

# Understanding Steam Boiler Course

## **MAINTENANCE & INSPECTION**

# SCOPE

- **BOILER MAINTENANCE**
- **BOILER INSPECTION**

# Maintenance, Inspection and Repair

- Maintenance
  - Preventive, Routine, Planned, Predictive, Breakdown, Statutory
  - Mechanical Cleaning
- Inspection
  - Visual Inspection, Liquid Dye Penetrant, Magnetic Particle Test, Boroscope, Radiography, Eddy Current Test, Ultrasonic
- Repair
  - Boiler Tube, Furnace, Steam Drum, Ducting, Headers, Burners, Valves and Fittings

# BOILER MAINTENANCE

# *BOILER MAINTENANCE*

## 1.1Background

- ❑ Maintenance is derived from the word "maintain" which has the following meanings ; carry on, preserve, support, sustain, keep up and keep supplied

# *BOILER MAINTENANCE*

## **What is maintenance ?**

Work or activities done to ensure the plant/equipment is safe and efficient to operate at its design capacity

## **Types of maintenance**

- ☐ Corrective maintenance
- ☐ Preventive maintenance
- ☐ Predictive maintenance

# *BOILER MAINTENANCE*

❑ For boiler system, it means :-

- ❑ to ensure safe operation by regular inspection
- ❑ to keep the boiler in operation
- ❑ to keep the boiler in operating condition
- ❑ to restore boiler efficiency
- ❑ to repair the damaged parts and keep it tight
- ❑ to clean the boiler

# *BOILER MAINTENANCE*

## **Maintenance Objectives**

- ❑ From the definition, boiler maintenance is any work done on the boiler system so as to meet certain objectives. These objectives are :-
  - ❑ to keep the boiler in operation so as to meet the design load
  - ❑ to maintain full reliability and maximize availability by zero unplanned down time and optimize planned down time
  - ❑ to meet safety and regulatory requirements

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## **Activities**

- ☐ Routine service (preventive)
- ☐ Repair (corrective)
- ☐ Inspection (preventive/predictive)
- ☐ Overhaul (predictive)

# ***BOILER MAINTENANCE***

| <i><b>Type</b></i>              | <i><b>Rate</b></i>                                                    | <i><b>Requirement</b></i>                                         |
|---------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>1. Routine</b>               | <b>Daily, Weekly, Monthly or Yearly (incl. regulatory inspection)</b> | <b>Require Procedure and Instruction including record keeping</b> |
| <b>2. Predictive</b>            | <b>depend on plant maintenance philosophy and program</b>             | <b>Requires special tool or program i.e. RBI, CBM</b>             |
| <b>3. Preventive</b>            | <b>depending on O &amp; M requirements</b>                            | <b>Regular inspection and test during operation or shutdown</b>   |
| <b>4. Reactive (Corrective)</b> | <b>when boiler system fail and damage</b>                             | <b>May require stock of part and external expertise</b>           |

# *BOILER MAINTENANCE*

## Boiler Cleaning

- Tube cleaning is used to remove waterside deposits to prevent tube failure. Two methods are available
  - Mechanical cleaning
  - Chemical cleaning
- Mechanical cleaners consist of a rotating cutter head driven by an air-powered motor that fits inside the tube.
- Chemical cleaning solution is a 5% hydrochloric acid solution with an inhibitor added to lessen boiler metal acid attack. Two cleaning methods are available
  - Circulation
  - Static (Fill and Soak)

# *BOILER MAINTENANCE*

**Burner cleaning** - *cleaning of burner tips from blockage which can affect combustion. Precaution has to be taken during cleaning so as not to damage the tips. Worn out or damaged tips can result in improper combustion*

**Soot blowing** - *cleaning of boiler tubes from deposits of unburned fuel elements (soot) while the boiler is in operation. Cleaning media could be steam, air or use of a vibrator. Dirty boiler tubes can result in poor heat transfer in the boiler and hence reduce efficiency*

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**Strainer cleaning** - *cleaning of fuel strainers from blockage. Dirty strainers can easily be noticed by the increase in the differential pressure across the strainers*

**Flame scanner/photo-cell cleaning** - *cleaning of flame sensing equipment from dirt, soot or any other substance which can reduce the tendency of detecting the flame. Dirty flame sensing equipment can result in boiler tripping*

# *BOILER MAINTENANCE*

**Testing of boiler water** - *taking of boiler water samples and tested for alkalinity and contaminants. Contaminated water can lead to tubes blockage, over firing and reduction in output/efficiency. Where as improper alkalinity can lead to problems of corrosion*

**Draining of condensate** - *removing of water in steam pipelines. Presence of water in pipelines can lead to water hammer. Steam together with the slug of water travel at a very high velocity hit any obstruction downstream and can result in severe damage*

# *BOILER MAINTENANCE*

**Testing/cleaning of water gauge** - *blowing of steam and water through the steam and water passage of the gauge glass so as to clear any blockage which can cause false level indication*

**Testing of control systems** - *important control devices such as low water fuel cut-out, combustion system, safety valves are to be tested for their accurate operation so as to ensure that they respond as designed*

# *BOILER MAINTENANCE*

## **MAINTENANCE INSPECTION**

- **Dimensional** - *erosion, corrosion, abrasive wear, deformation changes due to stress, cavitation*
- **Distortion** - *obstructed expansion, overheating, unequal expansion, over stress*
- **Cracks** - *fatigue, thermal stress, water hammer, improper welding, poor design*

# *BOILER MAINTENANCE*

## **MAINTENANCE INSPECTION**

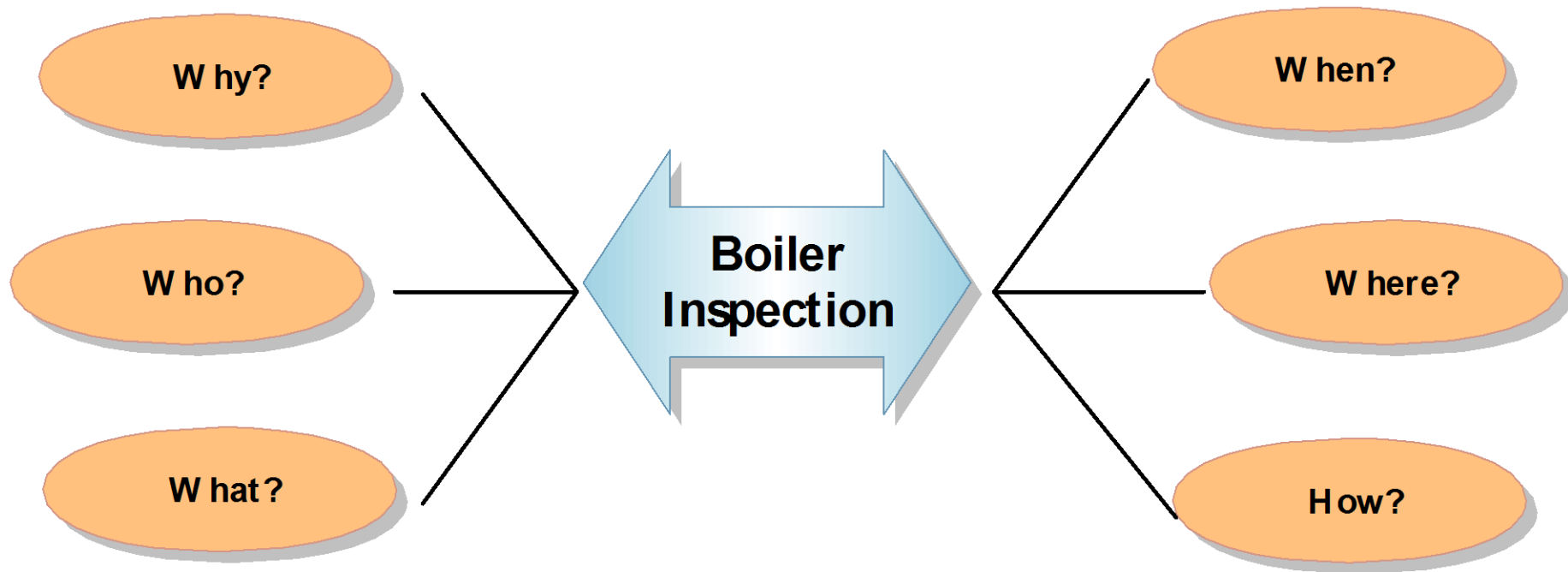
- **Deposits** - *incomplete combustion, rust deposits, dusty condition, upstream sootblowing*
- **Blockage** - *accumulation of scales, soot, foreign matter, damaged strainer*

# BOILER INSPECTION

# *BOILER INSPECTION*

- **Why do we inspect boiler?,**
- **Who does the inspection?**
- **What to inspect?**
- **When to inspect?**
- **Where to inspect?**
- **How to inspect?**

# *BOILER INSPECTION*



# *BOILER INSPECTION*

## Why?

- Why do we inspect Boilers?
  - Compliance to Factories and Machinery Act (FMA) 1967
  - Safety of man and equipment
  - Know integrity (condition) of boiler

# *BOILER INSPECTION*

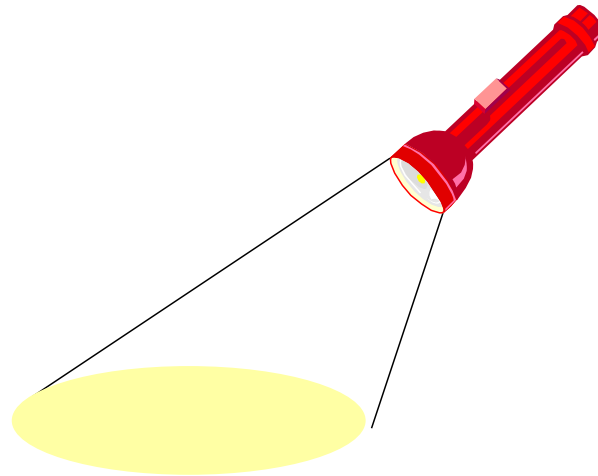
## When?

- When DO we inspect boiler?
- According to Law, FMA
  - Boilers have to be inspected initially- prior to be put onto service by Inspector (DOSH)
  - Regular Inspection ordinarily be every 15 months subject to such extension not exceeding 36 months by discretion of Chief Inspector.
- When boiler experience any problem that may affect the strength or safety of the boiler:-
  - This is the discretion of boiler operators e.g. acid or caustic ingress, lost of boiler water, melting of fusible plug and bursting of tube.

# *BOILER INSPECTION*

## Who?

- Who to inspect?
  - DOSH Inspector
  - Authorized Inspector
  - Qualified owner's inspector ; or
  - Qualified 3rd party inspector
  - Insurance Inspectors



# *BOILER INSPECTION*

## What?

- What types of inspection is there?
  - Jurisdiction inspection;and
  - Internal Inspection
  - External or operating inspection
  - Nondestructive testing (NDT) and inspection

# *BOILER INSPECTION*

## Internal Inspection

- Usually during jurisdictional inspection concurrently done as internal inspection
- Reason- to check on the structural soundness of pressure containing parts and to note any condition that can affect the strength to confine the pressure

# *BOILER INSPECTION*

## Typical internal inspection

| Where                         | What to inspect                    |
|-------------------------------|------------------------------------|
| Longitudinal seam of drums    | Crack and grooving                 |
| Unstayed heads                | Groove at fillet weld              |
| Manholes and opening          | Corrosion thinning & crack         |
| Welded nozzles and attachment | Weld washout, crack, deterioration |

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## Typical internal inspection

| Where                          | What                   |
|--------------------------------|------------------------|
| Stay & stay bolts              | Crack and even tension |
| Waterline in drums             | Oil and pitting        |
| Tubes and plate expose to fire | Bulging or blistering  |
| Tube to shell weld joint       | Crack or pitting       |

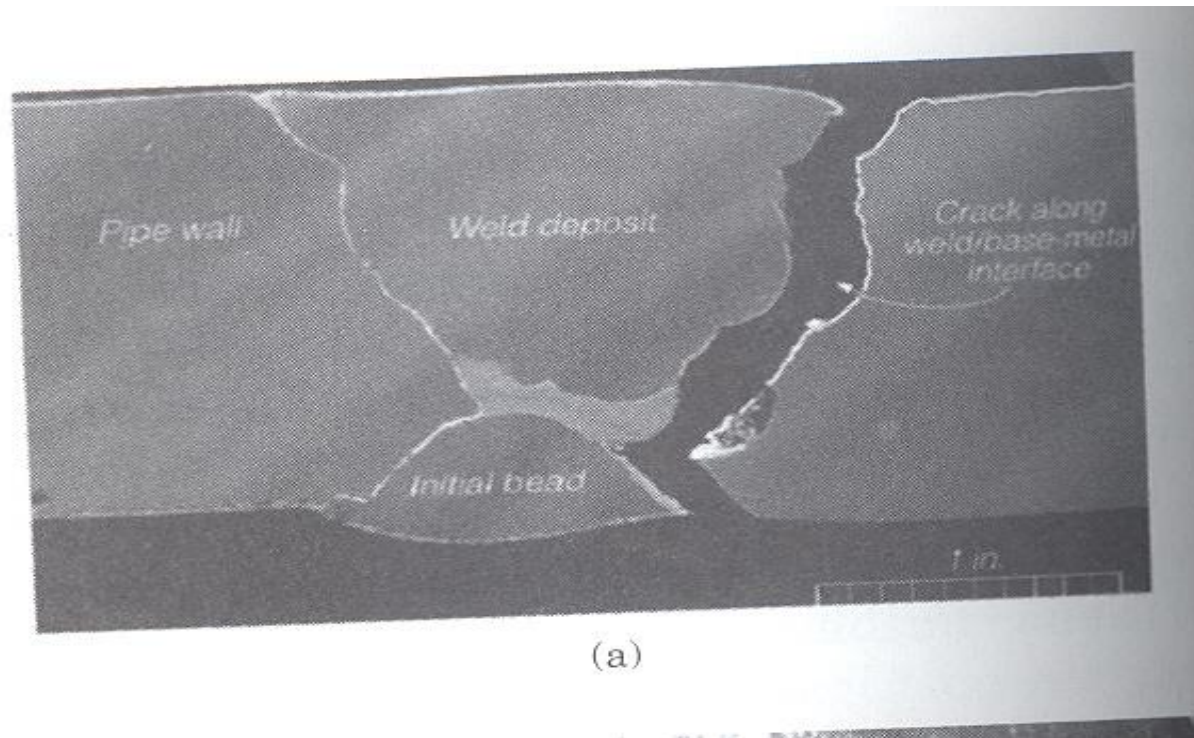
# *BOILER INSPECTION*

## Internal Inspection

- What to check for?
  - Wear
  - Deterioration
  - Corrosion
  - Scale
  - Oil
  - Crack
  - Grooving
  - Thinning
  - etc
- All the above technique is using Visual test or and NDT

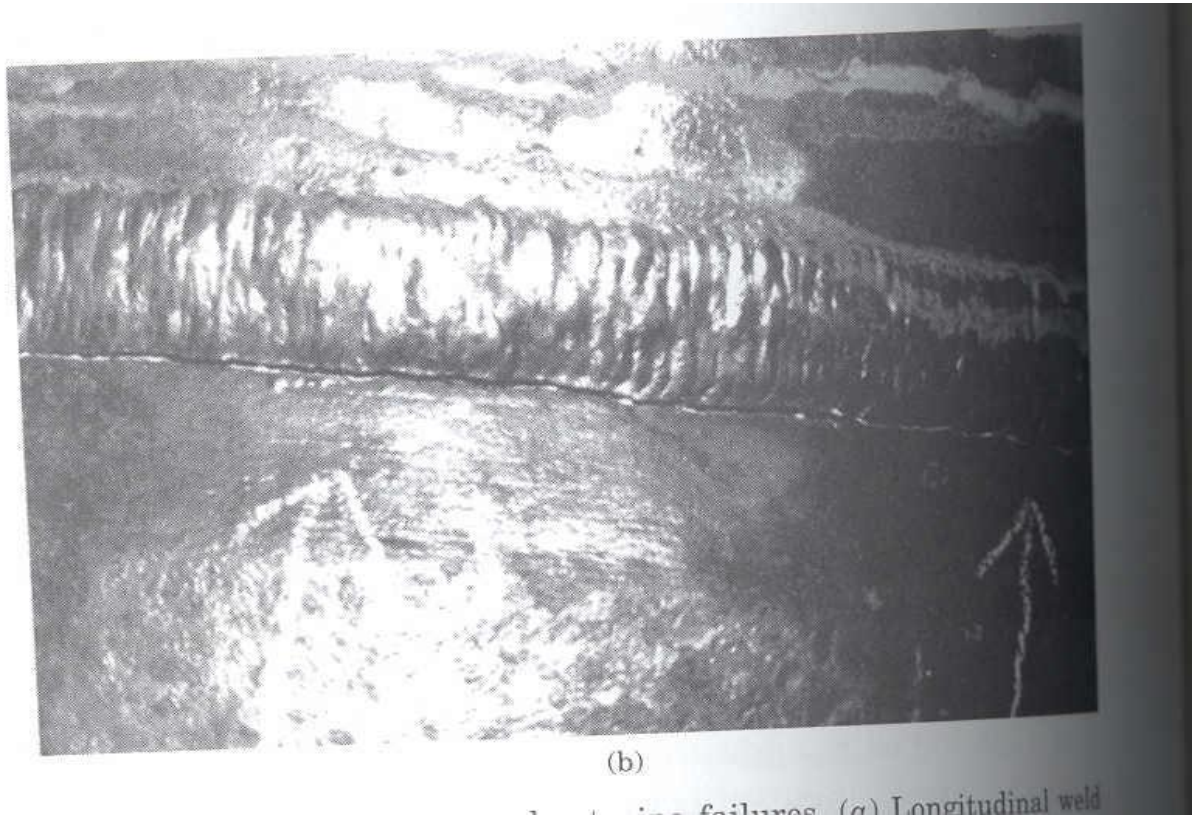
# *BOILER INSPECTION*

## Welding crack



# *BOILER INSPECTION*

## Visual inspection of crack



# *BOILER INSPECTION*

## External Inspection

- Check for any abnormalities or damage in the following area:
  - Platform and ladders
  - Insulation
  - Skin Temperature using Infrared Thermography
  - Any leakage or seepage at PSV and other valves and flanges
  - Any sign of water under insulation

# *BOILER INSPECTION*

## **NON-DESTRUCTIVE TESTING (NDT)**

What is non-destructive testing (NDT) ?

- ☐ Is the testing of material to detect internal and surface defects without damaging the material under test

# *BOILER MAINTENANCE*

## **NON-DESTRUCTIVE TESTING (NDT)**

Why is NDT important ?

- ❑ To prevent accidents & save human lives
- ❑ To improve product reliability
- ❑ To maintain quality level
- ❑ To lower manufacturing cost

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## How?

- Nondestructive Test
  - Visual Test
  - Dye Penetrant Test (DPT or dyepent)
  - Magnetic Particle Inspection (MPI) or WFMPT (wet fluorescence magnetic particle testing)
  - Radiography
  - Ultrasonic Test (UT)
- Other advanced NDT such as Remote Field Eddy Current ( C Steel boiler tubes) and IRIS (Internal rotating Inspection System), Hardness Test , Plastic replica and metallography

# *BOILER INSPECTION*

## NDT Methods

- Visual examination
  - Used to determine such things as the surface condition of the part, reinforcement and undercutting of welds, alignment of mating surfaces, shape or evidence of leaking
- Eddy current inspection or examination
  - Detects discontinuities in the pipe and tubing by subjecting the material to a strong external magnetic force
- Radiographic examination
  - Examines the surface and subsurface for discontinuities using a radioactive source and film

# *BOILER INSPECTION*

- Ultrasonic examination
  - Provides indications of surface and subsurface discontinuities, the depth of which can be determined by the use of the proper technique.
- Liquid Dye Penetration
  - Detects discontinuities which are open to the surface of the material being examined.
- Magnetic Particle Testing
  - Can be used only on a ferromagnetic surface to reveal surface discontinuities and to a limited degree, those located below the surface.

# *BOILER INSPECTION*

## **ADVANTAGES OF NDT**

- Tested objects can be used
- Requires minimum specimen preparation
- Inspection may be performed while the objects are in service
- Equipment are portable and suitable for field inspection

# *BOILER INSPECTION*

## **LIMITATION OF NDT**

- Results are normally qualitative
- Requires highly trained and experienced personnel

# *BOILER INSPECTION*

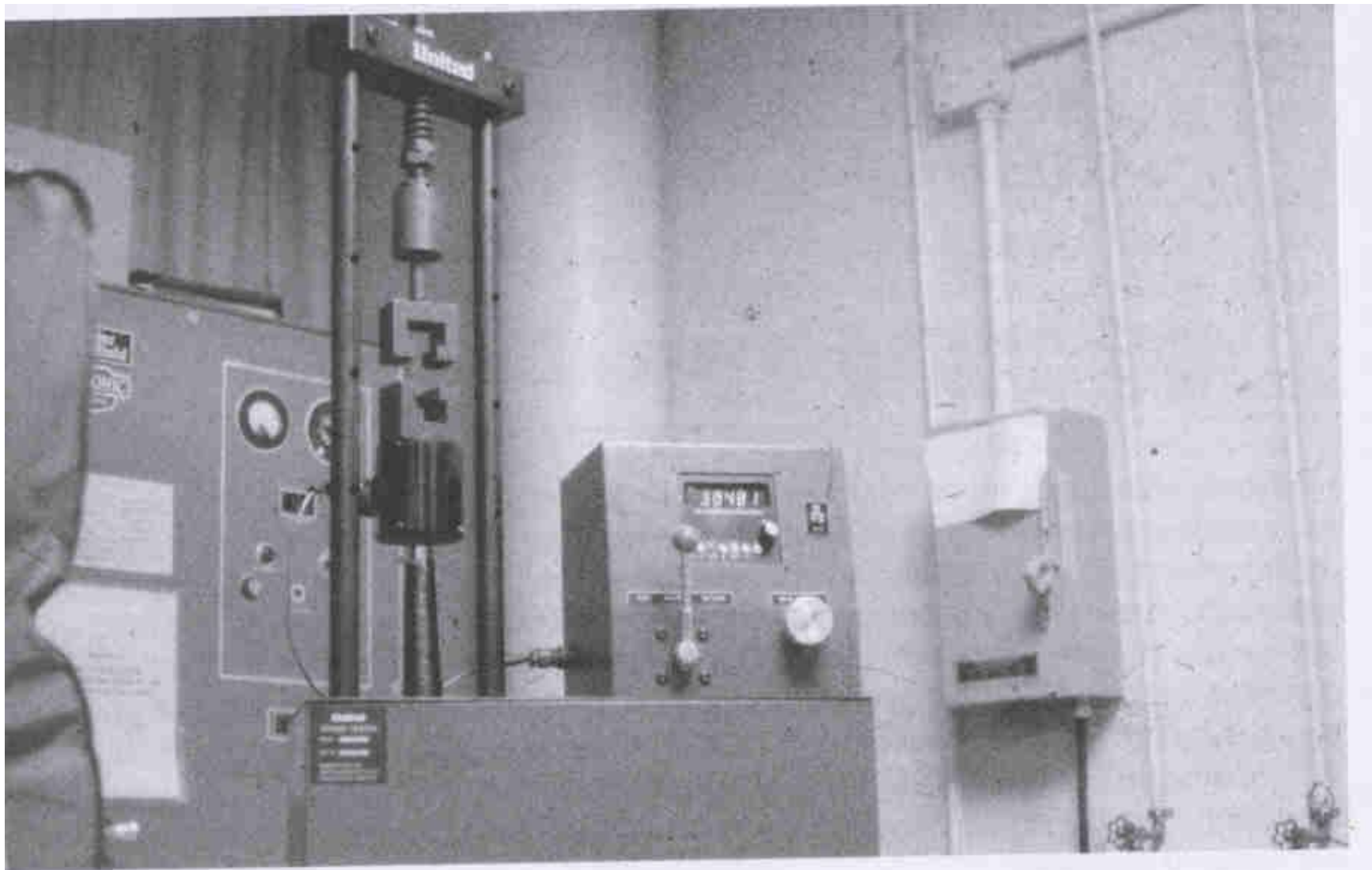
## **DESTRUCTING METHODS (DT)**

- ☐ Tensile
- ☐ Bend
- ☐ Charpy
- ☐ Hardness
- ☐ Fatigue
- ☐ Creep
- ☐ Metallography
- ☐ Chemical analysis

# *BOILER INSPECTION*

## How?

- Destructive testing
  - Specimen of part of boiler taken and tested to its limit to destruction
  - E.g Destructive testing -
  - Tensile Test -a specimen of boiler drum taken and put to a tensile test- usually old boilers to check for its mechanical properties- ductility , ultimate tensile strength (UTS)
  - Bend test- specimen of weld taken for bend test to check for weld flaws



**FIGURE 1-16** Typical tensile testing machine. (Courtesy of J. Devis Collection.)

# *BOILER INSPECTION*

## How?

- Equipment testing
  - After any repair or alteration of boiler, it is subject to test to see if the boiler is fit for operation and no leak is detected.
  - Methods of equipment testing
  - Hydro testing as per ASME rev July 2004, test up to 1.3 times Max Allowable Working Pressure. (Under FMA 1.5 times)
  - Leak testing
  - Hydro testing
  - pneumatic test
  - Halogen test with halogen tester ( Cl, Fl, Br and it's element)

# Hardness test equipment



**FIGURE 1-18** Typical hardness tester. (Courtesy of J. Devis Collection.)

# *BOILER INSPECTION*

## **Furnace**

- ❑ Inspection of the following parts :-
  - ❑ front wall tubes including the area of the burner
  - ❑ side wall tubes including peephole area
  - ❑ rear wall tubes including the boiler nose area
  - ❑ furnace floor area
- ❑ Waterwashing to remove deposits from all the walls

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## **Furnace**

- ☐ Repair the burner cell refractory
- ☐ Repair the furnace floor area
- ☐ Scaffolding erection in the furnace
- ☐ Cut the water wall tube for mechanical and chemical inspection
- ☐ Repair the water wall tubes
- ☐ Removal of fire bricks and refractory materials from furnace

# *BOILER INSPECTION*

## **Secondary Superheater and Reheater**

- ☐ Inspection of the following :-
  - ☐ secondary superheater tubes
  - ☐ screen tubes
  - ☐ secondary reheater tubes
  - ☐ manhole and sootblower area
  - ☐ boiler roof
- ☐ Waterwashing of tubes
- ☐ Removal of slag - by mechanical or chemical means
- ☐ Replace or repair the tube

# *BOILER INSPECTION*

## **Heat Recovery Area**

- ☐ Inspection of the following :-
  - ☐ Primary superheater/reheater tubes
  - ☐ Screen tubes
  - ☐ Manhole area
  - ☐ Sootblower area
  - ☐ Economizer tubes
- ☐ Removal of combustion products from hopper
- ☐ Water washing of HRA
- ☐ Repair the expansion joint
- ☐ Replace or repair the tubes

# *BOILER INSPECTION*

## **Force Draft Fan Ducting**

- ❑ Inspection of the following :-
  - ❑ FD fan suction screen
  - ❑ Steam air preheater area
  - ❑ Hot air ducting from air preheater to windbox
- ❑ Cleaning of suction screen
- ❑ Cleaning of steam air preheater steam tubes (externally) and tightening of leaking joints.
- ❑ Strengthening of hot air ducting and burner windbox guide vanes.

# *BOILER INSPECTION*

## **Steam Drum**

- ❑ Inspection of the following :-
  - ❑ Drum internal surfaces
  - ❑ All pipe fittings/joints inside the drum
  - ❑ Feed pipe, girth plates, baffles, scrubbers, chevron driers, separator
  - ❑ Gauge glasses
  - ❑ Isolation valves

# *BOILER INSPECTION*

## **Steam Drum**

- ❑ Wipe clean the drum internal surface
- ❑ Removal of deposits by vacuum cleaning
- ❑ Inspection by Inspector of Machinery before reassemble
- ❑ Overhaul the gauge glass and isolating valve.

# *BOILER INSPECTION*

## **Header**

- ❑ Inspection of the following :-
  - ❑ Superheater inlet and outlet header
  - ❑ Reheater inlet and outlet header
  - ❑ Waterwall header
  - ❑ Economizer inlet and outlet headers
- ❑ Removal of handhole or by cutting header cap for inspection and reweld.

# *BOILER INSPECTION*

## **Tubes**

- ❑ Cutting of tubes for inspection and rewelding.
- ❑ Replacing worn-out tubes.

# *BOILER INSPECTION*

## **Forced/Induced Draft Fan**

☐ Inspection of the following :-

- ☐ Impeller and shaft
- ☐ Suction part and impeller gap
- ☐ Casing and ducting
- ☐ Suction screen
- ☐ Bearing
- ☐ Fluid coupling

# *BOILER INSPECTION*

## **Forced/Induced Draft Fan**

- ☐ Water washing of the fan impeller, shaft and casing.
- ☐ Cleaning and easing of the damper, greasing and casing.
- ☐ Checking bearing clearances and renewing lubricating oil.
- ☐ Overhaul the fluid coupling and realignment.

# *BOILER INSPECTION*

## **Valves and Fittings**

- ❑ Overhaul of the following valves :-
  - ❑ All the safety valves
  - ❑ Boiler main stop valve and its bypass
  - ❑ Feedwater control valve and its bypass
  - ❑ All burner inlet and outlet isolating valves
  - ❑ Boiler and drum blowdown valves.
  - ❑ High Pressure dosing valves.

# *BOILER INSPECTION*

## **Valves and Fittings**

- ❑ Overhaul of the following valves :-
  - ❑ Sootblower steam isolating, bypass and control valves
  - ❑ Steam oil heater valves.
  - ❑ Steam traps and its bypass and isolating valves
- ❑ Overhauling the drum gauge glasses.
- ❑ Cleaning and easing of the boiler explosion door.

# *BOILER INSPECTION*

## **Economizer**

- ❑ Check interior of tubes and headers where possible for corrosion, oxygen pitting and scale.
- ❑ Check exterior of tubes and headers for corrosion, erosion and deposits. Check particularly at soot blower locations for impingement and leakage.
- ❑ Check for cleanliness and security of vent and drain connections and valves.
- ❑ Check exterior economizer casing for leaks and tightness and doors.

# ***BOILER INSPECTION***

## **Water Columns**

- ❑ Check gauge glasses for leaks, cleanliness and visibility.
- ❑ Check illuminators, reflectors, and mirrors for cleanliness and breakage.
- ❑ Check operation and condition of gauge cocks and valves. Inspect chains and pulleys if used. Repair or replace as necessary.
- ❑ Ensure that water column is free to expand with boiler.
- ❑ Check water column piping to drums for leaks, internal deposits, and missing insulation.
- ❑ Check condition of high and low water alarms and trips.

# *BOILER INSPECTION*

## **Feedwater Regulator**

- ❑ Examine valve externally for leaks, operability, and cleanliness. Do not dismantle if operation has been satisfactory. Check connecting lines and mechanisms for proper function.

# ***BOILER INSPECTION OPERATING CHECKS***

## **Leakage**

- ☐ Check for any flue gas, steam drum or water leaks
- ☐ Check for steam leaks at superheater headers and tube joint
- ☐ Check for air leaks around doors, seals and tubes joints
- ☐ Operating Checks Relating to Maintenance

# ***BOILER INSPECTION OPERATING CHECKS***

## **Refractory**

- ☐ Check condition of burner throat refractory
- ☐ Check condition of pit refractory (if applicable)
- ☐ Check for slag build up on refractory
- ☐ Check for missing insulation on headers and drum

# ***BOILER INSPECTION***

## ***OPERATING CHECKS***

### **Burner**

- ☐ Check for burner wear by noting flame shape and completeness of combustion
- ☐ Check ease of operation of burner vanes. This will indicate burner mechanism condition

# ***BOILER INSPECTION OPERATING CHECKS***

## **Superheater Tubes**

- ☐ Check for a change in pressure drop through the superheater indicating internal condition of the tubes

# ***BOILER INSPECTION OPERATING CHECKS***

## **Boiler drums**

- ☐ Check the steam quality. This will indicate the condition of steam scrubbers and separators
- ☐ Check for noises in drums. This may be caused by loose connections of drum internal piping

# ***BOILER INSPECTION***

## ***OPERATING CHECKS***

### **Economiser and air pre-heater**

- ☐ Check for a variation in temperature differences over both units at constant load, indicating deposits or buildup
- ☐ Check for a decrease in pressure drop over any part of the system at constant load indicating a misplaced or bypassed baffle

# *BOILER INSPECTION*

## *OPERATING CHECKS*

### **Furnace and Casing**

- ❑ Check the extent of expansion and contraction of pressure parts during startup and shutdown
- ❑ Check that header support hangers are always in tension. Looseness will indicate an obstruction to free expansion and contraction.

# *BOILER INSPECTION*

## **Pressure Safety Valve (PSV)**

- What do we look at during PSV inspection?
  - After dismantling from boiler, PSVs are tagged, blind, remove to bench test facility for an initial pop test.
  - PSV disassembled and check for any surface discontinuity at seat of PSV, DPT if necessary, If any discontinuity presence, remove it via lapping or changing faulty internals etc.
  - Assemble and do a leak test using method:
    - pneumatic pop test ;or
    - Nitrogen leak test; or
    - Water leak test

# *BOILER INSPECTION*

## **Pressure Safety Valve (PSV)**

- If passed then proceed to painting, if failed , then service again the PSV and repeat test
- There should be no rust scale or foreign matter in casing to hinder free operation

# Sampai Jumpa Lagi ...



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