

Engineering Procedure

SAEP-335

28 February 2005

Boiler Condition Assessment

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Saudi Aramco DeskTop Standards

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1 Scope

This procedure provides guidelines for performing Boiler Condition Assessment (BCA) for Saudi Aramco fired boilers. It details a three-phase approach for conducting this type of study. Boiler condition assessments may be undertaken upon request of the operating organization once a boiler reaches 10 years of age or following a major operational incident such as multiple tube failures.

2 Conflicts and Deviations

- 2.1 Any conflicts between this Procedure and other applicable Saudi Aramco Engineering Procedures (SAEPs), Saudi Aramco Engineering Standards (SAESs), Saudi Aramco Materials System Specifications (SAMSSs), Saudi Aramco Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this Procedure in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The requirements contained in the following documents apply to the extent specified in this procedure.

3.1 Saudi Aramco Documents

Saudi Aramco Engineering Procedures

SAEP-20	<i>Equipment Inspection Schedule</i>
SAEP-302	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
SAEP-355	<i>Field Metallography and Hardness Testing</i>
SAEP-1025	<i>Chemical Cleaning of Boilers</i>
SAEP-1143	<i>Radiographic Examination</i>
SAEP-1144	<i>Magnetic Particle Examination</i>
SAEP-1145	<i>Liquid Penetrant Examination</i>

Saudi Aramco Engineering Standard

[SAES-A-206](#)

Positive Material Identification

Saudi Aramco Materials System Specification

[32-SAMSS-021](#)

Manufacture of Industrial Watertube Boilers

3.2 Industry Codes and Standards

American Petroleum Institute

API RP 535

Burners for Fired Heaters in General Refinery Service

API RP 573

Inspection of Fired Boilers and Heaters

American Society of Mechanical Engineers Boiler and Pressure Vessel Codes

ASME SEC V

Nondestructive Examination

Electric Power Research Institute

EPRI RP2596-10

Condition Assessment Guidelines for Fossil Fuel Power Plant Components

4 Instructions

A flow diagram outlining the BCA procedure is shown in Figure 1. A typical examination and assessment workscope that could be adopted is given in Attachment A. This workscope is not to be applied routinely at every T&I. Rather, the Phase 1 survey will outline the appropriate workscope to undertake based on the inspection history and the future operating requirements for the subject boiler.

4.1 Phase 1 – Pre-inspection Survey

This is a familiarization exercise that should be performed four months prior to the Testing & Inspection (T&I) work. The T&I schedule is specified in [SAEP-20](#). The pre-inspection survey will consist of a review of the operational history of the boiler, the inspection and maintenance records to identify salient features of boiler operation and establish the significance of any incidents that may have occurred. Interviews with plant personnel will also be conducted so that maximum information is derived in preparation for the next phase.

Phase 1 may, depending on the operating conditions and life of the boiler, involve some preliminary bounding life calculations using conservative principles. This will assist in identifying and confirming the criticality of the components to be incorporated in the site inspection workscope.

A deliverable of this task will consist of a Phase 1 report. This report will detail all inspection and examination activities that must be included in the T&I schedule. This document should be available to plant management at least two months prior to the start of the T&I.

4.2 Phase 2 - Site Inspection

This phase will involve the implementation of the inspection/examination workscope defined in Phase 1.

The site inspection will utilize a variety of examination procedures and techniques to evaluate the condition of the workscope components. Each specialist will conduct his own examination relevant to his field of application. API RP 573, *Inspection of Fired Boilers*, and EPRI RP2596-10, *Condition Assessment Guidelines for Fossil Fuel Power Plant Components*, contain a good deal of very useful information that could be used in conjunction with this phase..

All preliminary examination findings and any immediate recommended actions will be documented and provided by team members to the BCA Team Leader prior to departure from site for compilation into the Phase 2 interim report.

The deliverable from Phase 2 will be the interim report describing all preliminary findings and any immediate recommended actions so that the boiler may be returned to service. This document will be provided to the plant management prior to the departure of the BCA Team Leader from site.

4.3 Phase 3 - Condition Assessment and Reporting

The participating specialists will conduct detailed analyses of plant condition data gathered from site to establish the current condition of the components examined and provide recommendations regarding their future serviceability.

The deliverable from Phase 3 will be the final report. The BCA Team Leader will be responsible for the compilation of this document, which should be issued four to six weeks following the completion of Phase 2. The report will include recommendations for future inspection and maintenance requirements of the boiler(s). If appropriate, a presentation meeting will be arranged at a mutually convenient time following issue of the final report.

5 Responsibilities

5.1 BCA Team Leader

The selection of an appropriate engineer to serve as a BCA Team Leader shall

be the responsibility of the Coordinator, Materials Engineering & Corrosion Control Division (ME&CCD) / Consulting Services Department (CSD).

The BCA Team Leader will:

- Assume the responsibility for coordinating all activities and act as the main point of contact with the plant. He will also ensure that adequate resources are available to accomplish the required work.
- Hold a kick-off meeting and identify the duties of all participants prior to commencing the study.
- Issue all correspondence.
- Compile and issue a Phase 1 report, detailing all inspection and examination activities that need to be scheduled for the T&I. This report must be available to the plant management and all project participants at least 4 weeks prior to T&I start.
- Prepare and issue a site inspection Gantt chart approximately two months prior to T&I start.
- Coordinate the transfer of documentation and collection samples between the plant and the appropriate specialist or laboratory.
- Coordinate the review of any significant findings with plant personnel to allow timely remedial actions, in order that the boiler may be returned to service.
- Compile and issue an interim report prior to departure from site.
- Compile and issue a final report to the plant management no later than 6 weeks following completion of the Phase 2 Site Inspection of the boiler.

5.2 Proponent

Plant management may request the undertaking of a BCA on their boiler(s) from Consulting Services Department (CSD), provided the boiler in question is either at least ten years of age or has suffered a major operational problem.

5.2.1 Phase 1 Requirements. The following information shall be supplied to the BCA Team Leader by plant Inspection and Engineering staff:

- Boiler design and construction drawings
- Process flow diagram and P&ID of boiler under consideration
- Process flow diagram of the entire steam cycle
- Safety Information Sheets (SIS) for all boiler items

- Representative sample of operating temperatures and pressures (1 month data of normal operation in either electronic format or log sheets)
- Inspection/failure/repair/modification/replacement history
- Details of any previous condition assessment study or specialized investigation
- Maintenance shutdown / T&I interval
- Details of any major operational upsets
- Total number of start-ups and shutdowns to date
- Start-up procedure and temperature ramp rate during start-up and load tests information
- Load increase as a percentage of maximum continuous rating (MCR) when one or more of the other boilers trip
- Type and composition of fuel used
- Details of fuel additive program if any
- Commissioning date and approximate service hours to date
- Details of chemical cleaning and hydrojetting, i.e. type and frequency
- Details of water treatment chemicals used and their recommended ranges
- Boiler make up water, feed water, boiler water, steam and returned condensate specifications
- Six months records of chemistry parameters for boiler make-up water, boiler feed water, boiler water, returned condensate and steam
- Thickness readings of drums and tubes from previous T&I's

5.2.2 Phase 2 Requirements. The following items and services should be made available by the proponent:

- Plant access security clearance
 - Details of plant safety regulations and requirements for any safety briefing or qualification prior to work start
 - Suitable access, scaffolding and lighting at all workscope components
 - Power supply to all workscope locations
 - Preparatory grinding / sandblasting / wire brushing prior to NDT
-

- Provision of NDT services (in-house or contracted-out), e.g., MT, UT, UTTG, and PT
- Assistance with general inspection work
- Office accommodation
- Chemistry lab support as required

5.3 Engineering and Inspection Specialists Responsibilities:

- Each specialist will review the plant information relevant to his field of application and draw conclusions and recommendations for inclusion in the Phase 1 report.
- Conduct detailed analysis or site examination (as appropriate) to establish the condition of the components examined. Immediately report any significant findings to the BCA Team Leader so that timely decisions can be made on the appropriate action to be taken.
- Provide a detailed report to the BCA Team Leader approximately 2 to 4 weeks from return from the site. The report shall include findings and recommendations on future serviceability of the boiler(s).

6 Technical Procedures

Non-Destructive Testing (NDT) or evaluation and other testing methods are applied to detect tube defects, to monitor for tube degradation and to provide data for boiler component failure prediction and prevention programs. The NDT methods most often used include visual examination, ultrasonics, radiography, magnetic particle testing and liquid penetrant testing. Other specialized testing methods such as remote field eddy currents and submerged ultrasonics are also used to investigate large-scale boiler incidents. However, these are not routinely employed.

6.1 Visual Examination

Visual examination or testing (VT) is the basic NDT method, and its value is in direct proportion to the knowledge and experience of the examiner. Visual examinations by experienced boiler personnel can provide significant data about the external surface conditions of boiler tubing. Visual examinations are performed most often for the detection of fireside erosion and corrosion problems, broken attachments and supports and fouling conditions. Borescopes, flexible fiber-optic viewers and miniature closed-circuit television systems are also used for internal examination and the detection of pitting, other types of corrosion and solids deposition. Personnel making visual examinations should

be familiar with boilers, and a simple checklist or sign-off sheet should be part of the examination procedure.

6.2 Ultrasonic Testing

Ultrasonic thickness measurement (UTT) and ultrasonic testing (UT) performed by qualified NDT personnel can provide significant data about tube wall thickness and surface material conditions. UT examinations are performed for the detection of wall thinning caused by pitting corrosion, erosion, other forms of corrosion, and for the detection of sub-surface material defects. UTT surveys are performed periodically on boiler tubing, header and drum components to measure the current thickness. Data from previous surveys taken at the same locations can be used to calculate a thinning rate, to estimate the stress level and to predict when tube replacement will be necessary.

Another ultrasonic technique for measuring boiler tube wall thickness involves using an electromagnetic acoustic transducer (EMAT). One of the main advantages of EMAT devices is that they do not have to be in direct contact with the workpiece. Since EMAT systems do not use a couplant, they can be operated at higher speed and in higher-temperature environments than conventional UT systems. They also have the ability to operate on rougher surfaces and with less preparation of the material surface.

6.3 Magnetic Particle Testing (See [SAEP-1144](#), *Magnetic Particle Examination*)

Magnetic particle testing (MT) locates surface or near-surface discontinuities in ferromagnetic materials. These examinations are performed for the detection of stress-corrosion cracking, fatigue, creep cracking and surface-related material defects in the base material and weldments. If higher sensitivity is required, as in, for example, the detection of small defects, then wet fluorescent magnetic particle testing (WFMT) may be employed.

6.4 Liquid Penetrant Testing (See [SAEP-1145](#), *Liquid Penetrant Examination*)

Liquid penetrant testing (PT) locates cracks or pores in materials – provided the discontinuities are clean and open to the surface. This method is applicable to magnetic and non-magnetic materials and is particularly useful when magnetic particle examinations cannot be used. PT examinations are performed for the detection of dissimilar metal weld cracking, stress corrosion cracking, fatigue cracking and welding defects.

6.5 Radiographic Testing (See [SAEP-1143](#), *Radiographic Examination*)

Radiographic testing (RT) detects surface and sub-surface discontinuities that can be aligned with the propagation direction of the radiation beam. RT

examinations are performed for the detection of various forms of cracking, corrosion fatigue and welding defects.

Radiographs are available to show the various types of discontinuities most often found in tubing welds. These reference radiographs can be most helpful when interpreting radiographs and judging the acceptability of welds. The reference radiographs were taken in accordance with the procedure commonly called the Radiographic Technique for Double Wall Viewing. This procedure is described in ASME SEC V, Subsection A, Article 2, Paragraph T-272 of the *ASME Boiler and Pressure Vessel Code*.

6.6 Positive Material Identification (PMI) (See [SAES-A-206](#), Positive Material Identification)

PMI provides a direct means of identifying boiler component materials and verifying they conform to specifications. In-situ, strictly non-destructive analyses can be made by means of commercially available, portable instruments. These instruments, based on either wavelength dispersive or energy dispersive X-ray spectroscopy, are capable of quantitative analysis of the metallic constituents of the material by comparison with built-in standards.

6.7 Metallographic Replication (See [SAEP-355](#), Field Metallography and Hardness Testing)

The weld or base metal locations targeted for examination are first subjected to rough grinding and profiling. The areas are then prepared using successive stages of fine grinding and various grades of silicon carbide paper with some inter-stage heavy etching. The etchant shall be 2% Nital (2% solution of nitric acid with methanol) for carbon and low-alloy steels. Final polishing shall be carried out using 6 micron and 1 micron diamond pastes. The 1-micron stage shall be repeated at least once. The polished site shall then be cleaned with a solvent wash followed by a solvent-soaked cotton wool swab. At least three replicas shall be taken at different levels of etching, i.e., light, medium and heavy. Replicas shall be made by applying an acetone wash to the etched replica site and carefully laying on the cellulose acetate film. Surface tension will cause the film to be pulled down onto the replica site. Replicas shall be left in place for approximately 5 minutes, i.e., until they are no longer soft and are easily removed. Identification labels shall be attached to the non-contact side of the replica before removing. The replicas shall then be peeled from the site and immediately placed flat in clean resealable plastic bags. Identification labels shall remain securely attached to the replicas. The replicas are then laid flat and mounted on a plastic or glass slide using double-sided sticky tape. These are then coated with gold or platinum for contrast enhancement and future optical microscopy examination. This coating is carried out in vacuum sputter coating units. Examination is performed by experienced metallurgical engineers under

optical microscopy or SEM to identify microstructural features and damage if present.

6.8 Hardness Measurement (See [SAEP-355](#), Field Metallography and Hardness Testing)

On completion of all replication, hardness measurements are usually required from both parent materials and the weld regions of each replica site. These measurements shall be performed using portable microhardness testers such as Krautkrammer Microdur 2 or similar. At least twenty measurements from each area are taken with the average value being reported.

6.9 Examination of Tube Samples in Metallurgy Lab

Tube samples removed from representative boiler locations can provide the engineer with a wealth of information not available by any other means. Based on the historical review and field inspection of the unit, representative tube samples can be selected from critical areas for metallurgical/mechanical testing in the laboratory. The objectives of these tests are to determine more accurately the nature and extent of damage and to characterize any of the several parameters, i.e., steam-side oxide scale thickness, material hardness, and microstructural degradation, used to estimate metal temperature for remaining life determination. Samples can also be removed from non-critical areas for comparison and life expectancy assessment. Removal of tube samples should be in accordance with Section 5.3 of [SAEP-1025](#). Replacement of boiler tubes should follow [32-SAMSS-021](#).

The extent to which each sample is examined is decided from the sample condition in conjunction with the life evaluation effort. The examination consists of several laboratory techniques:

6.9.1 As-Received Visual Examination

Samples are inspected for appearance, scales/deposits, corrosion, cracking, past repairs, and any other signs of distress. Scale and deposits from distressed areas are removed for chemical analysis to determine the cause of attack.

6.9.2 Dimensional Measurement

Portions of samples are sectioned transversely and cleaned before wall thickness and outside diameters are measured at various locations around the circumference. Variations in these measurements from the original dimension, or from each other, indicate areas that must be examined further for signs of overheating, corrosion or erosion. The measurements

also allow accurate determination of wastage rates and stress values for tubes, still in the unit, that appear to be in similar condition. The data are essential for determining the remaining life of these tubes.

6.9.3 Surface Examination

Portions of tube samples are longitudinally sectioned to permit inspection of the inside surface for oxide scale exfoliation. The samples are then cleaned for examination of the surface under the deposit or scale. Any sample damage observed (pits, cracks, etc.) is measured for possible use in the remaining life assessment.

6.9.4 Microstructural Examination

The microstructures of the distressed and undistressed areas of the sample are compared to aid in the determination of the cause of distress. Important changes in microstructure that need to be assessed include spheroidization, microcracking, the presence of creep voids (and the degree of coalescence), environmental damage, etc. The effects of these microstructural changes on mechanical properties are also used to support remaining-life estimation.

Accurate measurements of ID oxide-scale thickness can also be made using optical microscopy. EDXA (Energy-Dispersive X-ray Analysis) analysis may also be used to characterize the nature of any deposits that may be present at the tube ID, e.g., caustic compounds, copper, etc.

6.9.5 Mechanical Properties

Transverse specimens are tested for hardness through the thickness and around the circumference. Longitudinal sections can be removed for preparation of specimens for further mechanical testing if required.

6.9.6 Material Chemistry Analysis

If the microstructure or mechanical properties of the material are not characteristic of the specified material, chemical analysis is performed to establish material constituents.

7 Water Treatment

The water treatment specialist's input will come during Phases 1, 2, and 3 of the BCA.

7.1 Phase 1

During Phase 1, a thorough review of the water chemistry parameters, sampling

protocols, laboratory analytical procedures and boiler operating history will be performed. The plant utility engineer shall work closely with the water treatment specialist and provide information on operational history and problem areas.

7.2 Phase 2

7.2.1 Inspection

During Phase 2, the water treatment specialist is required to inspect the boiler waterside and fireside. In the waterside he will inspect the mud and steam drums and view the recordings of the video borescope examination of the boiler tubes. The main points of interest will be to see if there is adequate passivation on the waterside, and that the boiler is free of scale. If there is any evidence of deposit in the steam or mud drum a sample should be collected for analysis. In the fireside, he will look for tubes with black sooty deposits, wall tubes that are bowed out from the wall, any waterwall, screen tubes or target-wall tubes that show evidence of significant discoloration, bulges or cracks. He will look for evidence of significant accumulations of deposits on furnace tube surfaces. He will look for any evidence of cracked or missing refractory. He will examine floor and roof tubes and refractory for evidence of damage. If soot blowers are used, he will look for evidence of effective operation. If there is any evidence of deposit on the external surfaces of the tubes a sample should be collected for analysis.

If poor passivation is observed, as indicated by the absence of a coherent magnetite film in the boiler, then there are problems in the water chemistry of the plant, which should be investigated.

7.2.2 Vendor Involvement

The water treatment vendor should be notified of the inspection schedule so they may have the opportunity to provide their own input as to the condition of the boiler. Deposit samples and tube samples should be provided to the vendor if convenient and available. If approved by the Plant, inspection by competitive chemical vendors may be requested in some cases. Vendor inspections must be coordinated so they will not interfere with the on-going work schedule.

7.2.3 Scale Analysis

If the boiler tubes show organic or inorganic scale deposits or bulges, then a tube sample should be removed from the boiler for metallographic analysis, scale analysis and scale density index (SDI) measurement. The

water treatment specialist will determine the number and the locations of the tube samples that need to be removed. SDI measurement together with x-ray diffraction and x-ray fluorescence should be used to quantify the amount of scaling and determine the nature of the scale. Based on these results, the water treatment specialist, after consultation with CSD's chemical cleaning expert, will determine the need to either chemically clean or hydrojet the boiler tubes. The water treatment specialist will work with the plant process engineer to establish an action plan to determine the cause of the scale build-up or bulging and the best way to eliminate the problem. The water treatment specialist shall specify when to cut tube samples for SDI measurement and scale analysis to maintain a history of the tubes condition and corrosion/scale control.

The time required to complete the analysis of the deposit from both the waterside and the fireside is lengthy and should not be allowed to hold up the work schedule. The deposit result should be reviewed to evaluate the water treatment program efficacy and where improvement should be made. Quick "spot check" analysis is available to give a general idea of the qualitative analysis of the deposits. These spot checks can provide valuable information on the direction of T&I procedures, and /or operational changes.

7.3 Phase 3

During Phase 3, the water treatment specialist will be required to analyze the data, such as scale composition analysis, to determine if there are any problems with the water treatment program. If any problems are discovered, recommendations for changes in the water chemistry parameters, even up to a complete change in water treatment program, will be included in the final report.

8 BCA Task Force

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9 Plant Assessment and Material Identification Subcommittee

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Revision Summary

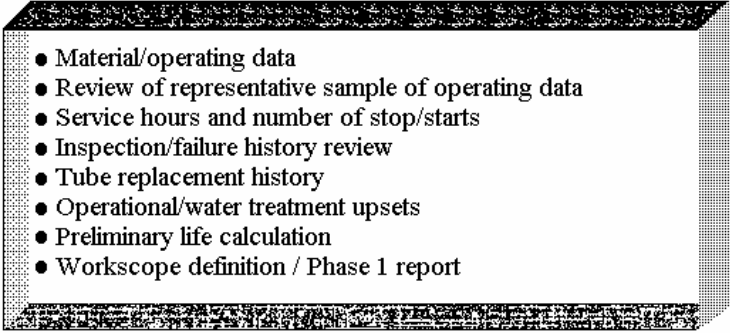
28 February 2005

Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes.

Figure 1

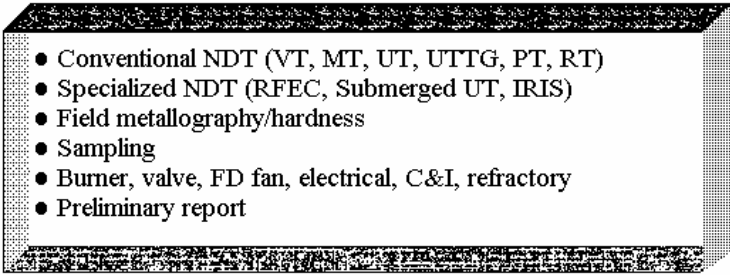
● Procedure for Boiler Condition Assessment

● Phase 1: Pre-Inspection Survey

- 
- Material/operating data
 - Review of representative sample of operating data
 - Service hours and number of stop/starts
 - Inspection/failure history review
 - Tube replacement history
 - Operational/water treatment upsets
 - Preliminary life calculation
 - Workscope definition / Phase 1 report

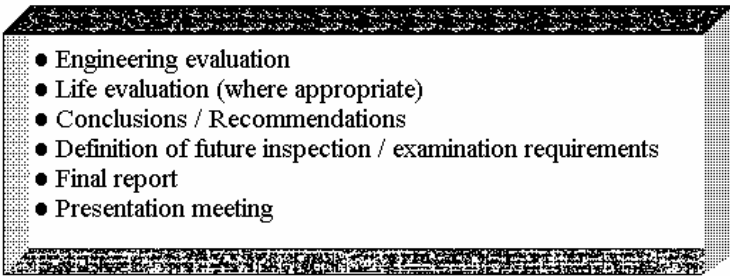


● Phase 2: Site Inspection / Examination

- 
- Conventional NDT (VT, MT, UT, UTTG, PT, RT)
 - Specialized NDT (RFEC, Submerged UT, IRIS)
 - Field metallography/hardness
 - Sampling
 - Burner, valve, FD fan, electrical, C&I, refractory
 - Preliminary report



● Phase 3: Analysis and Reporting

- 
- Engineering evaluation
 - Life evaluation (where appropriate)
 - Conclusions / Recommendations
 - Definition of future inspection / examination requirements
 - Final report
 - Presentation meeting

Attachment A – Typical Boiler Condition Assessment Workscope

Abbreviations:

VT = Visual Testing

MT = Magnetic Particle Testing

UT = Ultrasonic Testing (flaw detection/shear wave)

UTTG = Ultrasonic Testing Thickness Gauge measurement

WFMT = Wet Fluorescent MT

PT = Liquid Penetrant Testing

RT = Radiographic Testing

A.1 Steam Drum

A.1.1 Preparation:

Removal of internals

Cleaning of drum

Grinding of both dished head/shell circ. welds

Grinding of safety valve nozzle welds (external)

Grinding of 10% of longitudinal welds

A.1.2 Examination:

Visual examination prior to cleaning and collection of deposits for chemical analysis

Post-cleaning visual

UTTG at selected shell and dished head locations, Total = 20 points

MT/UT of shell/dished head circ. welds and 10% of longitudinal welds

MT of safety valve nozzle welds

A.1.3 Assessment:

This will be based on the main damage mechanisms relevant to the steam drum, i.e., corrosion and thermal fatigue.

A.2 **Mud Drum**

A.2.1 Preparation:

Cleaning of drum

A.2.2 Examination:

Internal visual

UTTG at selected shell and dished head locations, Total = 20 points

MT/UT of shell/dished head circ. welds and 10% of longitudinal welds

A.2.3 Assessment:

This will be based on the main damage mechanisms relevant to the mud drum, i.e., corrosion only

A.3 **Waterwalls (including Screen and Bank Tubes)**

A.3.1 Preparation:

Adequate scaffolding and lighting

Light grinding/wire brushing of tubes for UTTG survey

Removal of 2 tube samples (Refer to [SAEP-1025](#) for tube removal procedure) at areas to be identified following the initial visual for subsequent metallography and analysis at CSD. Tube samples may be removed from most severely bulged locations.

A.3.2 Examination:

Full visual of furnace waterwalls for evidence of overheating, excessive corrosion.

Internal borescope or video examination

Comprehensive UTTG survey

Radiography at selected tubes to check for internal metal loss and pitting

Specialized Examination: In cases where a specific operational incident is known to have occurred on a boiler, e.g., chelant attack, repetitive tube failures, extensive pitting damage, the plant should consider using specialized techniques such as RFEC (Remote Field Eddy Current) for

screening purposes complemented with submerged UT such as IRIS (Internal Rotary Inspection System) for detailed evaluation. This type of examination is particularly recommended to evaluate areas of the boiler tubing that may not be easily accessible for conventional NDT. It is advised that this is carried out on one representative boiler (for a group of parallel boilers) every 10 years or immediately following a major incident, whichever is the earliest.

A.3.3 Assessment / Metallography

This will be based on the main damage mechanisms relevant to the waterwalls, i.e., steam/water corrosion (internal), fireside corrosion and oxidation (external), hydrogen damage, thermal fatigue damage, etc. The metallography on the tube samples will involve a detailed study of internal and external features via EDS (Energy Dispersive Spectroscopy), through-wall examination and hardness. The assessment will determine the requirements for chemical cleaning in conjunction with the findings from the water treatment specialist and in accordance with [SAEP-1025](#).

A.4 **Waterwall Headers**

A.4.1 Preparation:

Access to headers

Light grinding/wire brushing of selected header/tube locations

Removal of selected inspection plug for internal visual examination

A.4.2 Examination:

UTTG of selected header locations

Internal visual examination of selected headers

A.4.3 Assessment:

This will be based on the main damage mechanisms relevant to these headers, i.e., internal/external corrosion

A.5 **Economizer Tubes and Headers**

A.5.1 Preparation:

Access to tubing and headers

Wire brushing of outlet header/tubes attachment welds

Light grinding/wire brushing of selected header/tube locations

Removal of inspection plugs/nozzles or tube stubs for internal examination (inlet header only)

A.5.2 Examination:

Visual for evidence of external corrosion, distortion, etc.

Internal visual for evidence of thermal fatigue damage (inlet header only)

UTTg at selected tube and header locations

Removal of one tube sample (Refer to [SAEP-1025](#) for tube removal procedure) at areas to be identified following plant data review and visual examination for subsequent metallography at CSD

A.5.3 Assessment:

This will be based on the main damage mechanisms relevant to the economizer, i.e., internal/external corrosion and thermal fatigue

A.6 **Superheater Tubes and Headers**

A.6.1 Preparation:

Access to tubing and headers

Wire brushing of outlet header/tubes attachment welds

Grinding of end cap/inspection nozzle/branch welds (if present) and header/pipe terminal weldments

Light grinding/wire brushing of specified header/tube locations (to be identified following the Phase 1 review)

A.6.2 Examination:

External visual for evidence of excessive corrosion, distortion

UTTg at selected tube and header locations

MT/UT at header/tube attachment welds, end caps, inspection nozzles and terminal weldments

Field metallography (replication and hardness, refer [SAEP-355](#) Field Metallography and Hardness Testing) at selected tube and header locations, to be identified following the Phase 1 review

A.6.3 Assessment

This will be based on the main damage mechanisms relevant to the superheater, i.e., creep (if the header is operating in the creep regime for the material in question) and oxidation. The assessment will utilize the plant operating data (temperature and pressure) and NDT information to evaluate the remaining life of these components.

A.7 Burners

Visual inspection: Burners should be inspected visually at the following locations:

Windbox: Dampers, vanes and casing of the windbox should be inspected for mechanical integrity, positioning and operability.

Air register control mechanism: Burners are provided with an external mechanism for controlling air distribution inside the burner by controlling burner air register. The mechanism should be inspected for operability and accurate positioning.

Air Registers: Air register vanes and dampers should be inspected for freedom of movement. Inspection of the air registers should be in conjunction with the external driving mechanism.

Air passages: Most burners have primary and secondary air systems. Both the primary and secondary air passages should be inspected for clearance from unwanted material or debris.

Burner Block: The burner block should be inspected for cracks, spalled sections and for compactness by means of a hammer test.

Gas and oil nozzles (tips): Gas and oil nozzles or tips should be inspected for cleanliness of their tips and for any signs of overheating.

Igniters (Pilots): Igniters or pilots should be inspected for operability, any signs of heat damage or any cracks and defects.

Miscellaneous: Other component such as atomizer, fuel gas and oil hoses and swirler should be inspected for integrity.

Dimensioning and Measurement Inspection: Actual measurement for the burner component should be conducted at different operating position and before and after T&I activities. Actual measurements of air register components, gas and oil nozzles and burner block should be in conformance with the fabrication drawings. Tolerances should be taken into consideration when comparing actual measurement dimensions to dimensions in the fabrication drawings.

Commentary Note:

API RP 573 Inspection of Fired Boilers and Heaters contains useful information.

A.8 **Forced Draft (FD) Fans**

To evaluate the reliability of the FD Fans, it is customary to follow the manufacturer's guidelines and the maintenance procedures available within the plants. In particular, FD Fan evaluation includes regular monitoring of the bearing housing vibration. This will provide an indication of fan and bearing condition and can give advance warning of bearing or fan problems.

Another item that requires regular checking is the fan damper control/linkage system. This item is known to have resulted in damper failures that, in turn, have caused FD Fan problems. Regular checks of this system will ensure that the controller is performing as designed, and that the dampers are free to operate. Checks should be done during boiler outages and the manway open so that the action of the damper can be viewed. Checks can also be carried out on line and the airflow and or pressure monitored to verify correct control.

During outages, the fan itself can be visually inspected for any physical damage, cracks, etc., which could propagate and cause failure in the future. Other parameters to be monitored during operation include the bearing temperature, the lube oil temperature and pressure and signs of discoloration of the oil.