Remaining Life Assessment (RLA) of Power Boiler

TCR Engineering Services

Need for RLA of Boilers

- To understand the health condition of pressure parts including tubing and pipes in Boilers that withstand high pressure and temperature

- Reason for Remaining Life Estimation Study
  - The high temperatures to which the pressure parts are subjected at elevated pressure lead to creep stress
  - The starting and stopping of the Boiler Unit results in fatigue stress
  - The fuels burnt can cause corrosion in various areas in the boiler
  - The water used for steam generation leaves deposits inside the tube which increases the metal temperature leading to long term overheating
  - Residual stresses during manufacturing, the vibrations due to flow over the tube, mechanical vibrations, erosion due to the abrasive nature of the fuel, etc, do occur in a boiler
  - Operation of the boiler at elevated temperature and parameters leads to stresses higher than the design levels
  - All of the above, individually or combined, lead to material degradations of different magnitude and will lead to a failure unless RLA is not carried out

DEFINITIONS OF COMPONENT LIFE

HISTORY BASED CRITERIA	30 to 40 years have elapsed Statistics of prior failures indicate impending failure Frequency of repair renders continued operation uneconomical Calculations indicate life exhaustion
PERFORMANCE BASED CRITERIA	Severe loss of efficiency indicating component degradation Large crack manifested by leakage, severe vibration or other malfunction Catastrophic burst
INSPECTION BASED CRITERIA	Dimensional changes have occurred, leading to distortions and changes in clearances Inspection shows microscopic damage Inspection shows crack initiation Inspection shows large crack approaching critical size
CRITERIA BASED ON DESTRUCTIVE EVALUATION	Metallography or mechanical testing indicates life exhaustion

Possible Failure Mechanisms

	Creep	Thermal Fatigue	Embrittlement	Erosion	Corrosion
- evaporator		X	H^2	X	X
- drum		X			X
- superheater / reheater tubes	X				X
- superheater headers	X	X			
- reheater headers,	X	X			
- desuperheater nozzles	X	X			
- steam lines	X	X			
- feedwater lines				X	X

- Evaluate the present state and the condition of the boiler components in order to continue stable and reliable boiler operation
  - Study the remaining life for Superheater and Reheater by metallurgical inspection
  - Evaluation of creep life and future inspection scheme by metallurgical inspection for water wall, economizer, Superheater and Reheater tubes
  - Study degree of creep damage for Superheater and Reheater by hardness test
  - Determine the remaining life based on thickness Measurement for water wall
  - Evaluate the remaining life based on thickness thinning for economizer due to low Temperature Corrosion
  - Evaluate the remaining life based on thickness thinning for Superheater and Reheater tubes due to high Temperature Corrosion
  - Confirm the cause of the inner scale generation
  - Evaluate the remaining life based on check of metal structure ,inner scale ,etc for sample tube

Damage Evaluation by Inspection

FAILURE	DAMAGE CAUSED	PHENOMENON	LIFE EVALUATION	INSPECTION ITEM
• CREEP	•Clogging with foreign material •Deposition and growth of scale on Inner surface •Long-term stress	•Swelling •Metal structure change	•Outside diameter and thickness measurement •Metallurgical inspection	•Metallurgical inspection for SuperHeater, ReHeater header •Metallurgical inspection and NDT (UT) for main steam pipe line and high temperature RH pipe
•FATIGUE	•Cycle thermal stress	•Growth of crack	•Stress analysis •Surface crack inspection (PT,MT)	•NDE (PT, MT) of spacer welded for SuperHeater, ReHeater Tube
•CORROSION FATIGUE	•Cyclic thermal stress under corrosive environment	•Interaction of corrosion and fatigue	•Ultrasonic test •Sample tube inspection	•Sample tube inspection for SuperHeater, ReHeater and water wall •Check of Burner Nozzle and Wind Box Damper
•CORROSION •EROSION	•High temp corrosion •Low temp corrosion •Ash erosion	•Thickness thinning	•Annual thickness measurement	• Measurement of tube thickness for SuperHeater, ReHeater, Water Wall and Economizer by UT •Steam drum •Boiler aux •Eco Hanger tube by endoscope, etc

RLA Methodology

- Analytic considerations, calculation methods, the relevant non-destructive tests, correct selection of Boiler components is important

- TCR’s “3 Level” RLA Methodology:
  - Level 1 : Design Data Collection & operation history
  - Level 2 : Operating / Maintenance / Inpsection history
  - Level 3 : Scientific Approach based on level 1 & 2 data in combination with quantified material properties

- Our Strong experience leads to focused analysis

- Remaining Life Prediction Technique used by TCR
  - Steam side oxide scale thickness growth and life fraction rule using Larson-Miller parameter
    - Every tube in service has a Larson-Miller parameter that increases with time.
    - The oxide scale thickness is correlated by many equations which is used to arrive at the remaining life along with the life fraction rule

RLA Study Approach

- Level II and Level III assessments based on calculation and design approaches, including steps such as:
  - Collection of **background data and history** of Boiler Operation.
  - Understanding the actual **degradation mechanism**
    - Fatigue
    - Thermal Fatigue
    - Thermo Mechanical Fatigue
    - Thermal Aging
    - Creep
    - Embitterment
    - Corrosion
  - Thorough **visual examination** by an expert
  - **Dimensional measurement** at critical locations
  - Collection of **scale and deposits samples** and it's analysis
  - Detailed **Thickness Survey**
  - Internal **oxide scale measurement** at Super Heater Tube and Re-heater Tube
  - **WFMPI of main weld joints** of Header and Steam Drum
  - In-Situ metallograpy to determine **thermal ageing and creep related problem** from a RLA perspective
  - In-Situ **hardness measurement** with portable hardness tester
  - Suggestions on **Repairing**
    - If required, repairing of the equipment is suggested, for life extension.
  - **Calculation and Judgment of Remaining Life** based on Analysis

Component	Tests	Location to be checked
Main Cylindrical Shell	Visual	100% after removal of insulation
	Thickness Measurement	Random
	WFMPI/UT	Weld joints, Side holes, mud holes and blow down outlet
	Replica & Hardness	Replica & hardness shall be on weld/HAZ & parent
Furnace tubes with bowling hoops	Visual	100% thru the hot gases side with weld joints
	Thickness Measurement	Random
	WFMPI & UT	Weld Joints
	Replica & Hardness	Replica & hardness shall be on weld/HAZ & parent
Smoke Tubes and Stay Tubes	Visual	100%
	WFMPI	Tube to Tube Plate weld joints
	Thickness Measurement	Random
	Replica & Hardness	Replica & hardness shall be on weld/HAZ & parent
Front & rear tube plates and end plates of wet back	Visual	External Side
	WFMPI/UT	Circumferential Weld seam
	Thickness Measurement	Random
	Replica & Hardness	Replica & hardness shall be on weld/HAZ & parent
Reversal Chamber	Visual	
	WFMPI	Weld Joints
	Replica & Hardness	Replica & hardness shall be on weld/HAZ & parent

Preparation for Inspection

- **Before inspection**
  - Superheater, reheater, economizer and water wall cleaning
  - Air heater washing
  - Scaffolding
  - Removal of insulation
  - Open man holes, inspection holes, flanges etc
- **During inspection**
  - Surface preparation of inspection parts
  - Surface finishing (grinding) of inspection parts
  - Instrument of apparatus of inspection
  - Cutting tubes
  - Welding tubes
- **Material requirement**
  - New tubes
  - Man hole packing
  - Insulation
- **Period of inspection**
  - Two weeks

Data Requirement from Clients

- **Boiler reference data**
  - Steam temperature ^{0}c
  - Maximum Steam flow Ton/hr
  - Boiler design pressure Kgm/cm^2
  - Feed water temp ^{0}c
  - Reheated inlet steam temperature ^{0}c
  - Reheated outlet steam temperature ^{0}c
  - Reheater design pressure Kgm/cm^2
  - Kind of fuel Gas, Oil

- **Functional inspection with boiler in operation**
  - Collection of drawings and main technical data
  - Recording of actual operating and functional data at different loads and conditions at MCR and Verification of the operation of the boiler
  - Collection of data relevant to the thermal history and interventions ,if any made on the boiler during his operation life

NDT Techniques for Inspection

Components	Dimension Checks	Thickness Measurement	Microscopic Examination Replica	Hardness Testing	PT/MT	Ultrasonic Testing	Radiographic Testing
- economiser headers	X				X	X	
- waterwalls	X	X				X	
- boilers drums	X			X	X		
- lower waterwalls and headers						X	
- junction headers	X				X	X	
- waterwall risers		X			X	X	
- waterwall headers					X		
- superheater headers (welds)	X	X	X		X	X	
- reheater headers (welds)	X	X	X		X	X	
- desuperheaters :							
liners						X	
nozzles	X				X		
- HT superheater tubing	X	X	X	X	X	X	
- steam piping	X	X	X	X	X	X	X
- feedwater piping		X					X

- **NON Destructive test for the following items**
  1. Economizer headers, coils, Piping from economizer to steam drum,.
  2. Steam drum.
  3. Furnace water walls, screen, roof wall, feeders, riser ,Water walls headers.
  4. Saturation steam pipe.
  5. Primary, secondary super heater.
  6. Connecting pipe between primary superheater and secondary superheater.
  7. Reheater.
  8. Main SH steam pipes

- **NDT Techniques**
  1. External visual inspection
  2. Internal visual inspection with endoscope
  3. UT for thickness measurements by UT
  4. MT and UT on circumferential welds
  5. MT on piping attachments
  6. Metallographic inspection by plastic replicas
  7. MT on nozzles welds of the coil tubes
  8. MT on nozzles welds to the shell of the inlet/outlet pipe

Thickness Measurement

- Minimum Required Thickness

$$t = \frac{PD}{2S + P} + 0.005D + e$$

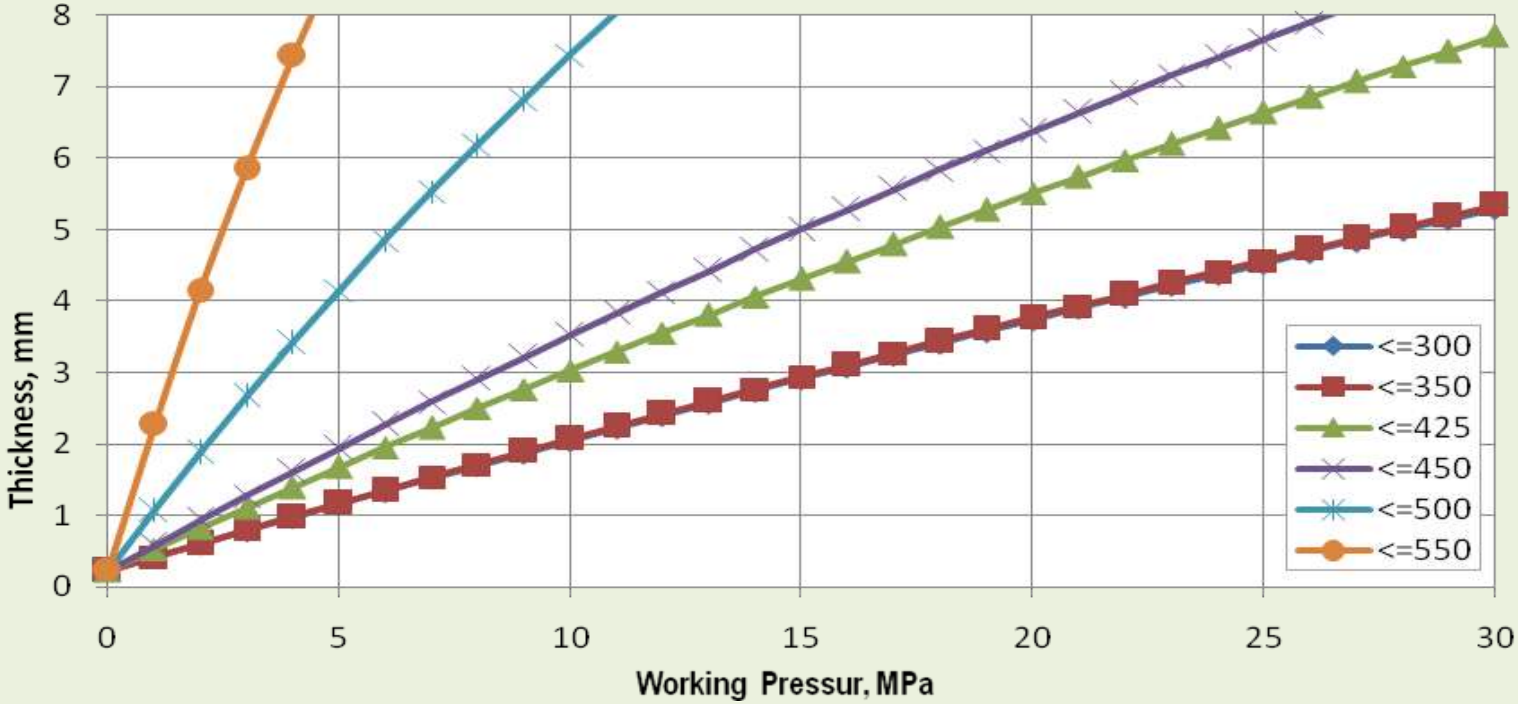
t = minimum required thickness.
D = outside diameter of cylinder.
e = thickness factor for expanded tube ends.
P = maximum allowable working pressure.
S = maximum allowable stress value at the design temperature of the metal.

- Design Information Needed
  - Material type or grade
  - Nominal outside diameter
  - Designing Pressure
  - Design Life
  - Design Temperature
  - Original nominal thickness

- Operating Information Needed
  - Maximum tube metal temperature
  - Normal operating pressure
  - Original measured minimum thickness
  - Metal thinning rate

Thickness measurements
of water wall tubes furnace

Minimum req. thickness for SA178-C



Minimum required thickness for different working conditions for materials SA178-C

Sample Tubes at Laboratory

- Destructive test for the Sample tube for Water Wall ,Superheater and Reheater tubes
  - Life diagnoses based on check of metal structure, thickness, inner scale, etc
    - water wall tubes are subjected to internal deposit analysis
    - Analysis of external deposits and study of corrosion
    - Thick walled components are analysed for spheroidisation and cavitation level
  - Sample tube taken according to the result of hardness measurement

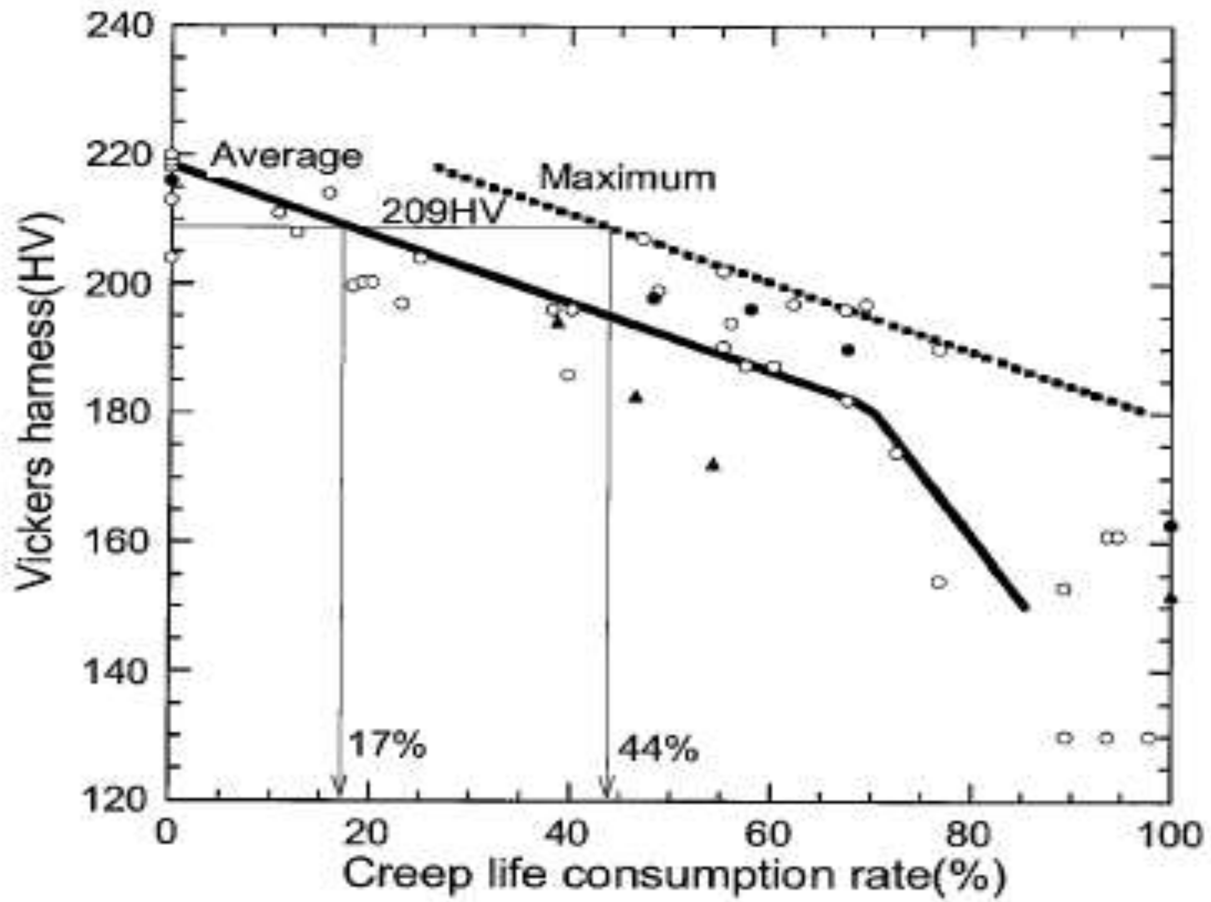
- Investigation done at TCR Lab
  - Visual inspection, Measurement of the inner scale thicknes
  - Non destructive test
  - Chemical analysis
  - Measurement of the tube dimension
  - Hardness measurement
  - Cross sectional microstructure observation
  - Steam oxidation observation
  - Creep rupture test

Thinning of bulged zone

Internal surface scale

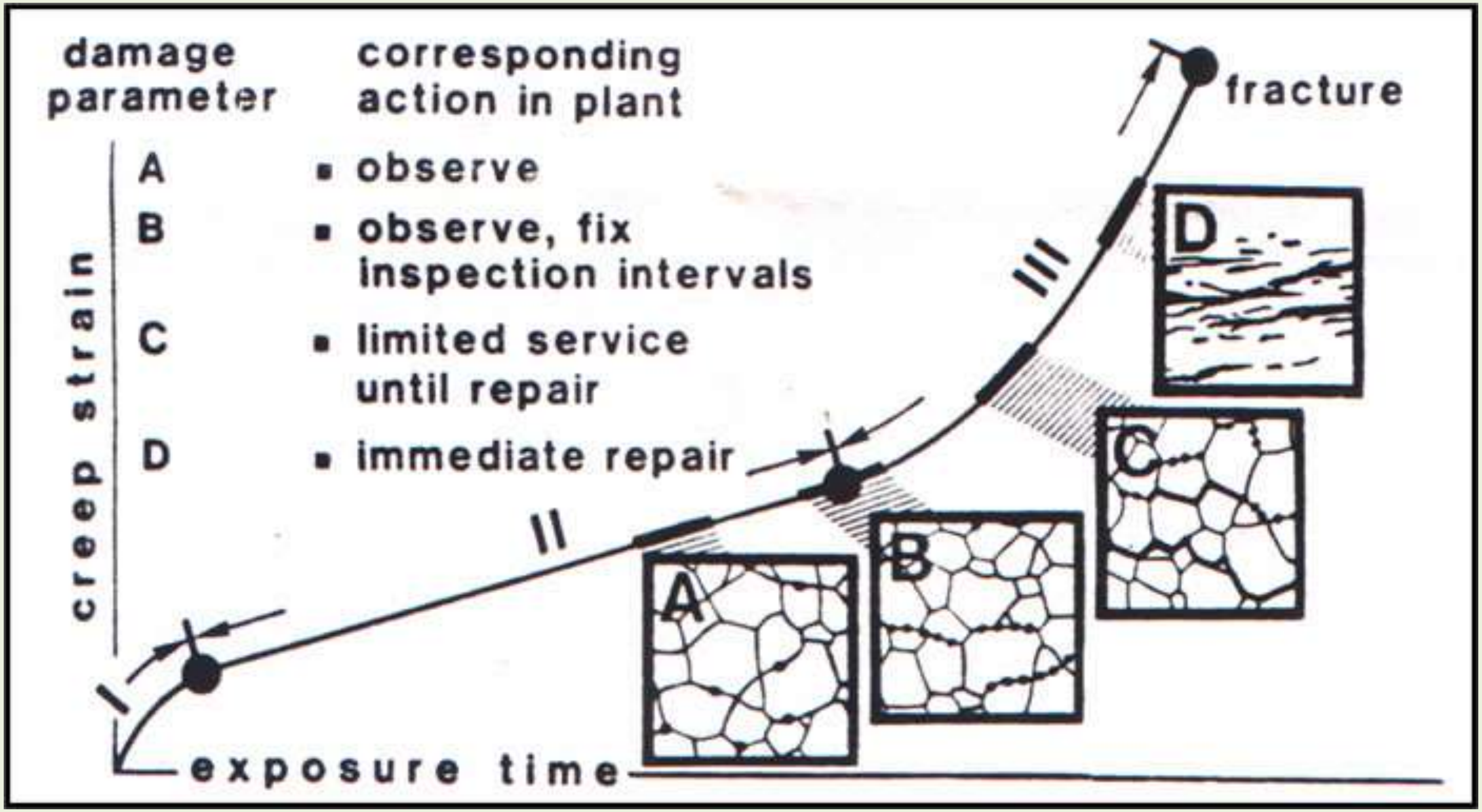
External surface scale

Hardness Measurement



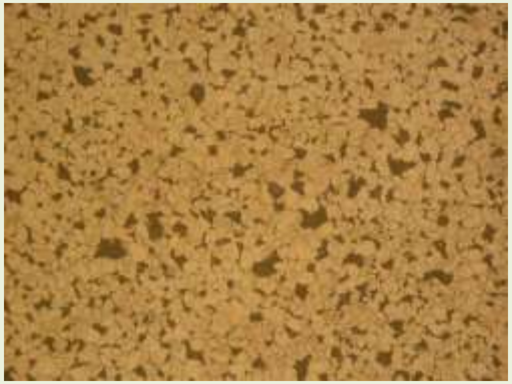
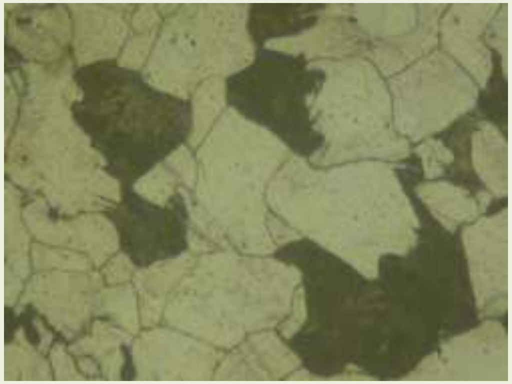
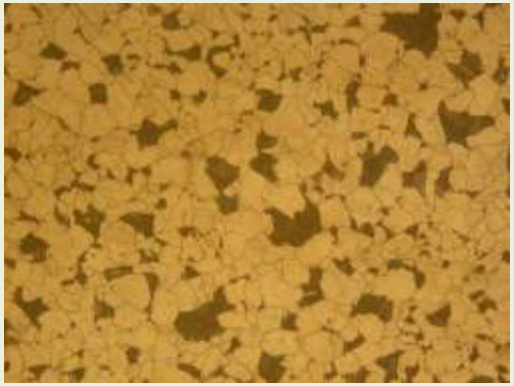
Evaluation curve for estimatingcreep damage in T91

Guidelines Based On Observed Creep Damage



Microstructure Reveal Information

- Optical Micrograph

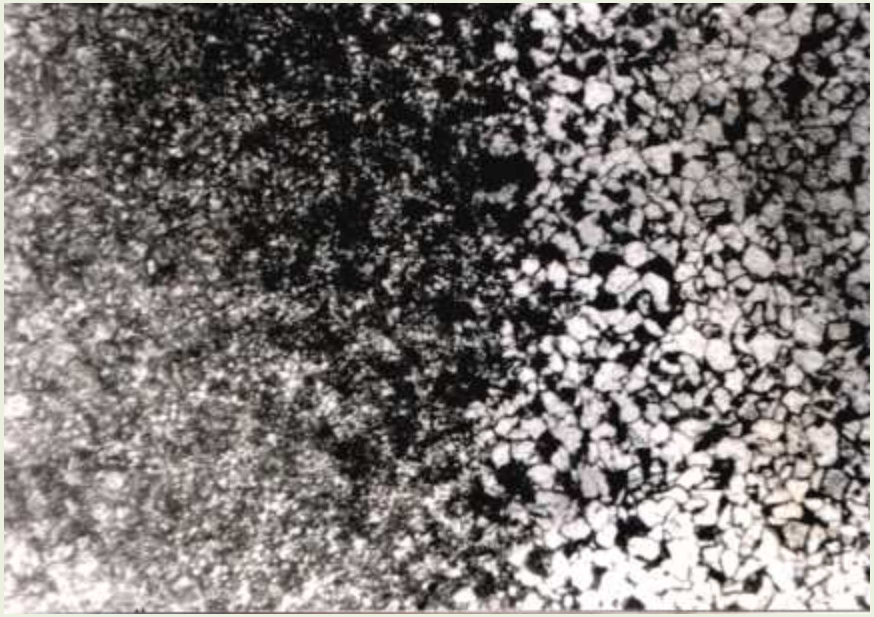
Optical micrograph of non-bluged zones tube wall side showing ferrite –pearlite structure with no internal defects

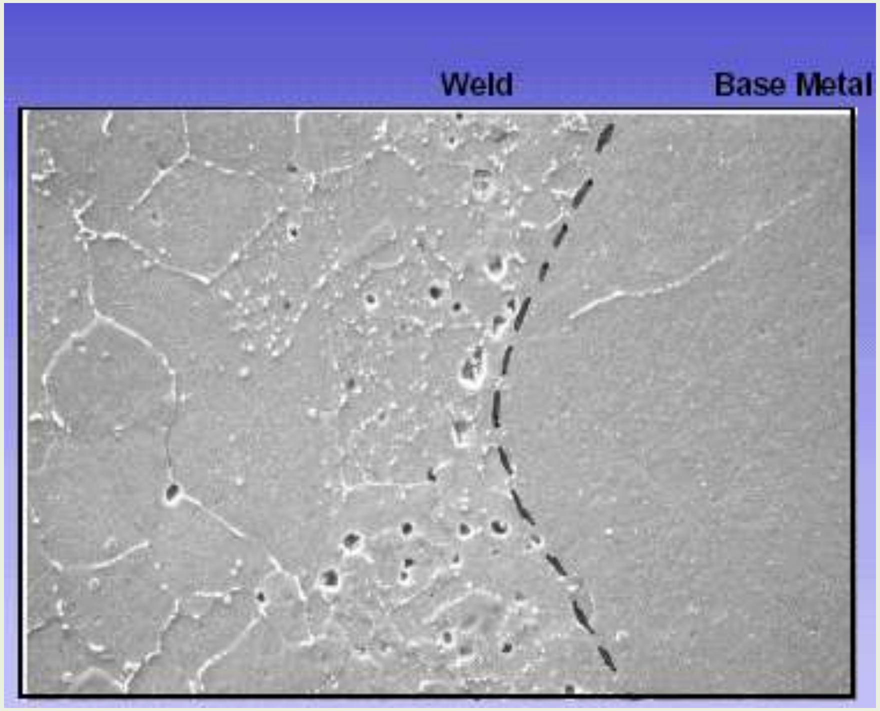
- Normal and deteriorated microstructure

Normal Microstructure (good condition tube)
Which shows a typical ferritic pearlitic structure

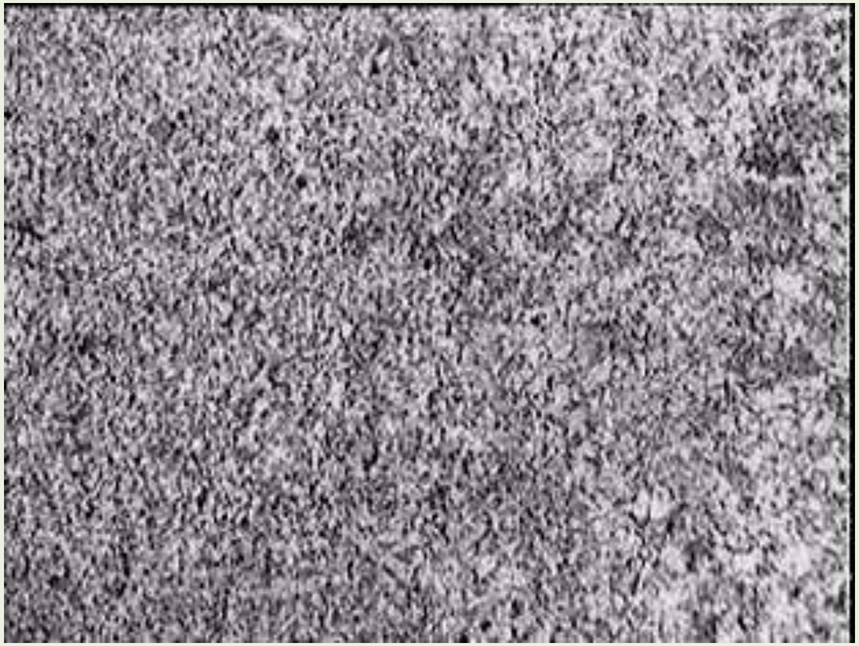
Deteriorated Microstructure which shows the decomposition of the pearlitic colonies

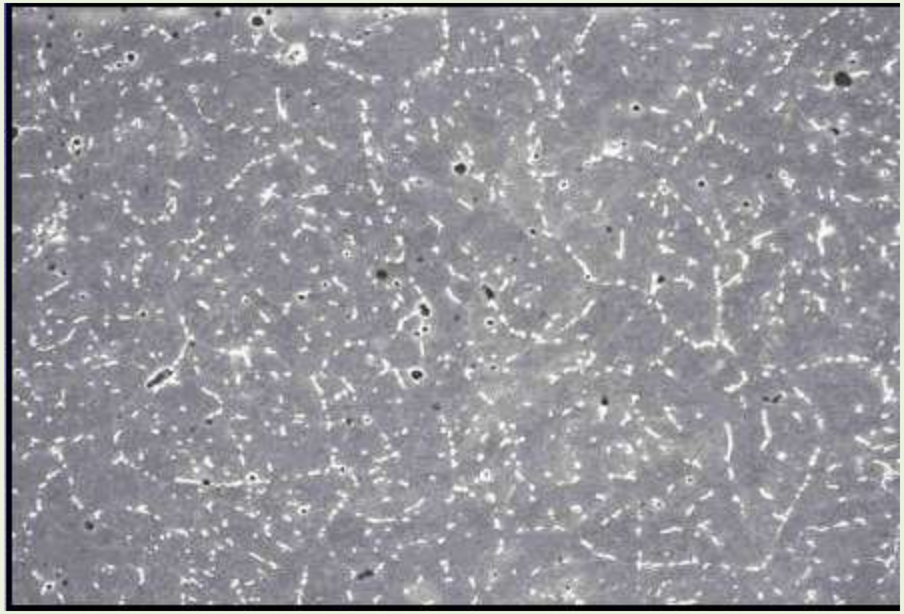
Creep cavitation at HAZ region, left hand side photographs shows optical metallography of Cr-mo steel at weld/HAZ, after approximately 20 years of service



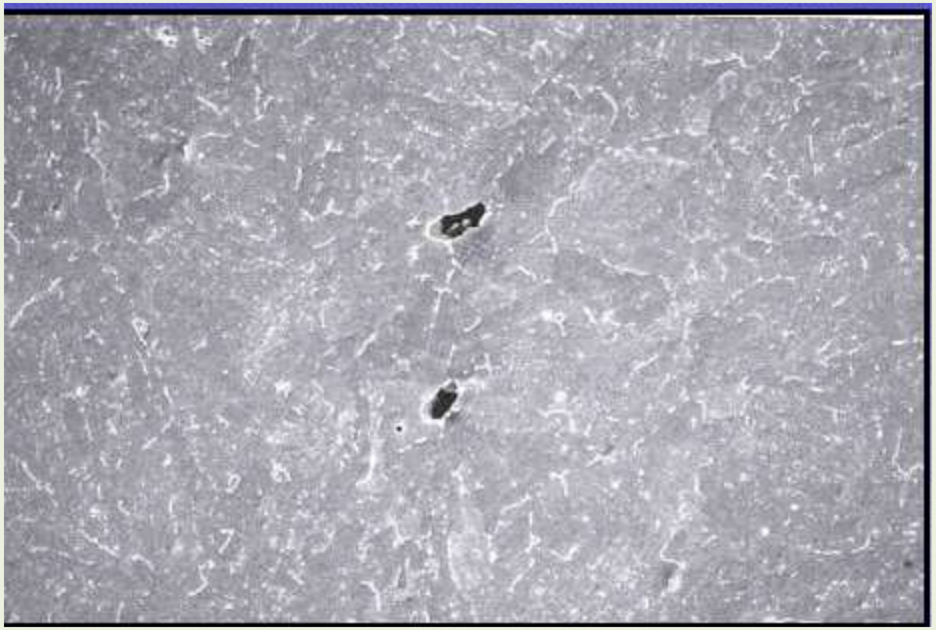


Isolated cavitation damage in the Cr-Mo weld after 25 years of service in the power plant. Carbide formation and cavitation damage is observed.

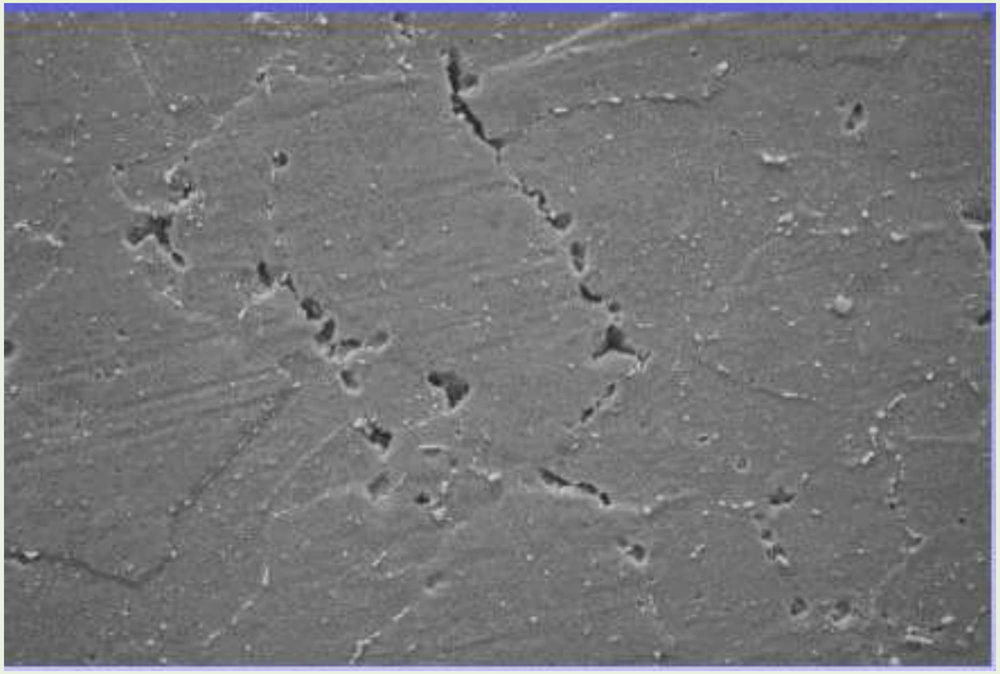




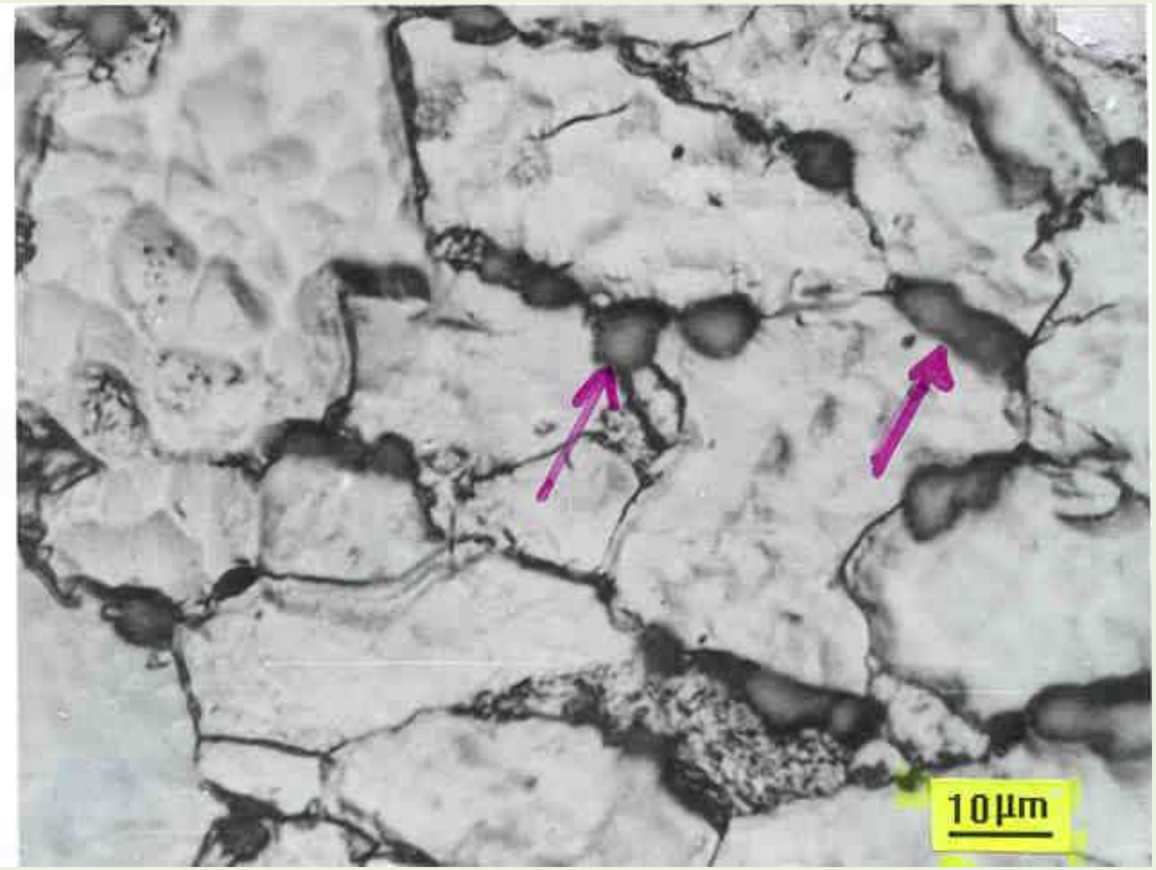
Cavitation damage in the weld at higher magnification



Oriented creep cavitation in the P22 header after 25 years of service.



SEM image of oriented creep cavitation damage of T11 super tubes –exposed to long term over heating.



Life Assessment of Boiler Tubes

- Creep Measurement
- Microstructure Analysis
- Oxide Scale Measurement

Creep Measurement

- Remaining Life can be estimated from:
  - Present Strain: Outer Diameter measurement and getting ratio of it to its original dimension.
- The Practical Equation is :

$$\text{(Life Remaining) } L_R = \left(1 - \frac{t}{t_r}\right) = \left(1 - \frac{\varepsilon}{\varepsilon_r}\right)^{\frac{\varepsilon_r}{\varepsilon_M}}$$

  - Where, t=Life Expended, t_r = Design life, ε= measured creep strain, ε_M = Strain at rupture, ε_r= strain rate (10 to 20 for ductile metals)

Creep Measurement

- Advantage
  - Handy and Easiest method of estimation
  - Does not require high skill and expertise of dimensional measurements
  - Fast, tubes in bulk can be analyzed

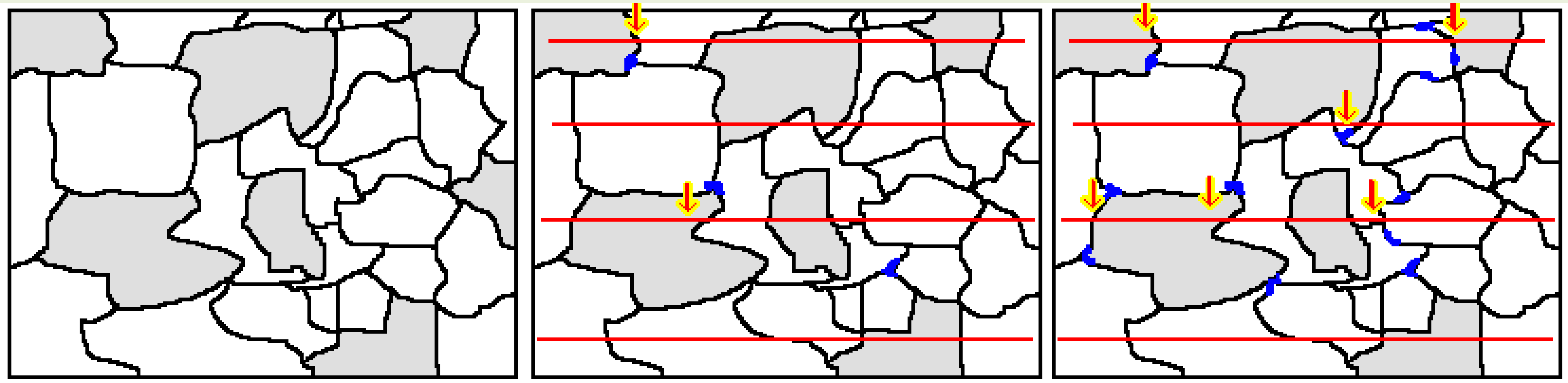
- Limitation
  - Based on assumption of Maximum creep rate as a fixed value (as a rule of thumb it is assumed to be 3%)
  - Assumed that uniaxial load prevails

Microstructure Characterization

- Considering Creep as the only governing factor for life expectancy, practical quantification of creep void count can be used as basis of remaining life time assessment.

Microstructure Characterization

- Virtual Lines (in red) are extended across microstructure and intersection points which are boundaries with cavities (in blue) are noted. Fraction of cavitated boundaries to total number of intersection points is called ‘A’ parameter.



Cavitated Boundaries	0	2	6
Total Boundaries	20	20	20
‘A” Parameter	0/20=0	2/20=0.1	6/20=0.3

Microstructure Characterization

- Generalized formula adapted for Remaining Life prediction is:
- $L_R = t_{exp}\left(\frac{0.51}{A + 0.095} - 1\right) \times t_D$ where, t_{exp} = expended life

  A= fraction, t_D = design life

Example: A replicated microstructure found with isolated cavities after 110,000 hours of operation and design life of 100000 hours can be evaluated as:

$$L_R = \frac{110000}{100000} \times \left(\frac{0.51}{A + 0.095} - 1\right) \times 100000$$

For 'A' value of 0.1, L_R = 177,652 hours

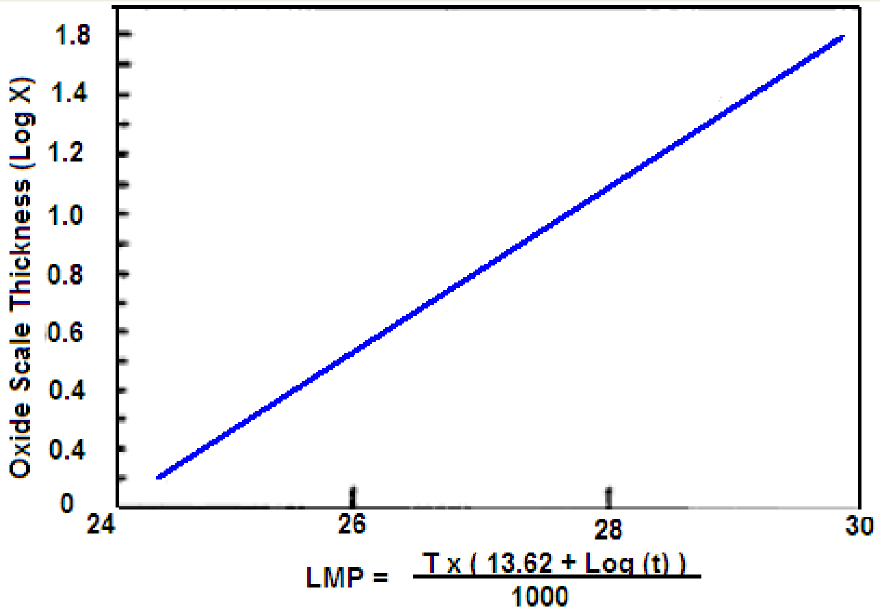
value of 0.3, L_R = 32,025 hours

Microstructure Characterization

- Advantage
  - Only method available for analysis of replicated structures in past time
- Limitations of Method
  - High Skills are necessary to identify between carbide precipitates and cavity
  - Minimum of 400 grain boundary intersections to be counted for each replicated structure
  - Field of view must be minimum of 400X magnification that attributes to time consuming exercise

Oxide Scale Thickness

- Growth of Oxide Scales is a function of Time and Temperature
- For Carbon Steels up to 3% Cr following Charts Apply



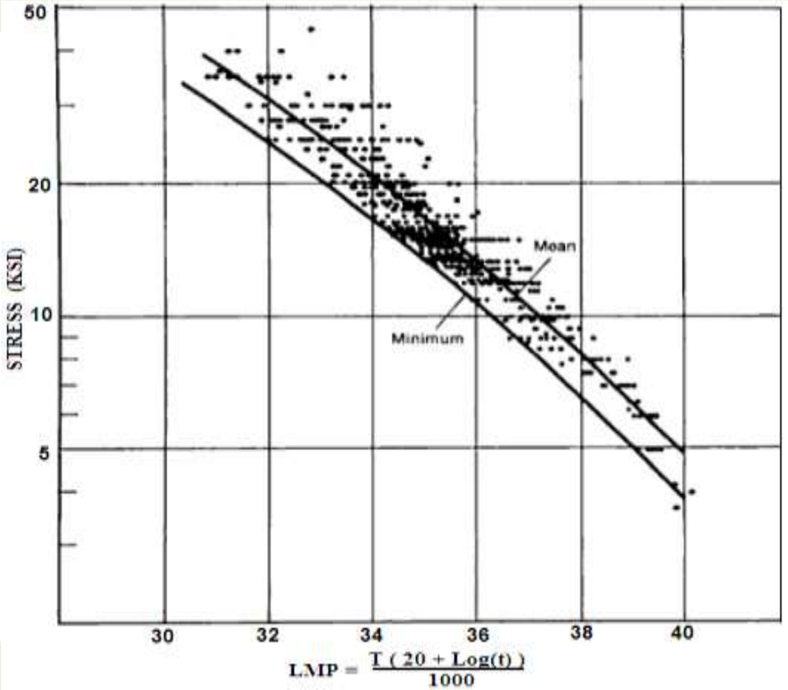


Chart 1, Chart 2

Visual inspection of other Boiler Parts

- A complete visual examination is carried out on other boiler parts
  - Burner
  - Wind Box
  - Hanger for riser pipe
  - Outer casing
  - Skin casing
  - Buckstay

Water Quality Survey

- This inspection to confirm the cause of the scale generation

- Inspection items
  - Check of laboratory analysis method for quality items
  - Confirmation of water quality results at previous load operation
  - Check of instrument condition on sampling rack used for water quality control
  - Confirmation of PH value and iron/copper balance in the cycle

Visual Examination for AUX Equipment

- This inspection toconfirm the cause of the scale generation
  - Condenser hot well.
  - Condenser tube side
  - Deaerator.
  - LP-feed water heater.
  - Feed water tank.
  - HP-feed water heater.

High Pressure Parts Inspection

- Economizer headers ,coils, Piping from economizer to steam drum,
- Steam drum
- Furnace water walls, screen, roof wall, feeders, riser ,Water walls headers
- Saturation steam pipe
- Primary, secondary Superheater
- Connecting pipe between primary super heater and secondary Superheater
- Reheater
- Main SH steam pipes

Economizer

- **NDE For headers**
  - External visual inspection
  - Internal visual inspection with endoscope
  - Measurement of thickness by UT
  - MT on nozzles welds of the coil tubes and headers attachments
  - MT and UT on circumferential welds between header and conical pieces

- **NDE For tube**
  - External visual inspection
  - Measurement of economizer tube and hanger tube thickness with endoscope
  - UT for thickness measurements

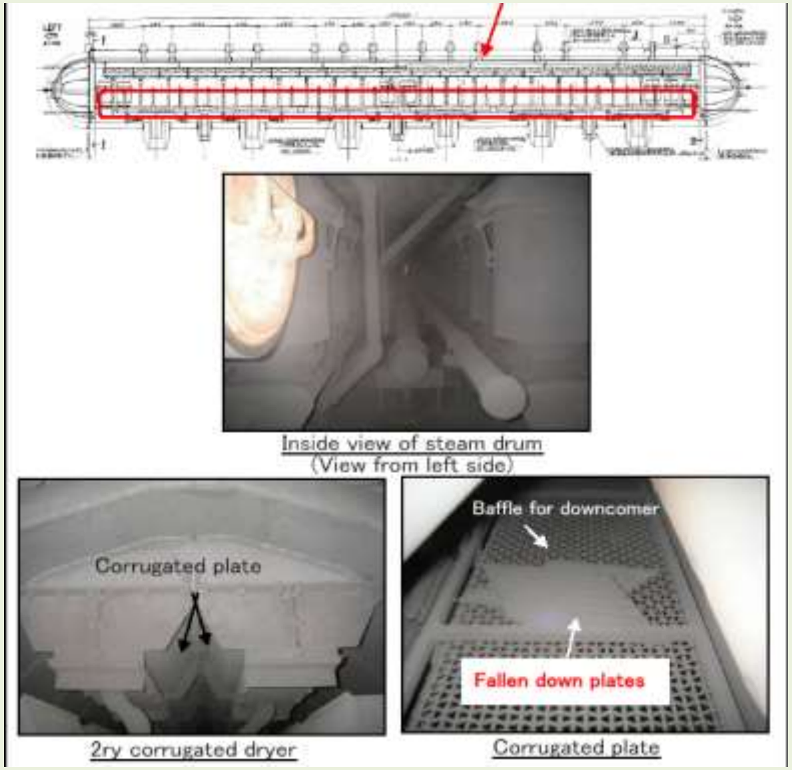
- **NDE For Piping from economizer to steam drum**
  - External visual inspection for piping, hangers and supports
  - UT for thickness measurements
  - MT and UT on circumferential welds
  - MT on piping attachments
  - MT on the elbows extrados

Steam Drum

- Before the NDT inspections, the internal parts of the drum shall be dismantled

- **NDE For steam drum**
  - External visual inspection
  - Internal visual inspection
  - UT for shell thickness measurements
  - UT for head thickness measurements
  - MT and UT on circumferential and longitudinal welds
  - MT on steam drum attachments (saddles and accessories)
  - MT on nozzles welds

- **NDE For downcomers**
  - External visual inspection for piping, hangers and supports
  - UT for thickness measurements
  - MT and UT on circumferential welds
  - MT on piping attachments



Furnace water walls, screen, roof wall, Feeders and Riser

- **NDE for furnace water walls, screen, roof wall**
  - External visual inspection
  - UT for thickness measurements
  - Metallographic examination by replicas
  - Samples for destructive test

- **NDE for feeders and riser**
  - External visual inspection
  - UT for thickness measurements

- **NDE for headers**
  - External visual inspection
  - Internal visual inspection with endoscope
  - UT for thickness measurements
  - MT on nozzles welds of the coil tubes
  - MT on branches welds and headers attachments, including drains tubes

Primary, Secondary Superheater

- **NDE for the headers**
  - External visual inspection
  - Internal visual inspection with endoscope
  - UT for thickness measurements
  - UT for head thickness measurements
  - MT on nozzles welds of the coil tubes
  - MT on nozzles welds to the shell of the inlet/outlet pipe
  - MT and UT on circumferential welds between header and heads/ piping
  - MT on headers attachments
  - Metallographic examination by replicas

- **NDE for Coils**
  - External visual inspection
  - UT for thickness measurements
  - Internal visual inspection with endoscope
  - Hardness measurements
  - Samples for destructive examinations

Connecting Pipes

- Connecting pipe between primary and Secondary Superheater, Desuperheater ATPS

- **NDE for connecting pipe**
  - External visual inspection
  - UT for thickness measurements
  - MT and UT on circumferential welds
  - MT on piping attachments
  - MT on the elbows extrados
  - Metallographic examination by replicas

- **NDE for desuperheater ATPS**
  - External visual inspection
  - Internal visual inspection with endoscope
  - UT for thickness measurements
  - MT on circumferential welds
  - Metallographic examination by replicas

Reheater

- **NDE For each one of the headers**
  - External visual inspection
  - Internal visual inspection with endoscope
  - UT for thickness measurements
  - UT for head thickness measurements
  - MT on nozzles welds of the coil tubes
  - MT on nozzles welds to the shell of the inlet/outlet pipe
  - MT and UT on circumferential welds between header and heads/ piping
  - MT on headers attachments
  - Metallographic examination by replicas

- **NDE For Coils**
  - External visual inspection
  - UT for thickness measurements
  - Internal visual inspection with endoscope
  - Hardness measurements
  - Samples for destructive examinations

Main SuperHeater steam pipes

- **NDE for each pipe**
  - External visual inspection
  - UT for thickness measurements
  - MT and UT on circumferential welds
  - MT on piping attachments
  - MT on the elbows extrados
  - MT on nozzles welds to the pipe
  - Metallographic examination by replicas

Future Recommended Inspections

- Neubauer and Webel Classfication of creep damage level based on number of cavities and their orientation
  - Class A - Isolated cavities;
  - Class B - Oriented cavities;
  - Class C - microcracks;
  - Class D - macrocracks;

- Inspection Actions based on each Damage:
  - Class A - No remedial actions required;
  - Class B - Replica tests at specified intervals;
  - Class C - Limited service until repair;
  - Class D - Immediate repair.

- Apply strong monitoring techniques and understand damage rate on components to get extended life

TCR's Strong Experience in RLA

Sr. No.	Name of Client	Nature of Work	Brief Description of Component / Plant
1	Electricity Board, Wanakbori, .	RLA Study of various components of Boiler No.- 2	Power Boilers
2	Hindustan Unilever Limited, Chiplun.	RLA Study of MP Boiler.	The Boiler is a smoke tube, 3-pass wet back oil fired horizontal packaged boiler. The Safe Working Pressure: 17.58 kg/cm2g, Design Pressure: 18.28 kg/cm2g, Hydrotest Pressure: 27.42 kg/cm2g, Steam Raising Capacity: 8 Tons/hour, Steam Holding Capacity: 3.6 M3 and Water Storage Capacity: 21000 Liters
3	Hindustan Unilever Limited, Orai	RLA Study of MP Boiler.	The boiler is fluidized bed combustion type water tube, bi-drum boiler using crushed powdered coal as fuel. The Safe Working Pressure: 17.5 kg/cm^2 (g) after modification, Design Pressure: 20 kg/cm^2 (g) after modification and Hydrotest Pressure: 30 Kg/Cm^2 (g) after modification
4	Hindustan Unilever Limited, Solan, H. P.	Damage Assessment of Fire Tube Smoke Tube of M. P. Steam Boiler	The Boiler NO.:MPBL/151, Make: - Misra Boilers P Ltd, Type: smoke tube, 3 pass, dry back, package type horizontal, Rating / Capacity : 331.1 m^2, Design Pressure: 18.25 bars, working pressure: 17.5 bars, steam evaporation: 10 tons per hour and Hydro test pressure: 25.5 bars.
5	Hindustan Unilever Limited, Sweri.	RLA of Stain Muller Boiler	This is a water tube oil fired single horizontal drum boiler. The Boiler Rating: 460 m^2, Economizer Rating: 800 m^2, and Safe Working Pressure: 15.8 kg/cm2
6	Hindustan Unilever Limited. .	RLA Study of MP Boiler.	The boiler is a smoke tube, oil fired horizontal three pass wet back boiler. The N type Boilers are of three pass, smoke completely wet back construction.
7	Unilever Bangladesh Limited, .	Remaining Life Assessment of Tube of Package Boiler	The Package Boiler Cochran Make Thermex 3. The Design pressure: 1.8 N/mm^2, Operating pressure: 1.24 N/mm^2 and Operating Temperature: 350º C
8	Hindustan Unilever Limited, Barotiwala	RLA Study of Boiler	Boiler is made by Nestler Boilers and a medium pressure steam boiler with horizontal cylindrical shell and having 5 tons/hour capacity
9	Ministry of Electricity and Water Shuaiba South Power & Water Production .	RLA Study of Main Steam Line Piping of SSPS Boiler	Make: Deutsche Babcock, Type: Natural Circulation Radiant Type Boiler with Pressurized Furnace, Steam capacity at MCR: 545 T/Hr, Design pressure: 1593 psig, Final steam pressure at S/H: 93.4 kg/cm^2 gauge, Final steam temperature: 510^{0}C, Fuel: Gas oil and Natural gas, Draught system: Forced draught, Drum pressure : 1507psig, Feed water temperature: 322^{0}C, Steam Press. At steam Outlet: 1250 psi (Design pressure is 1500 psi), Operating Steam temp. at M.S.S.V. °C : 540 deg c

TCR strength's RCFA of Boilers

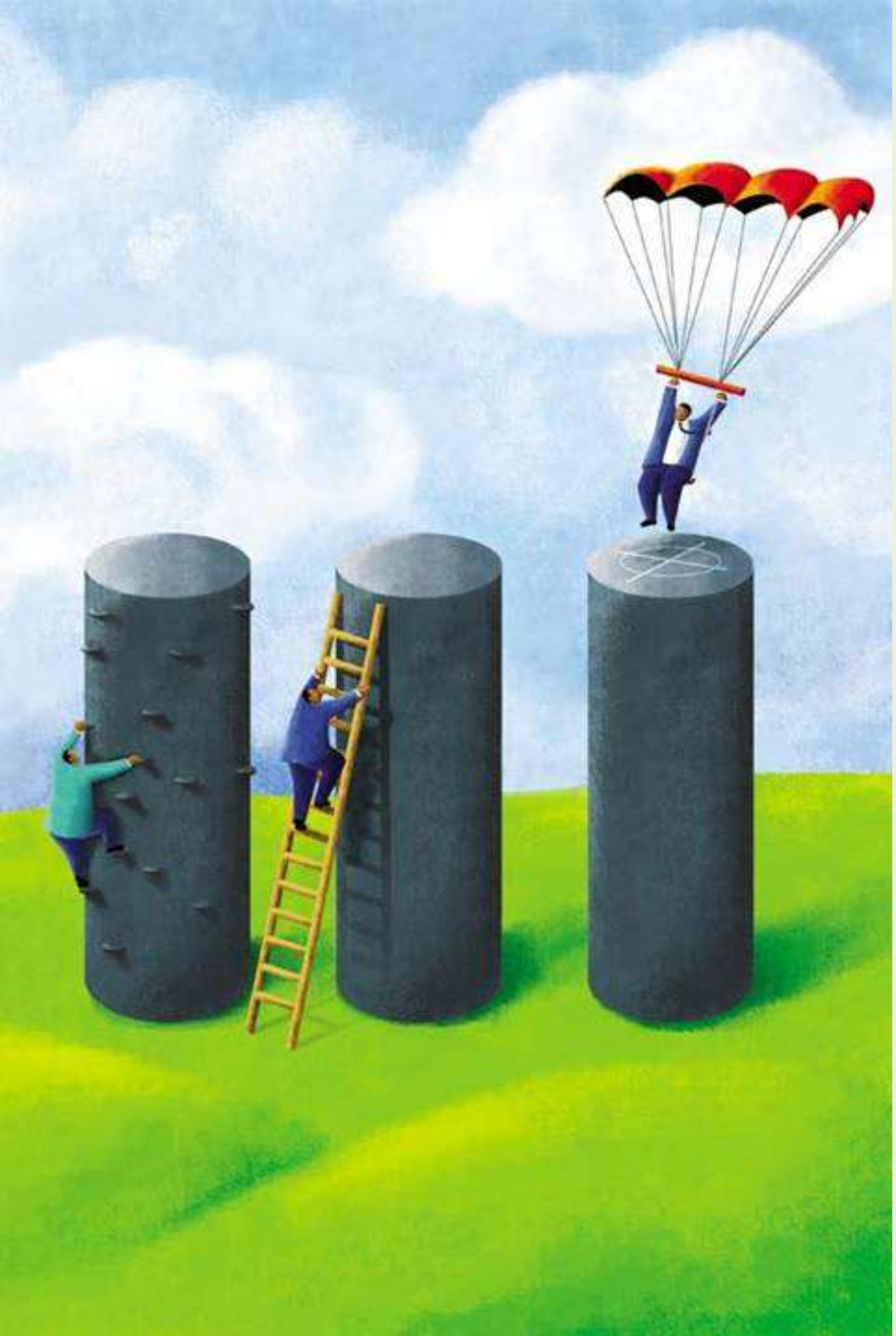
Name of Client	Nature of Work	Brief Description of Component / Plant
Alstom Projects India Limited, Vadodara	Failure Investigation of Primary Super Heater R- 4 Zone Tube of 140MW Boiler	Primary super heater tube of R-4 zone of 140MW boiler was reported to have failed. The tube is made of TU 15 CD 205 (French standard) specification with 63.5 mm OD X 5.5 mm Thickness. It operates at maximum steam temperature of 450 C with 140-kg/cm2 pressure.
Ahmedabad Electricity Company Ltd., Ahmedabad.	Failure Investigation of Water Wall Tube of 110 MW "E" Station Boiler	Tube is made from carbon steel material as per SA 210 Gr. A1 specification. The original dimension of the tube is 63.5 mm OD × 5.6mm thick. This is the riser tube (water wall) in the furnace. It is connecting between ring header located at @ 3 meter level and 45 meter level drum/header. This tube is failed at @ 15meter height and location is front water wall tube. The burners are kept at 17 mt. height. The basic function of tube is absorb heat after combustion of coal and transfer to the fluid. The DM water is used to form steam. The operating pressure at water wall tube is 150 kg/cm^2.
Gujarat Fluorochemical Ltd., Ranjitnagatr,	Failure Investigation of Re-Boiler E-404 of HF Recovery Plant	The re-boiler is a vertical shell & tube type of heat exchanger, handles process fluid on tube side and steam on shell side. Steam enters near top end of the shell at 3.5-kg/cm^{2}g pressure and at 147°C temperature. Steam leaves as condensate from bottom of shell. Process fluid vapors/liquid comprises of R-20, R-21, R-22, R-23, HF 2.5%, HCL 500-800 ppm and free Cl_2 300 ppm enters from bottom side and passes through vertical tubes at 35°-44°C temperature, which in turn gets heated from heat of steam. Heated vapors / liquid is sent back to C-402 column.
Gujarat Paguthan Energy Co. Pvt. Ltd., Bharuch	Failure Investigation of LP SH Tubes of HRSG-13 Boiler	The L.P. system is located in the HRSG vertical gas duct, and it is positioned after the H.P. system preceding the turbine exhaust gas flow. It consists of L.P. super heater and L.P. evaporated tubes. An L.P. economizer is not provided since the feed water temperature is close to saturation temperature of the L.P. system. The L.P. evaporator generates steam through a natural circulation loop connecting L.P. boiler drum. The L.P. super heater heats the saturated steam to the required L.P. live steam temperature.
Reliance Industries Limited, .	Failure Investigation of Rear Water Wall Tube of Auxiliary Boiler.	The material of construction is 15MO3 which is low carbon steel having Mo 0.3% nominal. The original dimensional of the tube are 63.5mm OD and 4mm thickness.
Hindalco Industries Limited., Dahej	Failure Investigation of Waste Heat Recovery Boiler Panel Tube	Boiler drum pressure: 40 kg/cm^2, Steam Temperature : 246 ^{O}C (saturated), Feed Water Requirement : 25 tonns per hour
Petromin Lubricating Oil Refining Co.,	Failure Investigation of Water Wall Tube of Boiler	The oil fired boiler B-8002 with front firing of four burners was installed in 1976 at Luberef, KSA having capacity of 65MT/hr. The design steam pressure for boiler is 53.8 Kg/cm^2 with design temperature of 399 °C.
Narmada Chematur Petrochemical Ltd., Bharuch.	Failure Investigation of Tar Connector Re-Boiler	The re-boiler is essentially shall and tube type of heat exchanger with horizontal layout. There are two re-boilers viz. E-7203 A & B. One of them operates as standby. The MOC of shell is SA 515 Gr. 60 and MOC of tube is SB 168 – 600 grade. The tubes dimensions are 25.4mm OD and 1.65 thick. Tube side process fluid that is circulated is a mixture of TAR + TDI + ODCB (40-60% Tar). The mixture enters into the re-boiler at a temperature of 162°C, and it increases to 172°C, which is further sent to Tar concentrator column C-7201. The pressure at tube side is 4.5 bar
Simalin Chemicals Pvt. Ltd.	Failure Investigation of Re-Boiler Tubes	Hot air with organic gases and water are fed into the reactor from top. There is catalyst bed just above the level of tube-sheet spread all over. The reaction involved is essentially exothermic in nature, and the products are in gaseous form. The temperature above the tube-sheet is in the range of 680°C - 700°C. The hot gases then pass through the tubes below. There are thousand tubes in vertical re-boiler whose individual length is 3 meters. Hot gases, at around 680°C enter from the tube side. There is DM water on shell side; the steam drum is kept at liquid level approx. 8.5 meter above tube-sheet. The temperature on shell side is 150°C.

Metallography on Boiler Parts by TCR

Sr. No.	Name of Client	Nature of Work
1	Gujarat Paguthan Energy Corp. Pvt. Ltd., Bharuch	In-Situ Metallography work conducted on Steam Drum and Super Heater Header of Boiler
2	Indian Farmers Fertilisers Co. Op. Ltd., Kalol.	In-situ metallography work on various critical locations of Auxiliary Boiler Tubes of Ammonia Plant
3	Indian Oil Corporation Ltd., Refinery, Vadodara	In-Situ Metallography work conducted on various locations of Boiler Tubes.
4	National Fertilizers Ltd, Panipath.	In-Situ Metallography work conducted on various components of Boiler.
5	Reliance Industries Ltd., .	In-Situ Metallography work conducted on various critical locations of Process Gas Boiler.
6	Reliance Industries limited, Hazira	In situ metallography at waste heat boiler components
6	Larsen & Toubro Limited.	In-Situ Metallography work conducted Boiler. At NTPC, Chattisgarh.
7	Electricity Board, STPS, Sikka	In-Situ Metallography work conducted on various critical locations of Boiler Drum
8	Tata Power Company Limited, Mumbai	In-Situ Metallography work conducted on various critical components of Boiler
9	Alstom Projects India Limited, Vadodara.	In-Situ Metallography work conducted various components of Boiler at BPHCL, Bakaro.
10	Alstom Projects India Limited, Vadodara.	In-Situ Metallography work conducted various components of Boiler at GEB, Ukai
11	Alstom Projects India Limited, Vadodara.	In-Situ Metallography work conducted on Boiler of Ammonia Plant at Kribcho, .
12	Alstom Projects India Limited, Vadodara.	In-situ Metallography work on Korba East Boiler Uat Chhattisgarh State Electricity Board; Korba
13	Gujarat Narmada Valley Fertilizers Co. Ltd. Bharuch	In-situ Metallography work conducted on various locations of Boiler.
14	Godrej Industries Ltd., Valia, Bharuch	In-Situ Metallography work on Falling Film Re-Boiler
15	Reliance Industries Limited, Hazira,	In-Situ Metallography work conducted on Primary & Secondary Super Heater Tubes of UB-1 Boiler
16	Essar Oil Limited,	In-Situ Metallography conducted on various components of Boiler
17	Alstom Projects India Limited, Vadodara.	In-Situ Metallography work conducted on Main Steam Line of Boiler at Tata Ltd., Jamshedpur and several power plants across India
18	Birla copper Dahej	In-situ metallography

Summary

- We listen closely and document each customer interaction
  - Deep understanding of project needs and adherence to timelines
  - Well documented internal work procedures that meets client/inspection agency approvals
- Strong commitment to local community
  - Active participant in Saudi Chapter of ASNT
  - Sponsors of Abdullah Al-Dabal Indoor Football Tournament
- Highly Competitive Pricing and Fast Mobilization
- Ability to Ramp Up team resources very quickly



TCR Engineering Services

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Questions?