Boiler Inspection
Fire Tube Boilers

(HIGH PRESSURE AND LOW PRESSURE)

030622R1 Master

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Boiler Inspections of Fire Tube Boilers

PREFACE

This presentation was designed to help ASOPE Licensed Engineer's to understand what a Fire Tube Boiler Inspection could consisted of. The information in this presentation is designed to increase your knowledge and improve your abilities as they relate to a Fire Tube Boiler Inspections. Within the presentation you will find information pertaining to Fire Tube Boiler Inspection and what **could** be inspected at the request of the Boiler Inspector.

Remember the Boiler Inspectors are Professionals. Their inspection is for Safety.

When they ask a question answer it truthfully, if they need help, aid them.

General Description

Fire tube boilers (Scotch Marine) are distinguished by the characteristics of having the gases of combustion pass through the tubes with the water in the shell surrounding the tubes. The shell is horizontal with the furnace being internal to the shell. The combustion gases exit at the rear tube sheet and are turned in a combustion chamber. They are directed through horizontal tubes affixed to the front and rear tube sheets which are flat. They may make two, three, or even four passes back and forth through the boiler tubes and combustion eh2mher before exiting to the breeching and stack. This is accomplished by refractory type baffles located at front and rear head areas.

The true "Scotch Marine" fire tube boiler (wet back) has a rear door, a combustion chamber crown, and a bottom combustion chamber area completely surrounded by water. The water acts as an insulator around the combustion chamber. This configuration is more efficient since it reduces heat loss and adds heating surface.

The "Scotch" Fire Tube Boiler which is often mistakenly referred to as being "Scotch Marine" is a dry back type. The rear door and combustion chamber has refractory and insulation instead of water.

Types of Fire Tube Scotch Boilers may be further categorized as:

Fire Tube Scotch Marine (wet back) Fire Tube
Scotch (dry back)
Fire Tube Scotch - Corrugated Furnace Fire Tube
Scotch - Plain Furnace
Fire Tube Scotch 2, 3, or 4 pass.

Primary service use of these boilers may be classified as:

- High Pressure, usually not over 200 psi
- Low pressure, 15 psi Hot water beating
- Steam heating, low pressure
- Manufacturing process steam
- Dry cleaners and laundry
- Food processing
- Power
- Chemical processing Absorption air conditioning.

Note

- Due to the various types of service, the amount of condensate or return water will vary from 100% return to zero return.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

- Overpressure can result as a failure of the pressure operating control and the high limit control.
- Overpressure can result due to safety or relief valve failure.
- Overpressure can result due to the steam gage supplying incorrect readings, allowing for improper limit control settings.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- Low water may cause bagging of the furnace, loosening of tube joints, sagging of tubes, blistering of tubes, rupture of the furnace, bulging of tube sheets, and rupture of the shell or tubes. Low water (dry firing) is the most common cause of damage and may be a result of the following:

  a) water gage glass in poor condition, dirty, or obstructed,

  b) connections to glass obstructed,

  c) connections to water column plugged,

  d) water glass installed at wrong level,

  e) failure of feed pump,

  f) make up feedwater supply interrupted,

  g) major leakage in boiler or system,

  h) return flow or condensate return interruption, 1) low water fuel supply cut-out fails to operate properly.

What Are The Boiler Inspectors Looing For: (Continued)

- High water can cause carry over into main steam lines and can cause rapid quenching that could damage or crack the steam lines or headers.
- Erosion

    a) If steam soot blowers or steam lances are used on the fire side, wet steam will cause erosion.

    b) Leaks can erode adjacent area.

    c) Oversized forced draft fans or burners can increase the velocity on the fire side to an unacceptable level.
- Internal Corrosion, consist of Scale, pitting, caustic, chelate, acids, oxygen, and other contaminates in the feedwater that affect water surfaces will cause internal corrosion.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- External Corrosion

a) Any moisture combined with the residue of the products of combustion will create external corrosion.

b) Soot resulting from faulty burners or improper burner settings will place acidic deposits on the fire side.

c) Slag is mineral or metallic fly ash that is a residue of combustion. It is particularly a problem when burning coal, due to large percentages of sulfuric acid in the coal.

d) High temperature corrosion occurs when using high alkali, high sulfur, high vanadium, and high sodium oils as a fuel. The result of residue from these fuels can cause severe tube wastage in the high temperature area by forming low melting point corrosive compounds which form slag. Fuel treatment with magnesium and good soot blowing practices effectively reduce this type of corrosion.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- Improper storage of boilers can create abnormal corrosion of both fire and water sides.

  a) All boilers when removed from service should be thoroughly cleaned on all water and fire side surfaces.

  b) For dry lay-up upon thorough drying, place moisture absorbent in the drum or shell (either quick lime at a rate of 7 lb. or silica gel at a rate of lb. for each 100 cubic feet of volume). Place the absorbent in trays for easy removal.

  c) For wet lay-up fill the boiler completely with water. The water should have approximately 200 PPM sodium sulfate having a pH of 10. High alkali, low acidic is the key.

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WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

: (Continued)

- Excessive scale cannot be tolerated.

    a) Too much scale causes poor heat transfer which reduces efficiency and causes overheating of the pressure boundary metal. This in turn may cause serious damage to the boiler metal.

    b) Scale is a result of poor feedwater treatment coupled with excessive make-up water.

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WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- Soot or fly ash blockage in the fire tubes can reduce the efficiency; however, it also blocks the flow of combustion gases which increases the chance of gases backing into the boiler room or creating conditions for fire box explosions or implosions. It also allows for acidic corrosion attack.
- Sludge is a sedimentary deposit formed by suspended matter in the make-up feedwater or by precipitation from the boiler water. It is soft and less adherent than scale; however, it can cause problems with beat transfer in the lower portions of the boiler. It is not a good heat transfer medium; therefore, accumulations of sludge may cause over heating of the metal. It is also dangerous to have sludge accumulations in the controls or in the lines leading to the controls or appurtenances.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- Oil of any kind on internal surfaces can have serious adverse effects. Oil can form, a hard, dense carbonaceous deposit which is hard to remove. It can cause serious hot spots, or localized burning or blistering of the metal It can cause the total dissolved solids in the feedwater to increase to a point that will allow foaming or priming to occur.
- Pitting can occur as a result of oxygen corrosion caused by excessive concentration of oxygen that results in the formation of a very localized non-productive layer of oxides. A differential oxygen concentration then occurs in a localized area, and severe pitting takes place in isolated spots, or in some cases linear or general gross areas.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- Caustic corrosion may occur when the caustic level of the boiler water reaches a high level. This allows the protective oxide coating to dissolve. When this occurs, caustic gouging, and ductile and crater corrosion may occur. In boilers, this corrosion most commonly attacks the tubes or small headers. In FTSM, it definitely attacks the tubes or auxiliary piping. The corrosion is larger than common pits and looks like large grooves cut in the metal.
- Chelate corrosion is found in localized areas of high steam and water velocity and turbulence. It usually appears relatively smooth with a near mirror like finish The loss of metal can be uniform which is deceptive over a large area. Uncontrolled oxygen treated with chelates can result in severe pitting that will appear free of corrosion products. In fire tube boilers, it usually occurs on the tubes near the feedwater inlet. The upper part of the top row of tubes nearest the steam outlet also are susceptible to this type of attack. Therefore, the inspector should carefully inspect these areas.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

: (Continued)

- Acid corrosion may be a result of residue not removed during a boiler acid Cleaning operation as a result of improper rinse or neutralization. It could also be a result of pH below 7 or the leaking of acid into the steam or returning condensate.

  Acid corrosion causes a severe localized metal loss, with very rough edges when it is a result of acid cleaning. Look for it to occur in hard to drain or flush areas, or where circulation is extremely slow.

  If acid corrosion occurs during operation, it may cause an overall attack resulting in microscopic roughness of the metal surfaces. Check all water wet surfaces. A close inspection of these surfaces is necessary in order to detect this potential metal thinning condition.

WHAT ARE THE BOILER INSPECTORS LOOKING FOR?

(Continued)

- Overfiring by adding fuel in a disproportionate amount to the heating surface available or the inability of the boiler to absorb or dissipate the heat that is released or applied can lead to overheating, weakening or burning of the metal. This can cause major problems near burners or first pass areas.
- Excessive forced draft can change velocity and flow characteristics of flue gas which precipitate erosion. This will cause problems at all sharp turns in the combustion gas flow pattern.

- The Inspector Starts With An External Inspection:
  - General inspection of the boiler room prior to starting on the boiler proper.
  - Checking these items;
    - Lighting
    - Ventilation
    - Personnel Safety
    - Housekeeping
    - Operating Logs and Records

The reasons for checking these items are given starting on the next slides.

General Inspection Boiler Room

Lighting

- The boiler room must be well lighted for the operators to see what is happing, and for them to preform proper maintenance and operating procedures. It also helps the inspector to do a better job. Large units need provisions for emergency lighting source in case of a power failure.

Ventilation

- Openings for air supply must be adequate to support complete combustion of all fuel burning equipment located in the boiler room. This is necessary it insure against operator exposure to carbon monoxide poisoning. A quick check may reveal that the total cross-sectional area of free air entering the boiler room provided by these openings is at least equal to the cross-sectional area of all burning equipment discharge pipes. Any doubt as to the adequacy of free air available in the boiler room must be reconciled as a result of closer examination of openings, flue gas discharge pipes, and boiler breechings.

Personal Safety

- In addition to the requirements for ventilation, checks for access routes to the area you are about to enter. The Boiler Inspector will enquire to whom will be accompanying the Boiler Inspector at all times. Safety should not be taken for granted.

Housekeeping

- A clean, neat boiler room generally tells the Boiler Inspector the boiler itself receives an equal level of care. The boiler room should be kept free of material and equipment not necessary to the operation of the boiler. This is particularly true of material which may be flammable or hazardous. The boiler room is not a warehouse or storage facility. Better maintenance can be achieved by having a clean boiler room.

Records & Licenses

- If the boiler is an existing unit, check the current license or operating permit for correctness and expiration date.
- Look at the logbook. It may indicate where you should concentrate your inspection activity.
- Check the maintenance schedule and records. This is an excellent source of information for items which need to be scrutinized. The information acquired could also indicate areas of least concern to inspect.
- Discuss past operational experience of the boiler operators.

Fire Tube Boiler Inspection

Before any internal inspection can be done the boiler must be prepared using the Boiler Inspection Procedure, Lockout and Tag Procedure, Confined Space and Procedure and the Boiler Inspection requirements.

Outer Casing

Outer Casing could be inspected for:

- The casing for evidence of 'hot spots" by discoloration.
- Holes or corrosion, resulting from possible leakage in the pressure boundary underneath.
- Missing or wet insulation while confined to the outer casing may be an indicator of more serious problems in the metal underneath.

Refractory and Seals

Refractory and Seals could be inspected for:

- The refractory and/or brickwork in the doors, baffles, and burner assemblies for any signs of burning, spalling, cracking, erosion, or general deterioration.
- Fire side seals and gaskets for damage and missing portions. The adjacent metal should be inspected for signs of erosion.
- Baffle seals for evidence of by-passing of combustion gases.

Tubes and Shell (Fire Side)

Tubes and Shell (Fire Side) could be inspected for:

- The tube sheet inspections steam space above the top row of tubes. Look for evidence of bulging. inspect for overheating and cracks. The ligaments between tube holes should be checked for cracking.
- Tube ends, especially on the first pass, for fire checks and erosion.
- All areas around tube beads or flares for evidence of leakage, fire checks, cracks, erosion, wear, or wastage of metal.
- Areas on both tube sheets that have welded or threaded braces or stays terminating at the tube sheet. Look for leakage or other discontinuities.
- The area of all nozzles to the shell any weld defects or leaks.

Shell (Water Side)

Shell (Water Side) could be inspected for:

- Area around all handhole and manhole openings. Look for evidence of leakage, erosion, or wastage of metal due to either air leaking back into the boiler when it is under vacuum, or water leaking out while under pressure.
- Handhole. and manhole plate covers, especially the gasket seat areas. Look for pitting, gouges, or other .
- The internal condition and tube sheet for scale on the tubes.
- All the areas possible to see if there is any evidence of other problems such as sludge, oil caustic corrosion, chelate corrosion, acidic attack.

Stays and Braces

Stays and Braces could be inspected for:

- Cracks, corrosion, erosion, wastage, and wear.

Tubes
(Fire and Water Side)

- The fire side for soot, fly ash, or obstructions of any kind.
- The initial tube passes for over heating.
- The water side of tubes, for excessive scale or sludge deposits.
- Bent, sagged, or warped tubes that may have been a result of low water, overheating, or hot spots.
- Water and fire side of tubes for wear, corrosion, erosion, or defects that might affect safety.

Supports

Supports could be inspected for:

- The supports and mountings for cracks, loose bolts, weld defects, and general stability.
- The support to shell attachment welds and heat affected zones for cracks or discontinuities.

Furnace and Combustion Chamber

Furnace and Combustion Chamber could be inspected for:

- The surfaces *for* corrosion, leaks, cracks, erosion, or metal wastage, hot spots or evidence of overheating, or burned metal.
- Bagging, blistering, or bulging. This is especially important for large, flat unsupported areas.

Safety Valve

Safety Valves could be inspected for:

- Condition of the spring or spring housing chamber.
- Hard corrosive deposits, or foreign matter of any kind between the spring coils.
- Valve body for cracks, corrosion, or external defects.
- Valve discharge piping is correctly discharged.
- Adjustment lead seals are all in place.
- Most authorized safety valve repair firms have replacement seals to put on the valve following completion of their work and re-assembly of the valve.
- External bolts and nuts, body to yoke attachments for tightness.

Safety Valve (Continued)

Safety Valves could be inspected for:

- Name plate for , code symbol, set pressure is limited to MAWP, set pressure adequately above operating pressure, and capacity in lbs./hr. or BTU/hr. equal to or greater than minimum firing input.
- The point of discharge. Make sure it will not endanger personnel. If there are extensive discharge lines outside the building, They are sloped and drained so water will not freeze in the line. Lines which exit vertically when outside and exposed to the elements must have drain pans, drain holes, shields, or some equivalent provision to prevent rain or moisture from accumulating on top of the safety valve disc and seat areas.

Water Column and Gauge Glass

Water Column could be inspected for:

- Gage glasses leaks, cleanliness and visibility.
- Try cocks are used, to see they are operable and have not been leaking.
- Remote illuminators, reflectors, and mirrors for cleanliness and adjustment.
- Operation and conditions of gage cocks, chains and pulleys.
- Connecting piping between boiler and water column for possible stress points, and it free to expand and contract with the boiler.
- High and low water alarms are in good condition and tested for operability.

Low Water Cut Off

Low Water Cut Off could be inspected for:

- The low water cut off of the float type should be removed from the float the float chamber. Looking at the float for evidence of leakage into the float ball and the connecting linkage for freedom of movement and missing cotter
- The internal surfaces of the float chamber to assure yourself it is free of scale, sludge, mud, or any other foreign matter that would falsely hold the float in the up position. The internal surfaces (top, bottom, and sides) to be certain that there are no hard corrosive growths, scale, or chemically induced barnacles which could interfere with the float movement.
- The lines between the boiler and the float chamber to verify that they are free and clear.

Low Water Cut Off (continued)

Low Water Cut Off could be inspected for:

- Note: If mercury switches are used, check the sealed glass capsules to be certain that the vacuum seal has not been lost due to damage to the glass or seal. If the entire surface of the glass is cloudy or has numerous moisture bubbles inside, the mercury switch must be changed.
- All mechanical linkage for proper functioning.

Low Water Cut Off (continued)

Low Water Cut Off could be inspected for:

- Any visible wiring for brittle or worn insulation. The electrical contacts are clean and tight, with no evidence of shorts or arcing.
- Inspect the bellows connection for leaks and corrosion Make sure bellows are sound and not distorted or collapsed.

Blowdown Valves and Lines

Blowdown Valves and lines could be inspected for:

- Corrosion, leakage, and to verify that they are properly supported and have freedom for expansion and contraction.
- Blowdown valves for evidence of leakage, corrosion, and loose body bolts. Being approved for the type of service including pressure at temperature ratings.

Feedwater Regulator

Feedwater Regulator could be inspected for:

- Cleanliness and operability.
- Excessive leakage and corrosive deposits on external surfaces could cause problems.
- Connecting lines and mechanical linkage or parts.
- Operability of the feedwater makeup by observing how fast it can recover from any low water condition.

Soot Blower

Soot Blower could be inspected for:

- External mechanical gears, chains, pulleys, etc. for broken or worn parts.
- Seals, gaskets, glands, and openings in the boiler casing for signs of leakage.
- Supply piping to soot blowers for faulty supports, leakage, and expansion or contraction provisions. This includes any valves located in these lines.
- Drain lines must be will be checked to see that they are clear and operable.

Pressure Gauge

Pressure Gauge could be inspected for:

- The lines to the pressure gage free and clear. This includes the syphon.
- The gage glass is in place with no cracks or discolorations.
- Gauge calibration.
- The dial should be clearly visible and should be graduated to approximately double the safety valve setting, but in no case to less than 1 ½ or 2 times the MAWP.
- The dial diameter should be located to provide the operator with a good view of the gage for easy operator reading.
- Pipe connections for gage dial diameters under 4 1/2 inches should be ¼ inch NPT, while gages over 4 1/2 in. in dial size should have ½ inch connecting pipes.

Valves

Valves could be inspected for:

- Packing gland leakage, stem or handle damage, body defects, and general corrosion damage.

External or Internal Items

- The items that could be inspected are all manhole and handhole plates and their seating areas for cracks, corrosion, and erosion.
- The items that could be inspected are the boiler blowdown piping and supports between boiler drum or header and the blowdown tank or separator for cracks, leakage, distortion, loose hangers, or distorted blowdown lines.
- The items that could be inspected are all boiler insulation to see that none is missing and that the casing is tight.

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