

H-5.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the HP secondary superheater since they are in the direct path of the GT exhaust gas.

(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-5.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or any abnormalities.

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-5.2.5 Lower Shield. Proceed as follows:

(a) Inspect lower shield for warpage.
(b) Check for cracks in welds or in shield material.

(c) Check for damaged or missing sections and loose or missing fasteners.

H-5.2.6 Pyro-Bloc Module (If Applicable). A Pyro-Bloc module is composed of two monolithic pieces of edge grain ceramic fiber with an internal yoke and two support tubes. It is covered with a sprayed-on inorganic hardening agent to improve its velocity resistance. It protects the outer casing from the flame generated from the duct burners combined with the hot gas from the CT.

Refer to the manufacturer's manual for more information on the structure of the module.

(a) Inspect module for damage.
(b) Check for missing sections.
(c) Check for deposits. Collect samples for testing where possible.
(d) Inspect hardening agent and assess if reapplication is needed.
(e) Inspect downstream fins for ceramic fiber (evidence of Pyro-Bloc erosion).

H-6 DUCT BURNERS AND CATALYSTS

H-6.1 General

The duct burners are located downstream from the secondary reheater. There are four rows of burner runners; each row consists of a gas runner with orifices and flame retention baffles on the top and bottom of the runner. The baffles help create a recirculation zone to assure stable ignition and combustion.

H-6.2 Offline Visual Inspection

Proceed as follows:

(a) Inspect the overall condition of the burner runners and baffles. Check for
  (1) cracks.
  (2) damaged elements.
  (3) deformed elements.
  (4) deposits. Collect samples for testing where possible.
(b) For burner runners and baffles
  (1) inspect for physical damage
  (2) check for damaged supports on burner assemblies
  (3) check for warped or deformed baffles
  (4) check for runner integrity
(c) Inspect fuel supply piping.
(d) Inspect burner supports.

H-6.3 SCR Catalysts

H-6.3.1 Ammonia Injection Grid (AIG). Proceed as follows:

(a) Inspect for damage and binding.
(b) Inspect ammonia injection grid structure and supports.
(c) Check for pluggage due to foreign objects inside nozzles. If extruded nozzles are installed, check for missing sections. If there are any missing sections, check if the missing section(s) is logged in the catalyst or has caused damage to the catalyst.
(d) Check for runner integrity. This is of critical importance; plugged nozzles can lead to severe system underperformance. Any debris from the vaporization system will lead to plugged nozzles.
(e) Check for deformation and corrosion.
(f) Inspect injection lance wall penetrations.
(g) Confirm the condition of tube banks downstream for evidence of any deposits and plugging.

H-6.3.2 CO Catalyst. Proceed as follows:

(a) Look for evidence of flow imbalances (strange dusting pattern).
(b) Inspect the support frame (reactor) for deformation or physical damage such as cracks.
(c) Check support frame for corrosion.
(d) Check for catalyst deformation or physical damage.
(e) Check for any shift in catalyst layer.
(f) Check for dust erosion of catalyst.
(g) Check catalyst for pluggage and dust accumulation.
(h) Collect any corrosion and/or deposit sample where applicable.
(i) Remove catalyst test sample for laboratory testing if required.

H-7 PRIMARY REHEATER

H-7.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom; some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

H-7.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-7.2.1 Tube Elements. Proceed as follows:
(a) Inspect tubes for physical damage.
(b) Check for damaged fins on tube elements.
(c) Check for warped or deformed tubes.
(d) Check for misaligned tube elements.
(e) Check for tube bundle misalignment.
(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.
(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-7.2.2 Center Baffle. Inspect center baffle for
(a) warpage
(b) cracks
(c) missing or damaged sections

H-7.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the primary reheater since they are in the direct path of the duct burners and GT exhaust gas.
(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-7.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.
(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-7.2.5 Lower Shield. Proceed as follows:
(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment.

H-8 HP PRIMARY SUPERHEATER

H-8.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.
(a) Most tubes are top-supported with tube bundle guides at the bottom; some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

H-8.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for
(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-8.2.1 Tube Elements. Proceed as follows:
(a) Inspect tubes for physical damage.
(b) Check for damaged fins on tube elements.
(c) Check for warped or deformed tubes.
(d) Check for misaligned tube elements.
(e) Check for tube bundle misalignment.
(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.
(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-8.2.2 Center Baffle. Inspect center baffle for
(a) warpage
(b) cracks in welds
(c) missing or damaged sections

H-8.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the primary reheater since they are in the direct path of the duct burners and GT exhaust gas.
(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-8.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.
(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.

(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-8.2.5 Lower Shield. Proceed as follows:

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment.

H-9 HP EVAPORATOR

H-9.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom. Some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

H-9.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-9.2.1 Tube Elements. Proceed as follows:

(a) Inspect tubes for physical damage.
(b) Check for damaged fins on tube elements.
(c) Check for warped or deformed tubes.
(d) Check for misaligned tube elements.
(e) Check for tube bundle misalignment.
(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.
(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-9.2.2 Center Baffle. Inspect center baffle for

(a) warpage
(b) cracks in welds
(c) missing or damaged sections

H-9.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the primary reheater since they are in the direct path of the duct burners and GT exhaust gas.

(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-9.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-9.2.5 Lower Shield. Proceed as follows:

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment.

H-10 IP SUPERHEATER

H-10.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom; some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

H-10.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-10.2.1 Tube Elements. Proceed as follows:

(a) Inspect tubes for physical damage.
(b) Check for damaged fins on tube elements.
(c) Check for warped or deformed tubes.
(d) Check for misaligned tube elements.
(e) Check for tube bundle misalignment.

(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.
(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-10.2.2 Center Baffle. Inspect center baffle for
(a) warpage
(b) cracks in welds
(c) missing or damaged sections

H-10.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the IP superheater.
(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-10.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.
(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-10.2.5 Lower Shield
(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.

H-11 HP/IP PRIMARY ECONOMIZER

H-11.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.
(a) Most tubes are top-supported with tube bundle guides at the bottom; some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

Close inspection of adjoining headers at the floor location is recommended. Differential expansion between the IP and HP sections may result in damage. Pay attention to straightness of the bundle and individual tubes. Bowed tubes indicate differential thermal expansion and future tube failures at tube-to-header connections.

H-11.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for
(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-11.2.1 Tube Elements. Proceed as follows:
(a) Inspect tubes for physical damage.
(b) Check for damaged fins on tube elements.
(c) Check for warped or deformed tubes.
(d) Check for misaligned tube elements.
(e) Check for tube bundle misalignment.
(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.
(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues. Record the location of bowed tubes for analysis of the root cause of the damage and for future inspections to monitor the change in damage or distortion. Distorted tubes may be located at baffles or feeder and riser tubes.

H-11.2.2 Center Baffle. Inspect the center baffle for
(a) warpage
(b) cracks in welds
(c) missing or damaged sections

H-11.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the HP primary economizer tube.
(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-11.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.
(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.

(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-11.2.5 Lower Shield. Proceed as follows:

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.

H-12 LP EVAPORATOR

H-12.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom. Some are bottom-supported with expansion guides located at the top.
(b) Tubes are finned tubes.
(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.
(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

In addition to the normal gas-side issues, it is critical that NDE methods are utilized to determine the presence and extent of flow-accelerated corrosion (FAC); see para. H-12.2.6.

H-12.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.
(b) damaged fins on tube elements.
(c) deformed tubes.
(d) deposits on tube elements and fins. Collect samples for testing where possible.
(e) deposits or debris on roof and floor of HRSG.
(f) corrosion.

H-12.2.1 Tube Elements. Proceed as follows:

(a) Inspect tubes for physical damage.
(b) Check for damaged fins on tube elements.
(c) Check for warped or deformed tubes.
(d) Check for misaligned tube elements.
(e) Check for tube bundle misalignment.
(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.
(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-12.2.2 Center Baffle. Inspect the center baffle for

(a) warpage
(b) cracks in welds
(c) missing or damaged sections

H-12.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the IP superheater.

(a) Inspect baffle for warpage.
(b) Inspect baffle welds for cracks.
(c) Check for missing or damaged sections.
(d) Inspect wall connection for cracks.
(e) Check for excessive gaps that allow gas bypassing.
(f) Check for binding due to thermal expansion.

H-12.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.
(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-12.2.5 Lower Shield. Proceed as follows:

(a) Inspect tube sheets for warpage.
(b) Check for cracks in welds or in tube-sheet material.
(c) Check for damaged or missing sections.

H-12.2.6 Flow-Accelerated Corrosion (FAC). Flow-accelerated corrosion occurs at the pressure and temperature typically found in LP systems.

(a) If the alloy of the riser pipes to the LP drum are confirmed to be P-11 or an alloy with a minimum chrome equivalency content, the risk of FAC damage in that area is small. If unsure of the alloy, it is recommended that the insulation be stripped off the risers from the LP evaporator to the drum; alloy test to confirm the installed material and, if not chrome alloy, then the pipe thickness should be mapped downstream at every change in flow direction of riser pipes and at the upper tube bends to the header (i.e., check each bend). It may be possible to do an internal inspection of the riser tube with a video probe from inside the LP drums to confirm the surface appearance and any visual FAC damage. Refer to section H-17 for the LP drum internal inspections.
(b) Similar to the riser pipe, the downcomers and feeder or supply tubes from the downcomers to the lower headers should be inspected for any indications of FAC damage.

The inspection will be necessary on an annual basis until sufficient trend data is available to predict wastage rates. Inspection frequencies should be extended for units with chrome alloy components. Some units have partial sections of tubing or piping with chrome alloys and these areas will not require the same frequency of inspection. A unit with chrome alloys may delay inspections until 5 yr of base load operations or less if operated in a cyclic mode. Reassemble insulation and consider removable sections with periodic inspection maintenance in mind.

H-13 FW HEATER

H-13.1 General

The front row is easily accessible for inspection. It will be difficult to inspect the other rows of tubes.

(a) Most tubes are top-supported with tube bundle guides at the bottom. Some are bottom-supported with expansion guides located at the top.

(b) Tubes are finned tubes.

(c) Baffles are installed in the gas path to reduce gas bypassing and improve heat transfer.

(d) When conducting an inspection, look as deeply in the tube bundles as possible for any defects.

In addition to the normal gas-side issues, it is critical that NDE methods are utilized to determine the presence and extent of flow-accelerated corrosion (FAC); see para. H-13.2.6. This examination must include the return bends at the top of the economizer, and the outlet and inlet piping.

H-13.2 Offline Visual Inspection

Inspect the overall condition of the tube elements and fin structure. Check for

(a) cracks.

(b) damaged fins on tube elements.

(c) deformed tubes.

(d) deposits on tube elements and fins. Collect samples for testing where possible.

(e) deposits or debris on roof and floor of HRSG.

(f) corrosion.

H-13.2.1 Tube Elements. Proceed as follows:

(a) Inspect tubes for physical damage.

(b) Check for damaged fins on tube elements.

(c) Check for warped or deformed tubes.

(d) Check for misaligned tube elements.

(e) Check for tube bundle misalignment.

(f) Check for deposits, corrosion, and debris. Collect samples for testing where possible.

(g) Inspect deposit distribution.

Inspect deposit distribution and damaged fin distribution, if any, for any unusual patterns. This may give an indication of operating and/or distribution problems in HRSG.

Typically corrosion is heavier in this area because of cooler tubes.

Tube bundle misalignment may indicate tube support problems or thermal expansion issues.

H-13.2.2 Center Baffle. Inspect the center baffle for

(a) warpage

(b) cracks in welds

(c) missing or damaged sections

H-13.2.3 Side Baffles. The side baffles should be thoroughly inspected, especially those in the FW heater tubes.

(a) Inspect baffle for warpage.

(b) Inspect baffle welds for cracks.

(c) Check for missing or damaged sections.

(d) Inspect wall connection for cracks.

(e) Check for excessive gaps that allow gas bypassing.

(f) Check for binding due to thermal expansion.

H-13.2.4 Tube Sheets. Tube sheets are installed in horizontal sections; they help to keep tubes aligned during operation. During inspection, look as far as possible in the tube bundles for any damage, misalignment, missing sections, deposits, or abnormalities.

(a) Inspect tube sheets for warpage.

(b) Check for cracks in welds or in tube-sheet material.

(c) Check for damaged or missing sections.

(d) Check for misalignment. Misalignment may cause damage to tube fins.

H-13.2.5 Lower Shield. Proceed as follows:

(a) Inspect tube sheets for warpage.

(b) Check for cracks in welds or in tube-sheet material.

(c) Check for damaged or missing sections.

H-13.2.6 Flow-Accelerated Corrosion (FAC). The critical area to examine for FAC is the final return bend at the top of the economizer. NDE thickness measurements should be used to map wastage rates in this zone. This inspection should be done biannually.

H-13.2.7 Inlet Header. The inlet header/economizer tube stub region is subject to thermal shock in service. A biannual inspection of the pipe internal bore at the tube holes is recommended.

H-14 SUPPORTS, GUIDES, AND EXPANSION JOINTS

H-14.1 CT/HRSG Main Expansion Joint

H-14.1.1 General. The expansion joint is located at the GT exit and the HRSG inlet duct.

H-14.1.2 Visual Inspection. Inspect the overall condition of the expansion joint.

(a) Inspect joint cover plates.

(b) Ensure there is no binding of the plates but they are maintaining protection for the joint.

(c) Check for tears in fabric.

(d) Check for overextension.

H-14.2 General Ground Level

Walk around and under the HRSG exterior and examine every penetration. Check all the bellows expansion joints, insulated pipe and header drains, tube bundles guides, beam supports, column supports, and grouting.

(a) Check for loose or broken grouting on columns and pedestals.

(b) Check for pipes with damaged or missing insulation.

(c) Check for deformed, cracked, or misaligned bellows expansion joints.

(d) Check header and drain guides for alignment.

H-14.3 General Top Level

Walk around the top of the HRSG exterior and examine every hanger, support, and downcomer penetration. Check all the drum pedestals, line hangers, and gratings. At this level, inspections will be made inside the HP, IP, and LP drums. Check for

(a) lines and pedestals with out-of-alignment issues

(b) pipes with damaged or missing insulation

(c) deformed, cracked, or misaligned expansion joints

(d) alignment and condition of supports

H-15 HIGH-PRESSURE DRUM

H-15.1 General

Proceed as follows:

(a) Check for any deposits or debris upon entry. Any debris found should be placed in a sample bottle and sent to the lab for identification.

(b) Normal HP drum coating would be a light layer of black magnetite for optimal chemistry.

(c) Inspect condition of the manway and manway gasket surface.

(d) Check for any cracks in external welds and any signs of leaking.

(e) Check for lock welds or jam nuts on internal bolted attachments.

H-15.2 Offline Visual Inspection

Inspect the overall condition of the assemblies inside. Any debris found should be placed in a sample bottle and sent to the lab for identification.

H-15.2.1 Chevron Dryers. Check

(a) that chevron dryers are in place and all brackets are secure

(b) supports for damage or cracks

H-15.2.2 Vortex Duct. Check the vortex connector duct and separator for cracking and alignment.

H-15.2.3 Piping and Tubing. Check

(a) the general condition of tube penetrations. Check for cracks in welds or any physical damage.

(b) for plugged tubes.

(c) that the feedwater piping is intact.

(d) that all brackets and bolting are in place.

For an example of a high-pressure drum, see Fig. H-15.2.3-1.

H-16 INTERMEDIATE-PRESSURE DRUM

H-16.1 General

Proceed as follows:

(a) Check for any deposits or debris upon entry. Any debris found should be placed in a sample bottle and sent to the lab for identification.

(b) Inspect condition of the manway and manway gasket surface.

(c) Check for any cracks in external welds and for any signs of leaking.

H-16.2 Offline Visual Inspection

Inspect the overall condition of the assemblies inside. Any debris found should be placed in a sample bottle and sent to the lab for identification.

H-16.2.1 Chevron Dryers. Check that the chevron dryers are in place and all brackets are secure.

H-16.2.2 Vortex Duct and Separators. Check the vortex duct and separators for cracking and alignment.

H-16.2.3 Piping and Tubing. Check

(a) the general condition of tube penetrations. Check for cracks in welds or any physical damage.

(b) for plugged tubes.

(c) that the feedwater piping is intact.

(d) that all brackets and bolting are in place.

See Fig. H-16.2.3-1 for an example of an intermediate-pressure drum.

H-17 LOW-PRESSURE DRUM AND INTEGRAL DEAERATOR

H-17.1 General

Proceed as follows:

(a) Check for any deposits or debris upon entry. Any debris found should be placed in a sample bottle and sent to the lab for identification.

(b) Inspect condition of the manway and manway gasket surface.

(c) Inspect for evidence of FAC damage in the riser baffle plates and the downcomer entrances.

(d) Check for any cracks in external welds and for any signs of leaking.

H-17.2 Offline Visual Inspection

Inspect the overall condition of the assemblies inside.

H-17.2.1 Chevron Dryers. Check

(a) that the chevron dryers are in place and all brackets are secure

(b) supports for damage or cracks

H-17.2.2 Drum Baffles. Proceed as follows:

(a) Check the baffles for cracking and alignment.

(b) Inspect baffles for FAC damage where the riser tubes penetrate the drum. If damage is found, additional inspection is recommended for FAC damage in the LP and feedwater sections.

H-17.2.3 Piping and Tubing. Check

(a) the general condition of tube penetrations. Check for cracks in welds or any physical damage.

(b) for plugged tubes.

(c) that the feedwater piping is intact.

(d) that all brackets and bolting are in place.

H-17.3 Integral Deaerator

Proceed as follows:

(a) Inspect trays for damage and orientation, and that they are in place and have not shifted.

(b) Loosen bolts on upper tray retaining bar and slide bar upward so that the trays can be removed.

(c) Remove trays from the tray compartment and inspect for deposits or damage.

(d) To remove and inspect the spring-loaded nozzles, the trays and the access door cover in the preheater section floor must be removed.

(e) The spring-loaded nozzles should be inspected to ensure that they are in place and free of sediment and deposit.

(f) Record all defects on the data sheet provided and report them to the foreman and/or supervisor or outage manager.

See Figs. H-17.3-1 and H-17.3-2 for examples of integral deaerators and low-pressure drums, respectively.

H-18 STACK AND STACK DAMPER

H-18.1 Stack

Inspect the general condition of the stack. Check for damage, cracks, and any unusual condition where possible.

It is recommended that UT inspection of stack wall thickness should be done every 6 yr.

H-18.2 Stack Damper

Walk the access walkway around the stack at the damper location and examine the damper area. Inspect the overall condition of the stack damper, linkage, and actuator. Check

(a) the damper for alignment, broken welds, and missing components

(b) for any loose fasteners

(c) piping connections, solenoid fasteners, limit switches, and any other controls for looseness

Refer to the manufacturer's manual for maintenance guidelines.

H-18.2.1 Damper Flange. Inspect damper flange for damage or corrosion. Check for any signs of leakage at the flange.

H-18.2.2 Blades. Proceed as follows:

(a) Inspect the overall condition of the damper blades.

(b) Check that the blade shaft bearings are lubricated and appear to be working.

H-18.2.3 Blade Seals. Check blade seals for damage, looseness, or missing sections. Damaged or loose seals will prevent proper sealing and possibly prevent damper operation. Damaged seals should be recorded for immediate replacement.

H-18.2.4 Linkage. Proceed as follows:

(a) Linkage hinge pins ride in self-lubricating sintered bronze bearings. Check for metal (bronze) filings on and around the linkage.

(b) Check the linkage for damage.

H-18.2.5 Packing Glands. The manufacturer recommends inspecting packing glands after 3 mo of operation and retightening as required. For offline inspection, inspect glands for damage, corrosion, or anything unusual.

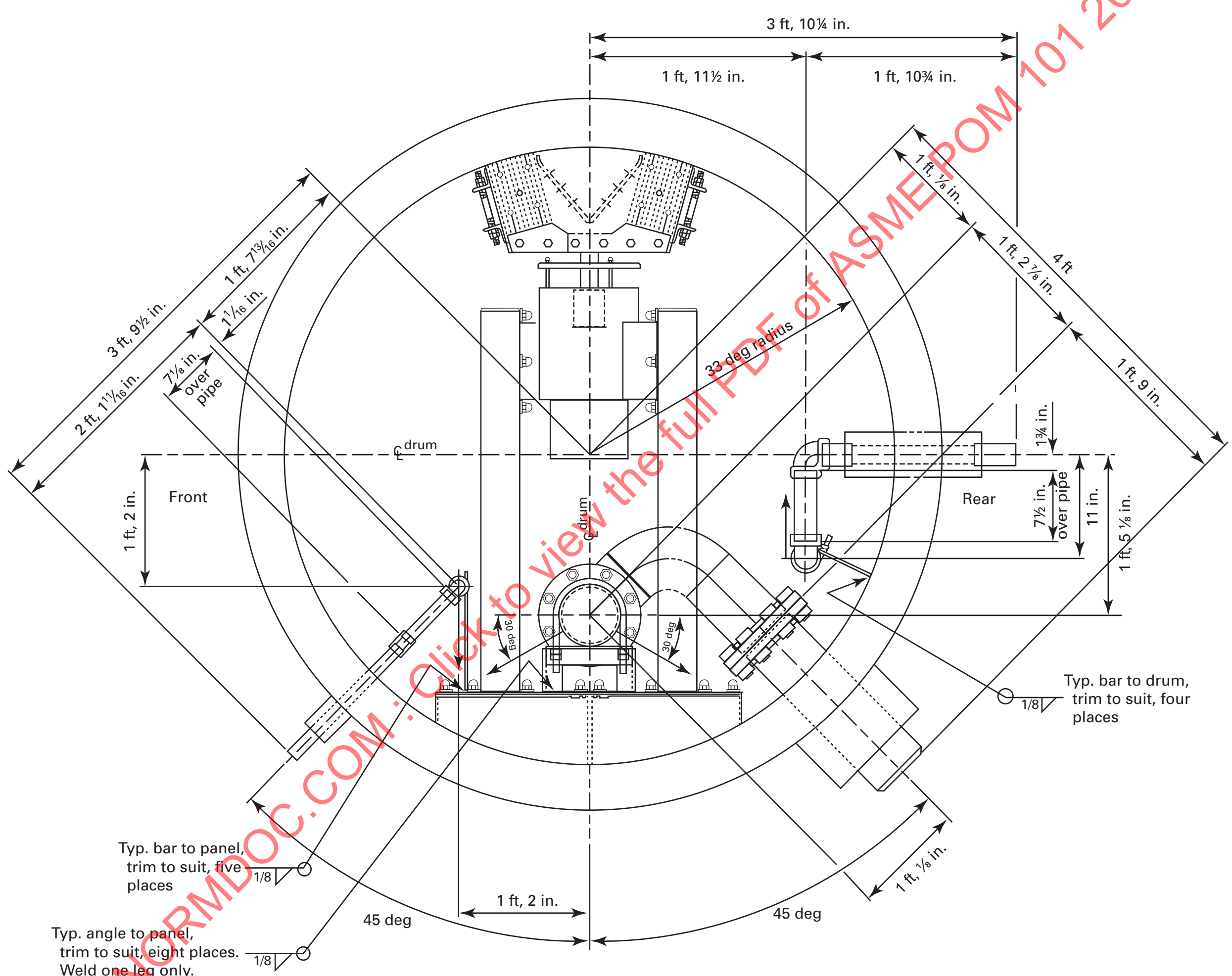
H-18.2.6 Actuator. Proceed as follows:

(a) Inspect the actuator for damage.

(b) Check the actuator for missing pins, alignment, and signs of binding.

H-18.2.7 Limit and Torque Switches. Limit and torque switches are located on the interior of the actuator. Refer to the manufacturer's specific instructions for details.

Fig. H-15.2.3-1 High-Pressure Drum



GENERAL NOTE: Arrows indicate direction of holes in internal pipes.

Fig. H-16.2.3-1 Intermediate-Pressure Drum

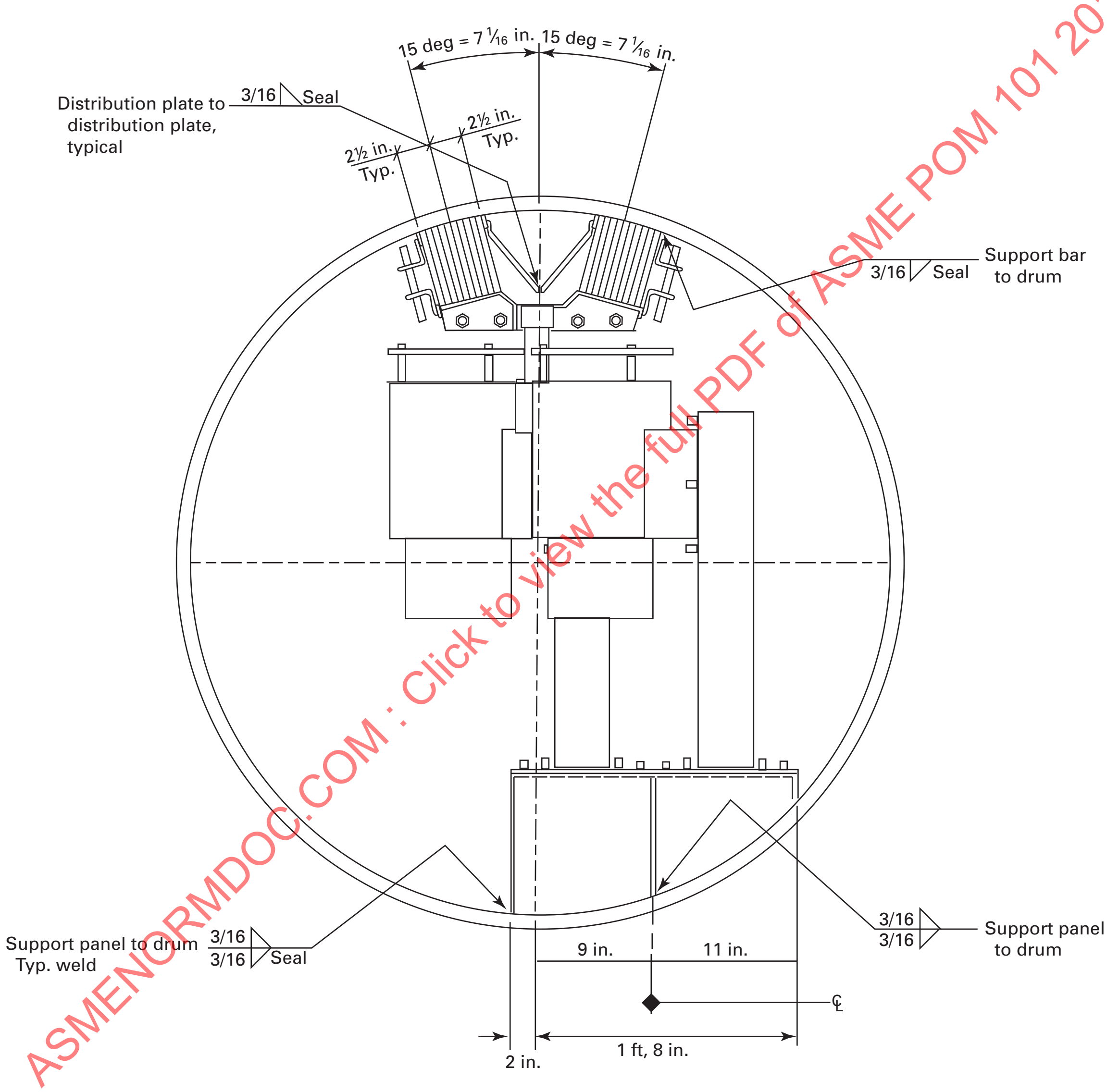


Fig. H-17.3-1 Integral Deaerator

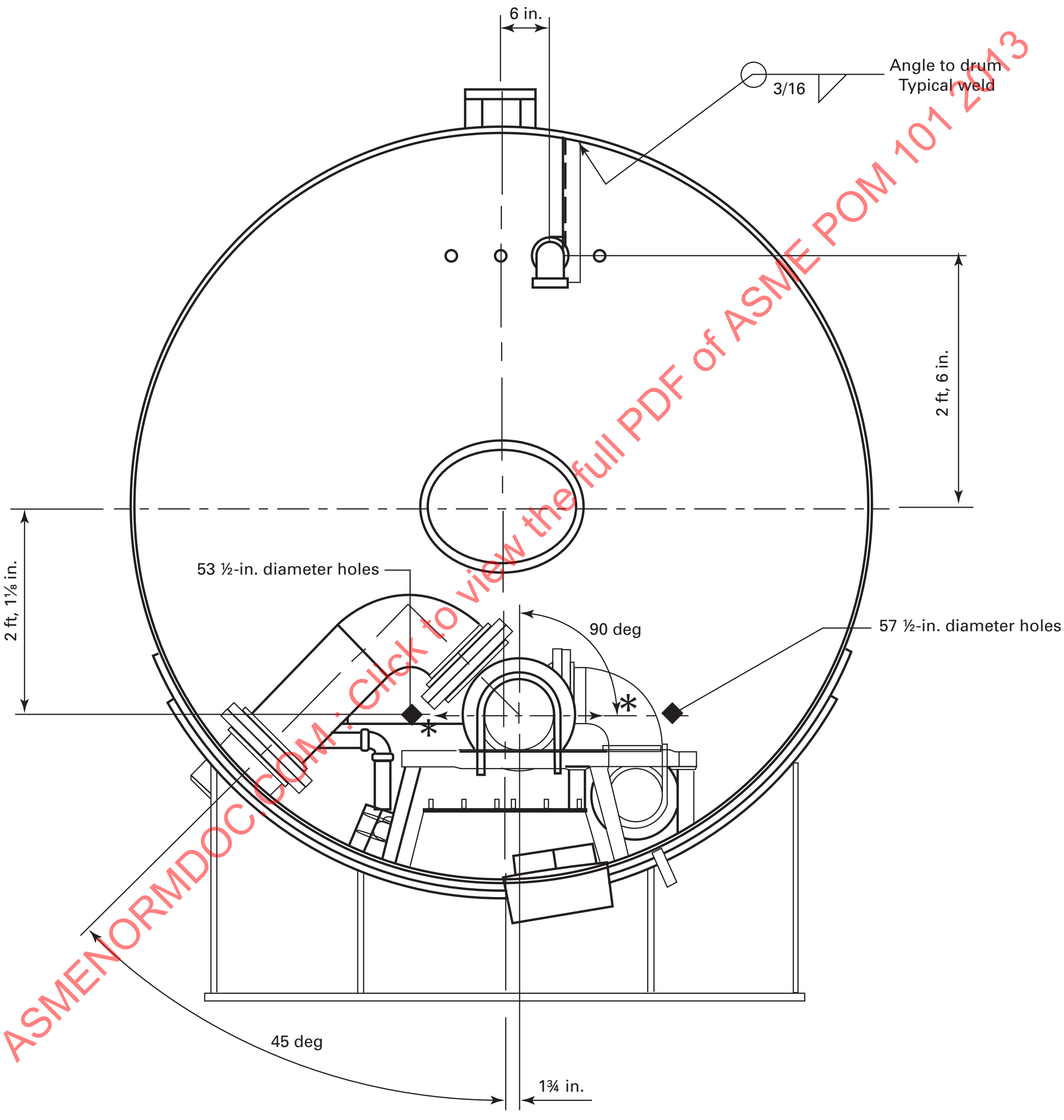
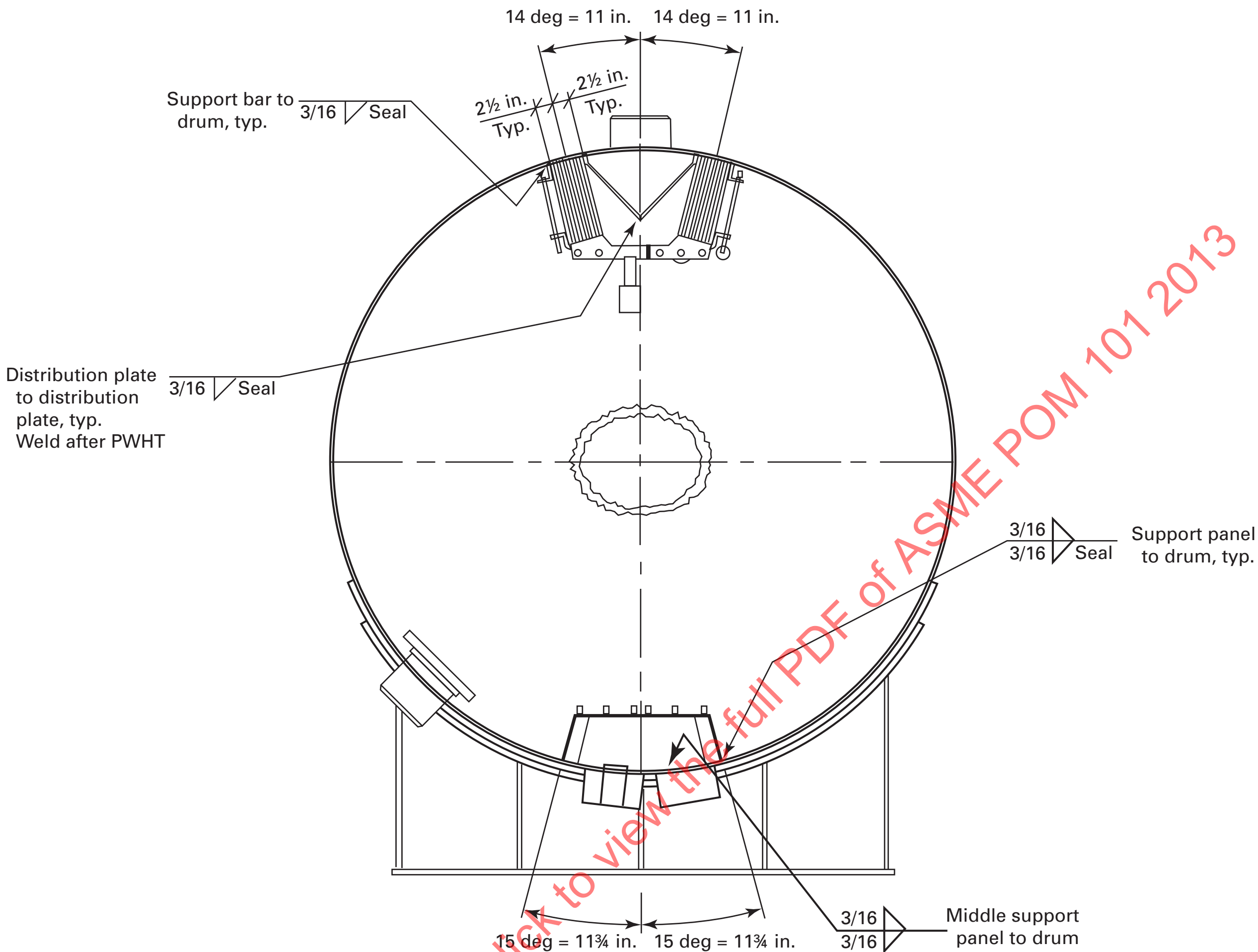


Fig. H-17.3-2 Low-Pressure Drum



NONMANDATORY APPENDIX I
BOILER SETTING AIR IN-LEAKAGE AND REGENERATIVE (ROTARY) AIR HEATER INSPECTION GUIDELINES

I-1 INTRODUCTION

This is a general inspection procedure. Not all areas or items will pertain to every boiler type and/or 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.

Boiler, ductwork, air heater, and fan inspections should be undertaken as a team effort. It is recommended that at least three individuals participate. Utilizing inspection team members from maintenance, engineering, and operations will broaden the view and improve the findings. One may rotate as the outside safety watch or all three may enter simultaneously if the safety-watch function can be performed by another. 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 is a multipart inspection; first prior to any cleaning, then after cleaning, and even later if needed. Ensure all notes and recordings are accurately labeled for future reference to the correct issues as identified.

I-2 INSPECTION PRIOR TO THE OUTAGE

I-2.1 Initial Review

The following review should be conducted prior to the outage:

(a) Review the last inspection report.

(b) Review recent operating history for

(1) boiler efficiency

(2) regenerative air heater performance

- leakage
- efficiency
- x-ratio

(3) draft, pressure drops, both air and flue gas sides (including all fans, ducts, wind box, furnace, convection pass, air heater, and air pollution control equipment)

(4) past inspection and/or forced outage reports to review trends/issues

(5) abnormal operating events

(c) Contact plant operations for additional information on operating history.

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

(e) All energy sources, steam, soot blowers, fuels, and chemical-injection equipment such as ammonia must be removed from service. Consider double block and bleed valve isolation for inspections if any connections exist to operating units.

(f) If other boiler back-pass maintenance activities (i.e., 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 maintenance activities in the areas upstream (or downstream) of the inspection area are taking place, the area of inspection should be covered to prevent unanticipated ingress of tools and personnel. Inspections involve heights, close spaces, hard metal, sharp edges, and fly ash. Inspectors should be physically fit and able to climb, and should not be bothered by feelings of claustrophobia.

(g) Obtain the following drawings prior to inspection (as feasible) to aid in the inspection and report/documentation: elevation, boiler, fans, airflow ducts, flue gas ducts, air heater, and general layout.

(h) It is recommended to use thermography to locate hot or cold spots on the external casing of the air boiler, ducts, and/or air heater. Thoroughly evaluate all deteriorated insulation and casing.

(i) Make a plan or checklist on the items and areas of interest that should be inspected. Identify which access doors you plan to use to enter and exit during the inspection.

(j) Make a safety plan and conduct a briefing prior to entering any confined space. Ensure all participants

are aware of their responsibilities, including looking out for each other, obeying the outside safety watch person, and evacuation plans.

(k) Gather personal safety equipment.

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

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

I-2.2 During Inspection

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.

Obey all instructions from the outside safety watch person.

I-2.3 After Inspection

Proceed as follows:

(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 boiler and/or 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 is retrievable in the future.

(e) Summarize all recommended actions.

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

NOTES:

(1) The unit loses heat through the exterior walls of the furnace and ductwork. If the surface temperature is reduced through insulation or lagging, the amount of heat leaving the unit is reduced and efficiency increases.

(2) Heat can be transferred in the following ways:

(a) convection — heat transfer from a solid to a fluid (liquid or gas) of different temperature

(b) radiation — heat transfer requiring no transfer medium

(c) conduction — heat transfer through direct contact between two surfaces of different temperatures

(3) Because we are not really worried about heat transfer into the ground or structures in direct contact with the ductwork or insulation, the two main focuses should be convection and radiation. However, considering that the losses are typically minimal as compared to other opportunities identified during an outage, all of the boiler inspection locations should be monitored — measured with an infrared/thermal imaging camera to determine if there are exterior heat losses that warrant insulation replacements that may be required during an outage.

I-3 GENERAL INSPECTION

I-3.1 Initial Inspection – Prior to Cleaning

The first inspection should be conducted prior to any cleaning activities as deemed safe for entry. This initial inspection is for the purpose of identifying accumulation of ash and overall boiler cleaning/vacuuming needs, as well as areas of air infiltration by viewing air-washed areas, mechanical discrepancies with tube alignment, and/or any issues that would accelerate localized erosion, change the furnace performance and dynamics, impact heat transfer, etc.

Photograph, video, or sketch the general condition of the unit. Piles of ash or slag may be significant; record their sizes and locations. Look for wear patterns from soot blowers and look for cleaning patterns to identify any area missed. Also note any signs of debris, foreign material, and corrosion products.

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

I-3.2 Second Inspection – Post-Cleaning/Scaffolding

A second and thorough inspection should be conducted after initial vacuuming, cleaning of the boiler, and/or a water wash-down. This inspection will enable those entering the unit to observe the actual mechanical condition of the components. Again, look for wear patterns, cleaning patterns, alignment, and mechanical issues of any sort. Note any signs of debris, foreign material, and corrosion products. Material and tools may have been inadvertently dropped from work 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.

I-4 INSPECTIONS OF BOILER, DUCTS, AND FAN — AIR IN-LEAKAGE

A general inspection should have a preliminary crawl-through inspection that immediately includes comments regarding the general boiler condition, tube alignment, areas of erosion, plugging, etc. This is considering that the boiler condition and paths for air and gas delivery can influence a unit's performance in such a way that combustion dynamics, thermal efficiency, and the overall ratio of the air and gas paths will influence the operational performance and reliability of the unit. An outline of a general inspection follows.

I-4.1 Furnace Inspection

I-4.1.1 Lower Furnace. Proceed as follows:

(a) Note tube erosion and/or wastage (if any).

(b) Evaluate the lower slopes for quench cracking from possible bottom ash water splash.

(c) Evaluate and inspect for any possible gouged, crushed, sliced, and dented tubes.

(d) Seal trough-bottom ash hoppers erosion/corrosion.

(e) Note ash pit condition (refractory/general).
(f) Check the ash hopper water seal (if applicable).
(g) Check clinker grinder/drag chain (if applicable).
(h) Inspect sidewall and buckstay damage adjacent to and behind the lower slopes as a result of possible clinker falls.

I-4.1.2 Mid Furnace. Inspect the following:

- access doors
- closure/seal
- refractory (inside furnace)
- wind box casing
- soot blower lance penetrations
- seals
- refractory (inside furnace)
- tube alignment/wind box/furnace casing construction

I-4.1.3 Lower and Mid–Upper Furnace. Inspect/observe the following:

- tube alignment/wind box/furnace casing construction
- slag and fouling pattern
- burner zone condition
- furnace (lower slope and division wall — UT/erosion/corrosion)
- radiant section — UT/alignment/erosion/corrosion
- note any or all blisters/bulges
- convection passes — UT/alignment/erosion/corrosion
- economizer — UT/alignment/clips/erosion/corrosion

I-4.1.4 Dead Air Spaces. Inspect the following:

- lower furnace
- nose arch apex
- penthouse

I-4.2 Fan Inspection

Inspect the following for forced draft, induced draft, primary air, seal air, gas recirculation, over-fire air (if boosted), and burner cooling fans:

- fan housing
- fan wheel observations — fly ash erosion (tip cracks, loose bolts or rivets, rubs)
- inlet vanes — stroke, fly ash wear, linkage, bushings
- inlet louvers — outlet dampers (check stroke, fly ash erosion, linkage pins/bolts)
- casing wear
- blade condition
- shaft seals
- inlet/outlet ducts/joints
- inlet box screens (if applicable)
- FD fan discharge duct/steam coils (if installed) — cleanliness and condition

I-4.3 Wind Box/Secondary Air

Synchronize secondary air dampers and verify operation from inside and outside damper drive limits and travel.

Inspect the following:

- burner tilts
- linkages
- draft gauges

I-4.4 Over-Fire Air

Inspect the following:

- general condition
- dampers and registers
- tilt and yaw (tangentially fired units)

I-4.5 Instrumentation

Inspect the following:

- airflow measurement elements
- pressure/taps/sensing lines/connections
- leak checks
- temperature/wells

I-4.6 Ductwork (Air Ducts, Gas Ducts, Economizer Hoppers)

Inspect the following:

- fly-ash erosion
- expansion joints
- casing cracks — joint integrity, corrosion
- ductwork supports
- fly-ash weight accumulation damage

I-4.7 Expansion Joints

Inspect the expansion joints.

I-4.8 Burners: Signs of Erosion, Physical Damage, or Malformation

Inspect the following:

- mechanical tolerances
- condition/centering (wall fired)
- tilt/yaw adjustment (tangential fired)
- igniters
- air registers
- nozzle condition
- separated air zones
- burner refractory
- condition
- angle

I-4.9 Burners: Refurbishment

Burners should be refurbished to design/optimum conditions.

Inspect the following:

- fuel pipe orifices
- burner throat refractory
- coal pipe nozzle