ASME POM 102-2014

Operating Walkdowns of Power Plants

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Operating Walkdowns of Power Plants

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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The American Society of Mechanical Engineers
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NOTICE

This is not a test code, but instead, it is a Standard that provides guidance to improve the thermal performance and reliability of operating power plants. Although developed by a Performance Test Code Committee, this document is not a test code because it does not provide guidance for the execution of a test or the analysis of test data. Instead, this Standard provides procedures to conduct outage inspections to ultimately improve power plant thermal performance and reliability based on the best engineering knowledge and practice currently available. It has been developed by a balanced committee representing all concerned interests.

FOREWORD

ASME POM 102, Operating Walkdowns of Power Plants, is the second Standard in a planned series of power plant performance operation and maintenance standards supporting knowledge transfer of current industry experts. 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. A new committee on Power Plant Availability and Performance (PAP) was initiated in 2014, and the ASME POM 100 series standards now report through this new committee.

This Standard was approved as an American National Standard by the ANSI Board of Standards Review on August 15, 2014.

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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.

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Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
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Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

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INTRODUCTION

This Standard on operating walkdowns contains a series of sections, each pertaining to specific equipment and/or systems commonly found in power plants. Inspections covered in this Standard are intended to take place during plant operation. Each section of this Standard can be used independently and includes recommendations on what to look for during inspections. For additional information on inspections that can be done when the equipment is out of service, please consult ASME POM 101-2013, Performance-Related Outage Inspections, which was the first standard published in the planned series of POM standards.

OPERATING WALKDOWNS OF POWER PLANTS

1 OBJECT AND SCOPE

1.1 Object

This Standard provides guidelines for operating equipment walkdowns that are designed to ultimately improve the thermal performance and efficiency of the power plant. Following these guidelines may also lead to more proactive maintenance practices, which can also be expected to improve the reliability of the plant.

1.2 Scope

This Standard provides guidelines for walkdowns of power plants using fossil fuels during operating periods. Some portions may be applicable to other types of power plants.

2 ACRONYMS

The following acronyms are used in this Standard:

ACC: air-cooled condenser

ACET: average cold end temperature

AH: air heater

CT: combustion turbine (see also gas turbine)

CW: circulating water

DP: differential pressure

ESP: electrostatic precipitator

FD: forced draft fan

GR: gas recirculation

GT: gas turbine (see also combustion turbine)

HHV: higher heating value

HP: high pressure

HRSG: heat recovery steam generator

HVT: high-velocity thermocouple

ID: induced draft fan

IGV: inlet guide vane

IP: intermediate pressure

LOTO: lockout/tagout

LP: low pressure

NPSH: net positive suction head

OEM: original equipment manufacturer

OFA: over-fire air

P&ID: process and instrumentation diagram

PPE: personal protective equipment

SCR: selective catalytic reduction system

SNCR: selective noncatalytic reduction system

ST: steam turbine

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 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 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 M provide details on activities to be completed prior to starting an operating inspection–walkdown.

3.1 Safety Considerations

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

Prior to walking down the operating equipment, it is important to identify all potential hazards that may be encountered. High-temperature and/or high-pressure piping should be located and identified, along with the locations of safety valves and steam traps that may release energy unexpectedly. Maintain a safe distance from rotating equipment and moving parts that are in the inspection–walkdown area.

Refer to Nonmandatory Appendix N for some specific safety considerations.

3.2 Pre-Walkdown Activities

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

(a) the last inspection–walkdown 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 Walkdown Plan

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

It should be noted in the plan where information may be collected from the control system or data historian prior to initiating the inspection–walkdown, as many of the subsections include calculation recommendations to augment the actual inspection–walkdown activities.

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–walkdown should be reviewed and agreed upon with plant operations staff for additional information on operating history prior to starting the inspection–walkdown.

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

3.4 Inspection–Walkdown Activities

During the inspection–walkdown, the following activities are recommended:

(a) Inspect the unit in a structured direction, e.g., from top to bottom, bottom to top, or front to back. This will help to provide complete coverage of the unit while minimizing time spent walking 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–walkdown report.

(c) Obey all site safety rules.

3.5 Postinspection–Walkdown Activities

The following items should be completed immediately following the inspection–walkdown:

(a) Report the significant findings from the inspection–walkdown 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–walkdown 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–walkdown 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 operating walkdowns:

(a) infrared temperature gun — for use in remote temperature readings

(b) thermal imaging camera — for use in remote temperature readings and also helpful for finding places with missing insulation

(c) digital/photographic camera

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

(d) ultrasonic sound meters for leak detection at valves

(e) portable ultrasonic flowmeters — nonintrusive meters that may offer validation of site metering devices (best used on liquid flows in closed and completely filled pipes)

6 REPORT OF RESULTS

When reporting the results of an operating walkdown, the following information should be included:

(a) site information

(b) date and time of walkdown

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

(d) equipment included in walkdown

(e) purpose of walkdown

(f) instrumentation used during walkdown

(g) analytical methods used, if applicable

(h) findings from walkdown

(i) conclusions and/or recommendations

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

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

  (1) raw data and measurements

  (2) photos

  (3) drawings or sketches

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

NONMANDATORY APPENDIX A
GAS TURBINE INLET AIR CONDITIONING SYSTEMS

A-1 PERFORMANCE CONSIDERATIONS

Gas turbines are air-breathing engines. The expected performance of a gas turbine is based on the quantity of air that can be ingested by the compressor and sent to the turbine section for power generation. A higher mass flow of air leads to greater power generation. When the air is denser, higher efficiencies also result. Since air is denser at cooler temperatures, gas turbine inlet cooling systems are popular options for power augmentation.

If an inlet cooling system is not operating correctly, the air to the gas turbine may not be cooled as far as achievable, and power capacity will be lost. If the system is cooling to the correct turbine inlet temperature but not operating as efficiently as expected, additional auxiliary power consumption will result, which reduces both net power generation and plant efficiency.

A-2 EQUIPMENT WALKDOWN

Below are some lists of items to observe while the unit is operating to verify that you are getting the most out of your inlet air conditioning system.

A-2.1 Evaporative Coolers

(a) Calculate the evaporative cooler effectiveness for comparison with design values.

(b) Check the water distribution system for balanced water flow, absence of plugged nozzles, and sufficient water levels in all basins.

(c) Check the media for balanced water distribution and observable dry spots. Dry spots will lower the effectiveness of the evaporative cooler, negatively impacting the capacity performance of the gas turbine.

A-2.2 Chillers

(a) Calculate the chiller efficiency (kW/ton) and current operating capacity for comparison with design expectations. Note the ambient conditions and cooling water temperature delivered to the chiller package, since efficiency may be a function of capacity and operating conditions.

(b) Walk down the chiller package to verify that the correct number of cooling tower fans are operating (for systems with a cooling tower).

(c) Verify the correct operation of any waterline bypass systems, and note the position of any valves for reference and comparison to design expectations at the current chiller system load.

A-2.3 Foggers

(a) Compare the measured gas turbine inlet temperature with the expected or fogger setpoint temperature value.

(b) Calculate the fogger performance factor and compare to expected and/or design values.

(c) Verify all nozzles are in operation per the operating schedule for the given temperature setpoint; note the observable water distribution and any overspray.

(d) If an observation port is available near the bell mouth of the compressor, visually verify that complete water-droplet evaporation is occurring. Incomplete water-droplet evaporation could lead to erosion on the first-stage compressor blades.

NONMANDATORY APPENDIX B
GAS TURBINES

B-1 PERFORMANCE CONSIDERATIONS

Gas turbines are air-breathing engines. The expected performance of a gas turbine is based on the quantity of air that can be ingested by the compressor and sent to the turbine section for power generation. A higher mass flow of air leads to greater power generation and often higher efficiencies. When tracking the operating performance of a gas turbine, it is best to look at corrected performance, such that an apples-to-apples comparison can be made over time.

Gas turbines are subjected to high operating temperatures, especially in the combustion section and the early stages of the turbine. These high temperatures cause normal degradation in the turbine section. The degradation may be recoverable with normal maintenance practices, but there are also some forms of degradation that are nonrecoverable. Additional performance degradation can be attributed to compressor fouling, which is often recoverable. Understanding how fast the unit is degrading relative to expectations will lead to better predictive maintenance practices and potentially longer parts life (and therefore lower total maintenance costs).

B-2 EQUIPMENT WALKDOWN

The following are some items to observe while the unit is operating to verify that you are getting the most out of your gas turbine:

(a) Calculate the current heat rate for the gas turbine in its current operating state.

(b) Calculate the compressor efficiency of the gas turbine in its current operating state.

(c) Note the gross output and IGV angle for the current operating point. If the gas turbine is on its base load curve, calculate the corrected output and heat rate of the gas turbine for comparison with design values.

(d) Note the current setting for the inlet bleed heat valve (if present). Once the gas turbine reaches a certain load level, the inlet bleed heat valve should be fully closed. When this valve is open, warm compressed air is circulated back to the gas turbine inlet, which lowers the density of air entering the compressor and reduces the amount of air available to the turbine for power generation.

(e) Note the differential pressure across the inlet filters. High inlet-filter pressure loss will result in lost capacity and higher heat rates.

(f) Observe and note the condition of filters.

(g) Walk around the gas turbine and record any observable fluid leaks (air, water, oil, etc.).

(h) Walk around the gas turbine and record any observable material problems, such as corrosion, loose fittings, or severe vibrations.

(i) An additional consideration is that following a water wash, and prior to starting the unit, water-wash drains should be verified to be clear, with no standing water. Standing water may impact instrumentation readings, leading to poor performance and/or unit trips.

NONMANDATORY APPENDIX C
HEAT RECOVERY STEAM GENERATORS

C-1 INTRODUCTION

This is a general inspection–walkdown procedure for heat recovery steam generators; not all areas or items will pertain to every HRSG. If HRSGs contain upper and lower dead air spaces, these will need to be inspected during an outage to complete the procedure.

C-2 SAFETY CONSIDERATIONS

Refer to Nonmandatory Appendix N.

C-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.

C-4 PRIOR TO INSPECTION

(a) Check the last inspection–walkdown report.

(b) Obtain a side elevation drawing of the unit to aid in documentation.

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

(d) Access doors are numbered from front to rear. For example, the number one (1) access door is located in the gas turbine outlet ductwork just before the high-pressure superheater.

C-5 DURING INSPECTION

(a) During the inspection–walkdown, it is recommended to use thermography to locate hot spots on the external casing. Any hot spot 130°F (54°C) and above should be documented for later inspection during a unit outage.

(b) Be sure to record all information and findings in the inspection–walkdown report.

(c) Report the significant findings from the inspection–walkdown immediately to the responsible plant contacts. Safety issues require immediate reporting and correction to remove any hazards.

C-6 VISUAL INSPECTION

During the walkdown, inspect and record the overall condition of the HRSG, including the following:

(a) any unusual noise and vibration.

(b) corrosion.

(c) gas leakage.

(d) steam piping — check for leaks and corrosion points.

(e) drum vents — should be verified to be closed and not leaking.

(f) bypass and letdown lines — should be verified to be isolated, using both local and control system indications for downstream temperatures and flows (as available).

(g) sky vents — should be verified closed and not leaking.

(h) pipe insulation — record any damaged or missing sections.

(i) ductwork.

(1) Check for hot spots on exterior ductwork. Hot spots 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.

(2) Areas where the ductwork paint has stripped off and there is metal discoloration may be due to hot spots. They can also be found using a thermographic camera.

(3) Check for any openings (or cracks) in ductwork that allow flue gas to escape. Leaks can often be identified by the discolored smear flue gas leaves on the ductwork.

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

(j) expansion joints and supports guides.

(k) bypass stack (if present) — inspect the damper, guides, and ductwork of the bypass stack. Visually inspect and record any physical damage that is visible externally. Check that insulation is intact using thermography; pay particular attention to the expansion joints and the blanking plate.

(l) fuel supply piping.

(m) duct burner (if equipped and in service) — look at burner, wings, and flame condition, and perforated plate.

(n) SCR — note and record the ammonia injection grid condition, if equipped; record the valve positions and flow at each branch; note any ammonia smell; observe and note the dilution air fan operation and filter.

NONMANDATORY APPENDIX D
WATER CHEMISTRY — SAMPLE PANEL

D-1 PERFORMANCE CONSIDERATIONS

During operation, the sample panel is often set to maintain a sufficient amount of water flow for continuous sampling to occur. Because the water that is used for sampling is often lost down drains and removed from the cycle, it can become a source of unaccounted-for losses in the steam cycle. Minimizing the water lost from the cycle will improve thermal performance but may lead to inaccuracies in the sampling results. A balance between sampling requirements and thermal performance is required for long-term stable operations.

D-2 EQUIPMENT WALKDOWN

When inspecting the water sample panel, record the current water flow rates for each sample line and note the final destination of each drain flow. Note where each water flow ends up, e.g., waste treatment or the blowdown tank for disposal, or the condenser for reheating and reuse.

NONMANDATORY APPENDIX E
STEAM GENERATORS

E-1 PREINSPECTION REVIEW

Review pre-outage and post-outage operations for any abnormal events and operating history. Post-outage performance testing and tuning should be considered in order to conduct a post-outage performance evaluation and provide information for comparison with pre-outage performance.

Abnormal variations in operating parameters, such as air and fuel flow, can lead to poor flow management, uneven heat distribution, and coarse particle fly ash. Poor air and fuel mix can also generate substoichiometric zones in the lower furnace, creating localized reducing areas leading to carbon carryover into the upper furnace. This often results in a host of reliability issues. A typical series of events that may occur under nonoptimal conditions related to air in-leakage and/or inadequate air and gas flow management is as follows:

(a) Secondary combustion results in the upper furnace.

(b) Furnace exit gas temperatures become elevated.

(c) Flue gas density is reduced and increased flue gas velocities occur.

(d) Plugging within the pendants induces accelerated velocities and increased flue gas volume in localized zones.

(e) Increased entrainment of coarse particle ash occurs.

(f) Accelerated erosion rates are introduced.

(g) Unit reliability issues occur due to tube leaks.

E-2 SYNERGISTIC CONSIDERATIONS

The synergy between the boiler inspectors, plant operations, performance, results, and engineering and management teams is crucial to evaluate a system holistically. Some of the information that should be shared is as follows:

(a) fuel quality evaluation

(b) fuel loading curves

(c) fuel and air delivery systems/rates of flow

(1) actual indicated versus theoretical versus measured values

(2) temperature compensation

(3) pressure transmitter accuracy

(d) post-outage performance tests to be considered should include

(1) air in-leakage survey

(-a) furnace exit HVT traverse to measure actual furnace exit oxygen levels via a representative grid

(-b) boiler exit flue gas oxygen (upstream of the air heater)

(-c) upstream and downstream of air pollution control equipment

(-d) stack measurement

(2) regenerative air-heater performance

(-a) leakage

(-b) efficiency

(-c) X-ratio

(3) boiler efficiency

(4) operational performance

(-a) fan amps (FD, ID)

(-b) draft (air/gas)

(-c) stack flow

(-d) damper settings

(-1) fans

(-2) wind box, burners

(-3) air and gas balancing dampers

(-e) furnace

(-1) flame propagation

(-2) secondary combustion (if present)

(-3) slagging propensity

(-4) temperature at the furnace exit

(-f) convection pass

(-1) pressure variations

(-2) temperatures

(-3) oxygen and CO levels

E-3 IMPACT OF FUELS ON PERFORMANCE

It's important to know which fuels are being fired and the expected effect on the steam generator's performance and reliability. Performance standards of the steam generator, both for normal plant performance and expected plant performance, should be documented and understood. These performance standards, which may include the results of performance tests, can serve as a baseline for actual plant performance and pre-outage/post-outage evaluation results. The fuel being fired will dictate selected operating parameters such as combustion airflow setpoints. Other related variables, such as measured airflow, fuel HHV, fuel moisture, and ash content, will have an effect on the overall flue gas volume leaving the unit.

E-4 EFFECTS OF THE AIR HEATER

A heat balance around the AH can be used to evaluate the effectiveness of the heat transfer, element performance, and/or the thermal efficiency impacts of the AH. The air heater is often referred to as the "last heat trap" on a utility boiler system. Gas-side efficiency should be corrected for "no leakage" and evaluated based on the expected efficiency at a given (or tested) X-ratio. For example, a lower-than-design X-ratio can lead to a higher AH gas outlet temperature and can be used as an indication for determining if there is boiler air in-leakage upstream of the AH and/or high primary/tempering airflow (cold air bypassing the AH) on a coal-fired unit. In conjunction with the X-ratio checks, total combustion airflow measurement and actual furnace exit-gas oxygen measurements can be used to validate the ratios of air and gas flow.

E-5 OPERATIONAL CHECKS

Considering the above, there are a number of online plant operational checks that can be considered and trended through a data archive for evaluating overall plant performance and condition. Some of these are as follows:

(a) airflow on curve.

(b) air preheaters.

(1) air/gas (air in-leakage and heat-transfer effectiveness)

(2) flue-gas constituents — O_2, gas, and air temperatures, in and out

(-a) rotary/regenerative [any unusual sound from air preheater (APH) during operation]

(-b) tubular

(-c) heat pipe

(3) air

(-a) steam coil — air temperatures in and out

(-b) steam flow and ACET setpoint

(-c) drain tank level and drain pump operation

(c) primary air fan/exhauster — observe that flow, pressure, hot and cold temperature, and damper positions, primary airflow control damper position, coal air temperature, and motor amps are within expected operating ranges.

(d) secondary air fan — observe that flow, pressure, temperature, damper position (if applicable), and motor amps are within the expected operating ranges.

(e) wind box to furnace differential pressure (damper positions) should be observed and compared with that expected for normal operation.

(1) for tertiary-fired and/or wall-fired boilers, note the register positions and over-fire air (OFA) flow rates for comparison with expected.

(2) instrumentation — note the operation of the primary and secondary airflow measuring devices (damper positions). Readings should be compared to the expected, along with cleanliness and general maintenance of the instrumentation.

(f) flow calibration and hot K factor for controls.

(1) pressure/taps/sensing lines/connections should be observed for general maintenance health

(2) temperature/thermowells should be verified to be in good working order

(g) coal feeder feed rates.

(h) flow (volumetric or gravimetric evaluations).

(i) bias.

(j) damper strokes.

(k) temperature/thermowells (all).

(l) wind box to furnace pressure drop.

(m) draft gages (all) — air and gas.

(n) operating air–fuel ratios on curve.

(o) balanced combustion airflow.

(p) air heater temperatures (air side and gas side).

(q) burner/over-fire air — air register, air sleeve settings; feedback versus local indications.

(r) excess oxygen on curve. (Although excess oxygen is an indication of excess air, the indication is only good if it is representative of the true oxygen levels in the furnace. Because of this, a sufficient quantity of probes is required. Furthermore, tramp air in-leakage upstream of the excess oxygen probes can have a major impact on combustion and overall thermal efficiency. Considering this, it is critical that the plant O_2 probes at the boiler exit are calibrated and representative of the average.)

(s) gas side.

(1) in-furnace camera, or visually through observation ports, verify all flame scanners are well positioned and check the following:

(-a) slagging and fouling pattern

(-b) burner zone/burner condition

(-c) furnace (lower slope and division wall)

(-d) radiant section

(-e) convection passes

(-f) economizer

(2) flue gas constituents, as reported on the emissions monitoring system, should be within expected operating ranges

(-a) economizer gas outlet — oxygen, CO, gas temperatures, NO_X

(-b) upper furnace — O_2 and temperature, if available

(3) seal trough level and temperature

(4) gas tempering or gas recirculation (GR) fans — expected tempering achieved; drives and dampers, motor amps at expected operating levels

(5) induced draft fans (ID) (and booster fans) — flow, pressure, and temperature, drives and dampers, motor amps

(6) check for proper instrumentation operation of the following:

(-a) flow devices

(-b) pressure and differential pressure, taps, sensing lines, and connections

(-c) temperature and wells

(t) coal crushers — sizing.

(u) pulverizer operation.

(v) mill outlet temperature.

(1) setpoint versus actual

(2) level control and bias (ball mills)

(3) classifier performance

(-a) positions (static)

(-b) speed (dynamic)

(4) coal pipe temperatures

(-a) indicated

(-b) local infrared

(w) pulverizer performance to drive maintenance activities/priorities.

(1) fineness

(2) dirty airflow distribution

(3) fuel flow distribution

(4) air–fuel ratios

(5) mill outlet temperatures

(6) heat balance

(7) pulverizer coal reject quantity (on vertical spindle mills)

(x) coal feeders — feed rate and mill bias.

(y) economizer hoppers (temperature).

(z) visual appearance of flames — burner zone/burner condition.

(aa) in-furnace camera, or visual through observation ports.

(ab) nose arch and superheater area for slag appearance/patterns.

(ac) lower furnace for possible slag bridging.

(ad) verify all flame scanners are well positioned, and check the following:

(1) furnace (lower slope and division wall)

(2) radiant section

(3) convection passes (as feasible)

(ae) lower furnace for clarity, oxidizing atmosphere.

(af) air heater inlet gas duct hoppers, hot, not plugged.

(ag) soot blower pressures and effectiveness.

(ah) steam temperatures optimum.

(1) superheater and/or reheater tube circuit temperatures

(2) superheater and/or reheater steam temperatures

(3) header temperatures

(ai) spray flows normally.

(aj) soot blower steam/air temperatures, condensate/thermal drains — operation and/or bypass.

(ak) raw coal sizing [yard crusher output less than $\frac{3}{4}$ in. (20 mm)].

(al) leak checks of airflow measuring elements (primary and secondary) — all pressure taps/sensing line connections.

(am) fly-ash sampling (by an in-situ sampler).

(an) airflow and fuel flow distribution and balance (all).

(ao) oxygen analyzer calibrations and local representation measurements.

(ap) damper stroke verifications.

(aq) steam temperatures and spray flow measurements; spray flows should be minimized for best performance.

(ar) furnace exit excess oxygen measurement (traverse, not single point).

(as) air heater leakage.

(at) soot blowing steam temperatures and thermal drains.

(au) superheater and reheater tube metal temperatures.

(av) ID fan performance.

(1) inlet/outlet pressure

(2) flow

(3) fan curve evaluation

(aw) normal plant results tests.

(ax) hot K calibrations of airflow measuring elements (primary and secondary).

(ay) furnace excess oxygen traverse by HVT probe to check oxygen and stratifications.

(az) measure oxygen rise from furnace to stack.

(ba) drum vents should be verified closed and not leaking.

(bb) bypass and letdown lines should be verified isolated using both local and control system indication for downstream temperatures and flows (as available).

(bc) sky vents should be verified closed and not leaking.

(bd) water side.

(1) boiler water wall and riser temperatures

(2) economizer — inlet and outlet temperatures

(3) boiler drum pressure

(4) drum levels

(-a) local, side to side, control room indication

(-b) control method/feedback signals used

(5) drum metal temperatures

NONMANDATORY APPENDIX F
STEAM TURBINE AND GENERATOR

F-1 INSPECTION OF ACCESSIBLE STEAM TURBINE-GENERATOR

Prior to initiating the inspection–walkdown of the steam turbine, a visit to the control room to note the current generator load (MW) and valve point is recommended, along with collecting sufficient information to calculate sectional efficiencies (all admission/extraction steam properties, including flow, pressure, temperature, and quality, as available) to assist in an overall unit condition assessment.

Observe entire HP, IP, and LP sections for liquid, water, and steam leaks; hot spots and hot valves; plus indirect indications such as damaged, missing, or moving insulation. Inspect accessible portions of the following:

(a) turbine deck.

(b) turbine belly.

(c) turbine valves. They should be essentially motionless; document if continually hunting or changing position.

(d) lube oil and control oil system, and the associated lube oil cooling system.

(e) stator cooling system, hydrogen coolers (if equipped).

(f) all visible instrument connections, including those behind unlocked doors, e.g., LP turbine skirt.

(g) integrity of sensor tubing and all process piping. Excessive vibration should be noted.

(h) external casing of the LP turbine. Thermography may be used to locate hot or cold spots on the external casing of the LP turbine. Any spot varying more than 20°F from normal or design should be documented. The discoloration of paint may also be an indication of a hot spot.

(i) leaks or wisps of steam from the gland seals.

(j) instrument panel, e.g., turbine supervisory. Ensure all parameters are operating and providing reasonable values. Note the position of the shell, rotor, and differential expansion devices; bearing vibrations; and proximity probe positions where applicable.

Observe hydrogen-cooled generators for abnormal conditions. Check and compare the hydrogen pressure and the hydrogen purity at local instrumentation and analyzers.

Document all findings on a dated report, even if "none" is the correct response.

NONMANDATORY APPENDIX G
STEAM SURFACE CONDENSERS

G-1 PRIOR TO INSPECTION

Recent operating history of the following should be reviewed prior to the inspection–walkdown:

(a) air in-leakage/off-gas flow rates
(b) dissolved oxygen levels in condensate
(c) actual versus expected backpressure
(d) tube leak history and plug map
(e) recent abnormal operating events

G-2 INSPECTION–WALKDOWN

(a) Temperatures should be recorded for all lines draining into the condenser hotwell. Lines that are found to be above 180°F (82°C) should be traced back to determine the source of the heat draining to the condenser. Hot lines may indicate leaking bypass valves and drains.

(b) Thermography may be used 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 normal or design should be documented.

(c) The air-removal system for the condenser should be verified to be in proper working order. The level of gas removal should be noted on any available flow-metering devices and compared with the expected. Excess air removal may be an indication of condenser air in-leakage or poor water chemistry.

(d) Instrumentation should be verified to be in good working order, especially the condenser pressure, temperature, and hotwell level indications.

(e) Observe and listen for unusual sound and noise, e.g., water hammer, loose parts and attachments, metal clanging, and sucking noise.

(f) Automated valves should maintain positions and not be cycling open to closed; note and check that the normally closed high-energy steam valves should be closed while the normally open steam cycle valves should be open.

(g) CW system should be checked, e.g., verify that CW is not air bound at the inlet and outlet sight glasses, and priming and evacuation system is lined up correctly. See pump-related walkdown items in Nonmandatory Appendix M.

NONMANDATORY APPENDIX H
AIR-COOLED STEAM CONDENSER

H-1 INSPECTION–WALKDOWN

Conduct an inspection–walkdown of all accessible ACC components. The following conditions should be noted:

(a) any leaks and missing devices, e.g., wind curtains, if equipped

(b) number of fans/cells in service plus the general condition of tube bundles

(c) debris and foreign objects on the tube bundles and fan inlet

(d) any noticeable fan noise/vibration

In addition to the above conditions, the observation of any plume should be noted along with its potential source, as this would be a highly unusual occurrence. Air currents around the ACC should be observed, if possible, to determine the presence of any potential recirculation.

NONMANDATORY APPENDIX I
COOLING TOWERS

I-1 PREPLANNING

Prior to initiating an operating walkdown of an operating cooling tower, precautions should be taken against pathogens that may be present in the circulating water or cooling tower plume, specifically Legionnaires' disease, which has been found in some cases.

Safety procedures related to lockout/tagout of rotating equipment and fall protection should be reviewed prior to beginning the walkdown. Appropriate PPE should be used at all times during the walkdown. See Nonmandatory Appendix N for additional safety recommendations.

I-2 PERFORMANCE CONSIDERATIONS

Cooling towers transfer the heat from the condensing portion of the steam cycle to the atmosphere by a combination of heat and mass transfer using evaporation of a portion of the circulating water flow within the heat transfer medium, or fill. For efficient heat and mass transfer to take place, it is important that the design air flow be achieved, and that the fill surface be clean and unfouled. For a cooling tower, the purpose of the operating walkdown is to verify the structural integrity of the equipment, and that the components that generate and distribute the air and water flow through the fill medium are functioning properly, and to note any discrepancies that may be leading to lost performance or impending equipment failure.

I-3 EQUIPMENT WALKDOWN

Generally, the walkdown should be conducted by starting at the fan deck on a mechanical draft cooling tower, and working horizontally from cell to cell at that level before dropping to a lower level. Due to the hazards of rotating equipment and the possible presence of pathogens, entering the cooling tower during operation is discouraged. The following items should be noted:

(a) Structure. For wood structure cooling towers, structural members should be observed for soundness and, if decay is suspected, probed with a knife or screwdriver for signs of rotten wood. Fiberglass structural members or concrete structural elements should be observed for signs of deterioration. Hardware should be checked for tightness and evidence of corrosion. Special attention should be given to ladders, stairways, and handrails. Check lighting stanchions, cable trays, lightning protection terminals, and cables for tightness and evidence of corrosion.

(b) Mechanical Equipment. Look for signs of excessive noise and/or vibration from fan motors, driveshaft couplings, gear speed reducers, and fans. Check fan stacks for evidence of excessive vibration, noise, and loose hardware. If possible to do so safely, observe the clearance between the fan blade tips and the fan stack, and verify that it is no less than ½ in. (13 mm) and no more than 1½ in. (38 mm) Adjustment of tip clearance should be done during a maintenance outage. Fan motor current draw can be measured at the motor control center and compared to the motor nameplate data.

(c) Air Inlet Area. If louvers are present, note any missing or misaligned louvers. Observe the pattern of the water falling within the tower, and note any maldistribution, which might indicate plugging or missing components in the water distribution system. It is not possible to correct water distribution problems during operation, but this should be noted for the next maintenance outage.

(d) Cold Water Basin. Note whether the water is at the proper operating level in the basin. Observe the flow of water through the trash screens, if visible, and note any obvious debris for later removal. Note the condition of the concrete basin curbs and piers for evidence of concrete deterioration. During operation in below freezing weather, note any formation of ice on structural members, louvers, fill, etc. Minor ice accumulations can generally be removed by shutting down the fan on one cell at a time, and allowing the warm water to gradually melt the ice. For larger ice accumulations, consult the cooling tower manufacturer for recommendations on the prevention of ice formation.

(e) Thermal Performance Data. It is helpful to take thermal performance measurements using plant instrumentation to track the trend of cooling tower performance over time. To account for varying ambient conditions, the data can be related to the design performance point using commercial software (e.g., see the Cooling Technology Institute's Web site, www.cti.org). Useful data for this evaluation include circulating water flow rate, hot water temperature, cold water temperature, and air inlet wet bulb temperature.

NONMANDATORY APPENDIX J
EMISSIONS CONTROL SYSTEMS

J-1 INSPECTION

The information on the following operating conditions should be recorded and then compared to the expected operation for each component:

(a) Baghouse

(1) differential pressure on each module

(2) number of modules in service

(3) reverse air valves operation

(4) pulse jet operation

(5) flow rates

(b) Electrostatic Precipitator (ESP)

(1) flue gas conditioning system for dry electrostatic precipitator

(-a) injection grid/nozzles — numbers and injection flow (control mode)

(-b) injection skid/metering system

(2) dry electrostatic precipitator

(-a) rappers/vibrators — rapping intensity, rapping cycle time

(-b) electrical — transformer/rectifier (TR) and automatic voltage control (AVC) — primary current and voltage (VAC), secondary current (mA) and voltage (kV), spark rate per minute

(-c) hopper and hopper evacuation system, hopper heaters

(-d) hopper level instrumentation and evacuation cycle (vacuum and cycle time)

(-e) observe and note any unusual sounds and noises, for example, hopper crotch, ash evacuation and conveying system, sparking, and loose rapper and rapper shafts

(c) Selective Catalytic Reduction (SCR) System

(1) NO_X in and out (control mode)

(2) ammonia injection grid and lance/nozzles — ammonia flow and dilution airflow

(3) differential pressure — system, mixers, each catalyst layer (all layers)

(4) temperatures

(d) Selective Noncatalytic Reduction (SNCR) System

(1) injection grid/injector — numbers and injection flow (control mode)

(2) injection skid — temperature, pressure, flow, and recirculation flow

(e) Dry Scrubber

(1) reagent flow

(2) control mode and SO_2 out concentration

(f) Flue Gas Desulfurization

(1) SO_2 in and out

(2) tower level/slurry density/bleed rate

(3) limestone quality, preparation, density, and grind/product quality

(4) recirculation pump spray level/nozzles: in service, control mode

(5) differential pressure — system, tray

(6) mixers — number in service

(7) mist eliminators and spray level/nozzles: differential pressure, spray cycle flow/pressure/cycle time

(8) forced oxidation air operation and flow

(g) Wet ESP

(1) electrical — TR and AVC — primary amp and VAC, secondary mA and kV, spark rate per minute

(2) wash header/nozzles, trough condition — wash rate, cycle time, if applicable

(3) insulators/insulator box — wet/water drain, sparking noise

(4) chemical composition of collected liquid

(h) Flue Gas Reheater

(1) temperatures, setpoint and control mode

(2) steam flow, drain tank level

NONMANDATORY APPENDIX K
PIPING SYSTEMS

K-1 GENERAL INSPECTION

Conduct the following inspection of pipe hangers and insulation:

(a) Pipe hangers should be in good condition. Any locations where hangers are damaged or placement is insufficient for the forces applied should be noted.

(b) Insulation should be in good condition with minimal penetrations. Places with water damage or in need of replacement should be noted, especially on high-temperature piping systems.

NONMANDATORY APPENDIX L
FUEL DELIVERY SYSTEMS — SOLID FUELS

L-1 INTRODUCTION

There are many different components in a solid-fuel delivery system. Operating information and inspection–walkdown guidelines for various components are provided below.

L-2 TRUCK SCALES

Perpendicular alignment of the load cells is essential in the proper scaling of wood trucks across the scales. Over time, the load cells can be forced off the vertical position, resulting in inaccurate scaling.

The conductors that forward the information to the scale computer can become damaged due to the physical forces involved with heavy vehicles constantly moving the scales in two axes.

The buildup of material between the platens and grade will also affect the accuracy over time. Frequent recalibration is imperative.

Pits constructed below grade will make preventive maintenance for the truck scale easier, since an outage to clean the truck scale would not impede the flow of material.

L-3 ELECTRONIC SCALING

Many sites are actively looking at ways to reduce manpower, and have converted to electronic scaling. The procedures for use of the electronic scales should be verified as accurate and easily accessible for the users. Truck drivers inexperienced with the systems are often required to scale in electronically. Site support is then required to support the truck drivers and train them in the use of the electronic scale systems. Intervention of plant personnel to correct scale problems often offsets the benefits of the automated solution.

L-4 TRUCK DUMPS

Delivery drivers of trucked-in fuel often are paid per truckload, which leads to anxious drivers and the potential to take shortcuts in delivery procedures. These shortcuts may lead to inefficiencies and potentially to plant equipment outages. Materials that flow freely (e.g., wood chips) are often held up by loads that do not flow freely (e.g., bark). The high-end material is constrained by the inability of the fuel-handling system to transfer low-value material. Fuel delivery schedules should be reviewed to verify the proper scheduling of fuel suppliers.

Most truck-dump receiving hoppers have a variable speed setting that can be adjusted for the material received. It's often left up to the operator to adjust the speed of drag chains and other equipment to meet the requirements of the fuel being loaded. Since speed adjustments are normally manual, the fuel types should be scheduled accordingly to ensure as little human intervention as possible.

Where multiple truck dumps are available, they are normally interlocked to prevent both dumpers from being lifted simultaneously. See Fig. L-4-1.

Truck drivers often "bounce" their loads in an attempt to loosen the material from their trailers. Hydraulic flow fuses often prevent such occurrences and should be implemented.

The backstop area of the truck dump platter often accumulates built-up material that increases the potential for the trailers to jump the backstop. Every means to keep the truck scale backstop platter clean should be taken.

Once the material flows up the truck dump hopper, it normally encounters an equalizing roll that attempts to level the flow onto the conveyor. This device works well with materials that will easily shear but stringy material will often jam the equalizing roller, causing a trip.

A back rake is a device that drags the material back to the main hopper and prevents the buildup of material at the discharge end of the truck dump. Stringy material and bark will require the use of a back rake.

Centering the load on either side of the belt conveyor is required to prevent belt tracking problems.

L-5 MAGNETIC SEPARATORS

Ferrous metals are removed from the fuel stream to protect equipment upstream. Magnets can be mounted perpendicular to fuel flow or parallel to flow.

Operationally, these devices have to be monitored constantly, so a person dedicated to the fuel receiving system is essential.

Removable metal bins assist in the fast removal of tramp steel via a skid steer loader.

Always refer to the manufacturer's recommendations for the installation height above the material and the type of idlers permitted below the device.

Fig. L-4-1 Interlocked Truck Dumps

Self-cleaning magnet belts should show a belt sag of about $\frac{3}{4}$ in. to $1\frac{3}{16}$ in. (20 mm to 30 mm), measured from the magnet base to the inside of the belt.

Nonmagnetic material must be used in proximity to the magnetic separator.

(a) conveyor idlers 39.37 in. (1 m) ahead, under, or behind the magnet

(b) trays and discharge chutes inside of the magnetic field

(c) chutes and any sheets beside and under the magnet

Rectifier current draws should be routinely compared to commissioning data.

L-6 METAL DETECTORS

Metal detectors detect any metallic object about to enter the disc screen or scalper. Often these devices stop the feed conveyor to the disc screen on detection of any metallic object. The result is a tripped feed conveyor that requires operator intervention to find the piece of metal. A handheld metal detector will speed up the process to find the metal that has made its way past the magnet; this material is often mostly aluminum.

Fine-tuning of the metal detector is required, since volume versus mass is an issue. A soda can may result in a trip, as will a solid chunk of aluminum. Tuning of a metal detector can save hours of nuisance tripping.

L-7 DISC SCREENS (SCALPERS)

Proper sizing of the discs should have been determined during the initial fuel specification. If fuel specifications have changed, contact the manufacturer's representative to determine if any resizing is required.

Disc drive chains should be checked for proper tension and frequent lubrication.

Verify the amperage draw of the prime movers.

The oversized material is usually passed to a wood grinder for resizing.

The chute itself poses a danger of oversize material being kicked back; a means of guards or overhangs is required to protect personnel.

Removable guards should be placed high enough on either side of the screen to prevent operators from reaching into the rotation equipment.

L-8 VIBRATING SCREENS

The shimming of the vibrators, their alignment, and amperage draw should be checked against the OEM specifications.

Deck wear and hole sizes should be measured and compared to the original specifications.

Sealing conditions should be verified.

Verify the correct selection of the vibrating motor counterweights and compare with the original commissioning report.

L-9 WOOD GRINDERS AND HOGS

The following subparagraphs apply to wood grinders and hogs:

(a) Transmission Belts. Transmission belting should be checked for even tension. Belts should be replaced as matching sets.

(b) Anvils and Hammers. Anvils and hammer replacement records require review. The type of hard-facing welding rods used to build up the hammers must meet OEM specifications. The clearances between the anvils, screws, or hammers and the grate have to be measured when allowable to establish maintenance intervals.

(c) Grates. Stationary grates should be sized for the present fuel specification requirements; building up of the grates' holes to proper size requires documentation. Check grates' sheer pins for wear on a regular basis.

(d) Safety Devices. Safety devices used to shut down the wood grinders in the event of foreign object damage (FOD) require regular testing to prove their ability to stop the machine.

(1) Drive sheaves' grooves should be free from rubber buildup.

(2) Rotating shaft should be checked for cracks propagating from the driven end.

(3) Guards surrounding the drive sheaves must be well reinforced, properly attached, and in good repair.

(4) Inspect drive sheave spokes for signs of cracking.

(5) Verify the operation of any devices used to aid in lifting the shell for maintenance and cleaning.

(-a) Check for manual dogs that hold the shell in the open position.

(-b) There should be an interlock directly wired to the starter or drive, to prevent accidental starting with the shell open.

(6) Examine the condition of the chute seals and fasteners used to remove the grinder shell for maintenance.

(e) Fasteners. Frequent failure of the fasteners used to hold anvils or knives can be attributed to

(1) not thoroughly cleaning the knife receptacles before inserting knives. (This will cause the knives to work loose in the rotor and stretch the fasteners to failure.)

(2) improper torque procedure, which could leave the fasteners loose or overtorqued beyond their limit. (Clean and inspect all threads, oil lightly, and use a torque wrench in stages. The large torque value requires a torque multiplier.)

L-10 FUEL DIVERTER GATES

Check all sealing aspects.

Check gates for impact damage and warping.

Hinge-point shafts and bearings should be straight to prevent rough operation.

Pneumatic and hydraulic systems should be exercised regularly.

L-11 CONVEYOR BELTING

Any conveyor belt inspection–walkdown should start with a comparison between original drawings and specifications with actual equipment for the following:

(a) Rubber Belting

(1) width

(2) ply

(3) length

(4) type of carcass versus cover

(b) Belt Splices

(1) Vulcanized splices have to be inspected for any delaminating.

(2) Mechanical lacing-type splices must have a 45-deg chamfer cut into the edges to prevent catching and rolling under the idlers.

(c) Pulleys

(1) Tail pulleys are subjected to grooving; excessive thinning will cause roll failure. The standard taper-lock bushings have to be retightened regularly. Inspect the endplates of pulleys for cracks. Belting should be centered on the pulley. Mechanical tension adjusting rods must have double-locking nuts. Inspect any pulley cleaners for proper tension and lack of buildup.

(2) Head pulleys are inspected in the same manner as the tail pulleys. Most head pulleys are lagged with grooved rubber to prevent slippage.

(-a) The applications of sliding rubber strips in tracks that are screwed to the pulley have a tendency to come loose. Inspect the tracks.

(-b) Vulcanized endless lagging is far superior to the mechanical method; check for delaminating and thinning of the vulcanized rubber.

(-c) Power transmission belts should show equal tension and good alignment.

(-d) The inside of the fuel transitions that house the pulleys should not have excessive buildup or signs of rubbing.

(d) Gear Boxes. Gear boxes should not have excessive leakage, noise, or excessive heat. There should be records of oil changes and analysis. Some oil should be drawn off to check for water contamination.

Gear box orientation is critical when determining which plugs are used to determine a full gear when changing oil. Check the manufacturer's drawings.

If any power transmission equipment has been changed from the original, verify belt speed with a handheld tachometer and compare it to OEM specifications.

(e) Bearings. Bearings should run cool with little noise; a buildup of fines on the bearing indicates worn seals at the shaft penetration points in the fuel chute transition. Bearing collar set screws must be checked regularly.

(1) Grease viscosity index should be checked. The older standard of Saybolt universal seconds (SSU) has been replaced by the centistoke (cSt). Transferring one specification to the other without conversion can be detrimental to system operation. Conferring with a lubrication engineer is recommended.

(2) Habitual leaking gearbox seal problems can be overcome by the use of semifluid grease. The grease matches the lubrication viscosity of the oil with less leakage. Contact a lubrication engineer for applications.

(f) Idlers

(1) Inspect for worn idlers or rolls that are seized or drag occasionally.

(2) Verify that the correct CEMA class idlers meet the fuel system requirements. The material's angle of repose determines troughing idler angles. Impact grade idlers are especially subject to damage.

(3) Troughing idler spacing should match the original construction specifications, providing there has not been a drastic change in fuel specification. A rule of thumb for belt return idlers is every 10 ft (3 m).

(g) Belt Tracking[1]

(1) The steering action of a troughed belt conveyor is accomplished by the middle horizontal rolls of the troughing idlers. Running the belt with a properly centered load is critical when evaluating belt tracking.

(2) Shifting idlers and pulleys in an attempt to train the belt is a last resort.

(3) If a belt shifts towards and then away from the observer in synchronism with each revolution of the whole belt, then the belt itself is not straight. The difficulty is usually found to be an uneven splice of the ends.

(4) If the belt rides steady at one point but runs continuously to one side or the other at a particular point in the system, then there is an alignment problem.

(5) A belt can be guided by "cutting" the idlers. It's better to shift very slightly a larger number of idlers. Start adjusting 15 ft to 20 ft (4.5 m to 6 m) back, where the belt starts to shift.

(6) When adjusting major pulleys, the belt will always ride to the low side of the roll.

Training idlers are used as a safety measure in the event of extreme misalignment. The side rollers should be set back considerably from the edges of the belt to prevent wear.

L-12 CONVEYOR TRANSITIONS

Conveyor transitions should discharge material at two-thirds of the belt width.

Diverter gates within the transitions should be adjusted to center the material load, to prevent conveyor belt misalignment.

In cold weather climates, the transition chutes are often lined with ultra-high-molecular-weight polyethylene (UHMW) to prevent freezing of material to the transition walls.

Abrasion-resistant plate is often used in the fabrication of transition chutes. UT thickness measurements provide a guide to replacement.

Shaft seals that penetrate the transitions should be inspected regularly.

The interface between transition and takeaway conveyors uses side seals to prevent spillage. These seals are usually made of UHMW and require frequent adjustment.

Cleated or chevron belts use brush seals that require frequent replacement and adjustment. The material selection of the brush seals requires consideration.

Plug detectors located in the transition chutes need to be inspected and tested regularly. These devices provide sequential tripping of upstream conveyors through the control system.

L-13 DRAG CHAIN CONVEYORS[2]

The sag of a free-floating drag chain must not exceed 3% of chain length with tension on the drive side.

Offset drive chain (logging deck chain) must have the narrow end of the chain on the load side and should travel towards the smaller sprocket in the system.

Drag chain life will be determined by measuring chain elongation.

(a) Locate a section of chain under tension and measure the distance between pins.

(b) Using the formula "(measured length – standard length × 100%)/standard length," where standard length = (chain pitch × number of links)

Chain Elongation, %	Large Sprocket Number of Teeth
1	≥ 140
2	> 72
3	≤ 72

(c) Replace chain if the percent elongation exceeds the above limits.

Operating drag chain's tension should be checked twice a month if possible.

Sprocket wear limits occur when the depth of wear exceeds ¼ in. (6 mm) when compared with new chain. With increased wear, the chain tends to cling to the sprocket or vibrate.

Two sprockets keyed on a common shaft are referred to as "keyed in line." One sprocket is keyed to the shaft and the other is allowed to float by use of set collars. This method allows the "floating" sprocket to self align as needed.

[1] Information taken from Handbook of Belting, The Goodyear Tire and Rubber Co.

[2] Reference from Engineering Chain Catalog, U.S. Tsubaki, Inc.

L-14 INSTRUMENTATION

Zero speed switches installed at the tail roll allow the control system to sense slippage. Inspect to ensure that there are enough targets for proximity probes feeding the PLC or that the mechanical zero speed switch drive couplings are tight.

Belt conveyor misalignment switches should be wired directly to the conveyor motor starters to ensure conveyor inspection–walkdown is required for a restart.

Transition plug sensors are installed to interlock the system in the event of plugging. These devices can be wired to the control system.

Different technologies used in level detection depend on application. Consideration of environmental conditions determines application. Dust is of major concern when selecting electronic sensing devices. Radar, sonar, ultrasound, nuclear, vibrating reed, or mechanical can be assessed.

Chain conveyors with interconnecting flights should have proximity probes on each chain strand to sense misalignment and shut down the conveyor.

L-15 SAFETY

Manual emergency stops have to be hard wired to the motor starters to prevent automatic restarts from the control system. Frequent testing is required.

A warning before system start should be integrated into the control system. The warning before start has to include an audible and visual warning at both ends of the conveyor system. The warning before start should incorporate a significant time delay to allow personnel time to evacuate.

Man guards are required whenever moving parts are concerned. Inspection–walkdown of such man guards and the addition of such are mandatory.

Safety interlocks are required if crucial man guards are removed during operation of the fuel handling system.

Interlocking of sequential conveyor faults should comply with industry standards.

OSHA dust standards have to be considered when evaluating belt cleaning systems.

L-16 FIRE PROTECTION

Fuel feed conveyors are often equipped with heat-sensing wire, interlocked with a tripping interlock. Redundant wires hooked into a voting scheme would prevent nuisance tripping due to a broken wire. (Both sensing wires would require heat sensing to trip the conveyor.)

Sprinkler system heads are often damaged by foreign objects and will trip a deluge valve in the fire system. Logic in the fire detection system would require both a broken sprinkler head and heat detection to trip the deluge valve, which eliminates nuisance tripping.

The installation of resistance temperature detectors attached to head and tail pulley bearings can prevent catastrophic fires that spread to the entire fuel handling system. The signal would alarm and then trip the system, depending on the level of bearing temperature.

NONMANDATORY APPENDIX M
PLANT AUXILIARY SYSTEMS — PUMPS

M-1 ROUTINE INSPECTION

Routine pump inspection–walkdowns must be performed to ensure that the pump will perform as required, when required. A pump that fails when it is needed most is expensive. A pump that is not performing properly is costly from pump losses at less-than-peak efficiency. There are limited walkdown inspections that can be performed to identify pump issues.

This guideline presents a description of various types of pumps, basic recommended walkdown inspections, and a description of more-detailed pump inspections.

M-2 SAFETY

Routine plant walkdowns in an operating power plant are covered by the plant's safety program. Operating staff should follow the routine guidelines listed below.

(a) Be aware that loose clothing may be caught in rotating machinery.

(b) Rotating equipment shafts may not appear to be rotating. Personnel should verify that equipment is off before touching rotating assemblies.

(c) All equipment should be off and tagged out before performing maintenance on rotating equipment.

(d) Some equipment temperatures and pressures are hazardous. Power-plant process conditions can cause injury and death. Personnel should take appropriate precautions when working with process equipment.

(e) Appropriate safety equipment should be used around equipment.

M-3 PUMP DESCRIPTIONS

There are various pumps used in the power industry. The general classifications are kinetic (dynamic) pumps and positive displacement pumps. Kinetic pumps are generally centrifugal pumps. Other dynamic pumps, e.g., educator pumps, are not discussed in this guideline.

M-4 NOISE

A crackling noise is generally an indication of cavitation. Throttling the pump discharge will reduce the flow and restore the pump conditions where the available NPSH is higher than the required NPSH and determination of cavitation can be confirmed.

A rumbling noise is generally caused by an issue in the pump discharge. Operation at low loads when the pump is not hydraulically stable, or operating at capacities beyond the design, can cause the rumbling.

Piping vibration can induce pump vibration and cause a higher noise.

M-5 PACKING AND SEALS

The shaft is sealed to prevent fluid leakage between the impeller and casing and the atmosphere. There are two types of packing — compression packing and mechanical seals.

(a) Compression packing is used in a packing gland. The packing material is generally a soft material that prevents scoring the shaft. The packing is compressed to prevent air in-leakage (suction) or high-pressure fluid leakage (discharge). There should be some amount of leakage allowed past the packing. Subatmospheric pump suction packing is provided with a water source to prevent air in-leakage.

The packing contains a lubricant. Over time, as the packing wears, the packing is compressed, releasing some of the lubricant and reducing the water flow. If the packing is overtightened, the lubricant is lost more quickly, the packing overheats, and shaft scoring can result.

(b) Mechanical seals are often used to minimize leakage. The design is based on pump pressure, capacity, temperature, and speed. A stationary disk is held against a rotating disk, with a small amount of lubricating fluid between the two surfaces. Mechanical seals require tight tolerances and must be carefully adjusted during assembly and operation. The lubricating fluid must be maintained clean, since a small amount of contamination will reduce the seal life.

If the mechanical seal has a water separator, the separator should be checked for debris and cleaned.

M-6 LUBRICATION

Since lubrication determines the life of a bearing, and bearing failure causes other operating difficulties, attention to lubrication is important. Lubrication should be maintained at proper levels, but the correct lubricant should be used. Manufacturer's recommendations should be followed. Lubricants should be free of contaminants, e.g., dirt and water. If the lubricating medium becomes contaminated, it should be changed.

M-7 BEARINGS

Pump bearings allow the pump and motor to operate with low levels of friction and keep the rotating element in position without rubbing. Modern bearings are designed to operate for long periods without problems if they are properly maintained.

Bearings are either radial or thrust bearings. Radial bearings carry a radial load and can be balls or rollers, sleeve type, or journal bearings. Thrust bearings absorb axial loads. In smaller pumps, antifriction bearings can handle radial and limited thrust loads.

Smaller pumps may use grease-type bearings, while larger pumps use oil-lubricated bearings.

On normal inspection–walkdown, bearing temperatures can be measured remotely with an infrared temperature gun. Larger bearings will have bearing monitoring systems.

M-8 OIL

The type of oil used for lubrication depends on the service, temperature, and pump speed. The manufacturer's recommendations should be followed. Oil bearings may be the flooded type, ring-oiled type, or use oil-mist lubrication.

In general, oil temperatures should be maintained between 120°F and 160°F (49°C and 71°C). Babbitt metal temperatures should not exceed 220°F (104°C).

An oil-flooded lubrication system is a common approach. The sump maintains a level of oil near the centerline of the lowest ball. A constant level oiler acts as a reservoir while maintaining a predetermined oil level in the bearing housing. The liquid seal between the reservoir and the bearing keeps the reservoir level constant. If oil is consumed, the liquid seal is broken and the air enters the reservoir to release oil. Each oiler setting is different and should be marked on the reservoir. If the oil level is too high, there will be foaming that generates heat in the reservoir. If the level is too low, there will be inadequate lubrication.

Ring-oiled systems are used in larger horizontal pumps where the simple flooded system is inadequate to maintain lubrication. Adjacent to the bearings, rings of a diameter larger than the shaft ride on the shaft and dip into an oil reservoir. The reservoir is maintained with one-fourth to three-eighths of the ring bore immersed. Rotation carries the oil from the reservoir up to oil flingers — and directed to the bearing.

Oil-mist lubrication is a dispersal of an oil aerosol into the bearing housing.

M-9 GREASE

Grease is oil mixed with a metallic soap that is thicker than oil. The bearings are "packed" with grease on assembly. On larger motors and pumps, there will be a grease fill line and a grease removal line. It is important that the bearing is not excessively filled with grease (overpacked), which will increase friction and heating.

M-10 VIBRATION

A proximity probe measures displacement. Proximity probes are used to measure shaft runout, shaft position, and rotor vibration. Increasing vibration over time indicates a problem developing. Sudden changes could indicate cavitation or pump damage.

Accelerometers can be used to develop pump signatures as part of a predictive maintenance program. The specific frequency and amplitude is associated with a specific component in the pump. A background in machinery vibration is required for analysis.

Routine recording of parameters allows trending of pump performance, which is helpful in identifying small problems and troubleshooting.

M-11 ROUTINE INSPECTION–WALKDOWN

Routine inspection–walkdowns are somewhat limited but important to discern changes in pump operation. Normal plant walkdowns are generally the first indications of pump trouble. The important aspect of inspecting pumps is to note changes in pump conditions. An example is that a pump bearing may be hot, but if it has run hot for 2 yr, it is more important that a change is noted rather than the current absolute value.

Prior to the inspection–walkdown, a visit to the control room to collect sufficient data to plot the current pump operation on the manufacturer's pump performance curve may prove useful in determining overall equipment condition.

The following inspection–walkdowns should be performed on each walkdown:

(a) visual inspection for leaks from oil and lubricating lines

(b) visual observation of oil levels

(c) visual inspection of packing leakage

(d) observation of pump and motor noise and vibration levels

(e) observation of pump and motor bearing temperatures

(f) recording and assessment of pump pressures and flows

(g) inspection to ensure that running guards and shrouds are in place

M-12 DISCERNIBLE CHANGES

Changes in operation will generally appear in one of the following areas:

(a) Packing. Packing should be checked for leak off and temperature.

(b) Mechanical Seals. Mechanical seals are generally low-maintenance items and require little attention. They should be checked at least weekly for excessive leakage. Seal water should be checked to ensure a clean and reliable flow to the seal.

(c) Bearings. Bearings should be monitored at least daily. The bearing housing temperature should be checked to detect an increase in temperature. Cooling-water flow and pressure should be checked. Check lubricant oil levels, or lubricant flow and pressure. If the bearing or oil system has a cooling system, the lubricant should be maintained above 120°F (49°C). When the pump is stopped, the cooling water supply should be shut off to prevent condensation.

(d) Couplings. Couplings should be checked visually for excessive runout and vibration. An inspection for loose bolts or any damage should be noted.

M-13 REFERENCES

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NONMANDATORY APPENDIX N
SAFETY CONSIDERATIONS

N-1 GENERAL CONSIDERATIONS

The following is a list of some safety equipment and procedures applicable to performing an inspection. This applies to all equipment, as described in the preceding appendices. Follow all plant safety procedures.

(a) steel-toed boots, hard hat, safety glasses or goggles, coveralls.

(b) gloves, primary and backup flashlights, dust mask or respirator with HEPA filter for ceramic fibers.

(c) lifeline harness.

(d) cell phone or radio.

(e) confined-space gas monitor.

(f) confined-space training must be completed.

(g) complete the confined-space testing procedure prior to entering the confined space. Restrict access until the confined spaces of the unit are below 100°F (38°C).

(h) safety watch person for permit-required confined spaces.

N-2 EQUIPMENT-SPECIFIC CONSIDERATIONS

N-2.1 Cooling Towers

Safety should be paramount in any undertaking performed. The following safety equipment and procedures are recommended prior to performing an inspection:

(a) Identify all hazards that may be encountered during the inspection.

(b) *Lockout/Tagout*

(1) Ensure all energy sources are isolated.

(2) Ensure all fans are de-energized.

(3) Ensure all circulation water pumps are de-energized.

(c) *Moving Parts:* Be aware of all moving parts that will be inspected or are in the inspection area.

(d) *PPE:* Fall protection, if mandated.

(e) *Biological Hazards*

(1) Due to the nature of the operation, cooling towers are prone to biological contamination.

(2) Visually inspect tower for cleanliness.

(3) If tower appears dirty and there is a distinct odor, assume biological contamination and don appropriate protective equipment.

(4) May require respirator.

N-2.2 Heat Recovery Steam Generators

Two sprockets keyed on a common shaft are referred to as "keyed in line." One sprocket is keyed to the shaft and the other is allowed to float by use of set collars. This method allows the "floating" sprocket to self align as needed.

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.

N-2.3 Boiler Setting Air In-Leakage and Regenerative (Rotary) Air Heaters

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.

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, able to climb, and not be bothered by feelings of claustrophobia.

N-2.4 Boiler: Steam and Water Side

Safety should be paramount in any undertaking performed. The following safety equipment and procedures are recommended prior to performing an inspection:

(a) Identify all hazards that may be encountered during the inspection.

(1) steam lines

(2) blowdown lines

(3) feedwater lines

(4) chemical addition lines

(5) oxygen content in the drums should be monitored continuously

(b) *Lockout/Tagout*

(1) Ensure all energy sources are isolated.

(2) For systems with multiple drums to a common header, there should be two isolation valves between any live steam and the boiler to be inspected. Ideally, a bleed valve should be between the two isolation valves.

(3) It is important to note that steam is not the only concern, e.g., ammonia leaking from one operating drum to another drum is to be inspected in a 2 × 1 HRSG configuration; the same is true for blowdown lines that feed a common header.

(4) Double block and bleed to ensure live steam and water cannot be introduced into the boiler during inspection.

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