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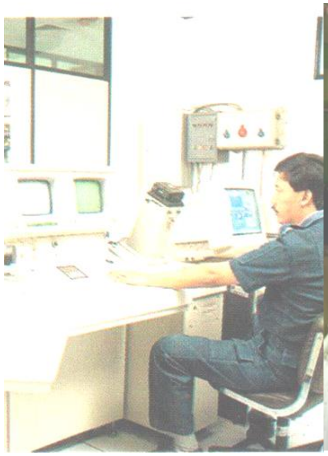

POWER PLANT ENGINEERING SERVICES BY PT. EMPU AGUNG SAKTI


Perkantoran Vila Delima No. 28, Lebak Bulus, Jakarta Selatan 12440. Tlp. 021-7502151
Mobile Phone/WA : 0811925351 ; E-mail : empuagungsakti@gmail.com ; emas@empuagungsakti.com

SCOPE OF SERVICES

***PT. Empu Agung Sakti or EMAS* is an *Engineering and Metallurgical Assessment Services* company which provides services in the fields of:**

I. ROOT CAUSE FAILURE ANALYSIS (RCFA) of power plant components and equipment

II. CONDITION AND REMAINING LIFE ASSESSMENT (RLA) of power plant components and equipment, and

III. QC/QA FOR VENDOR'S PRODUCT FABRICATION/MANUFACTURING SURVEILLANCE:

- **Development of WPS/PQR**
- **Repair Work**
- **Remanufacture/Reverse Engineering , and**
- **Re-Engineering Work**

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SCOPE OF SERVICES

POWER PLANT EQUIPMENT covered :

- **Boiler and Combined Cycle Plant (HRSG) Equipment**
- **Gas and Steam Turbines and Generator Equipment**
- **High Energy Piping**
- **BOP (Balance of Plant) Equipment**

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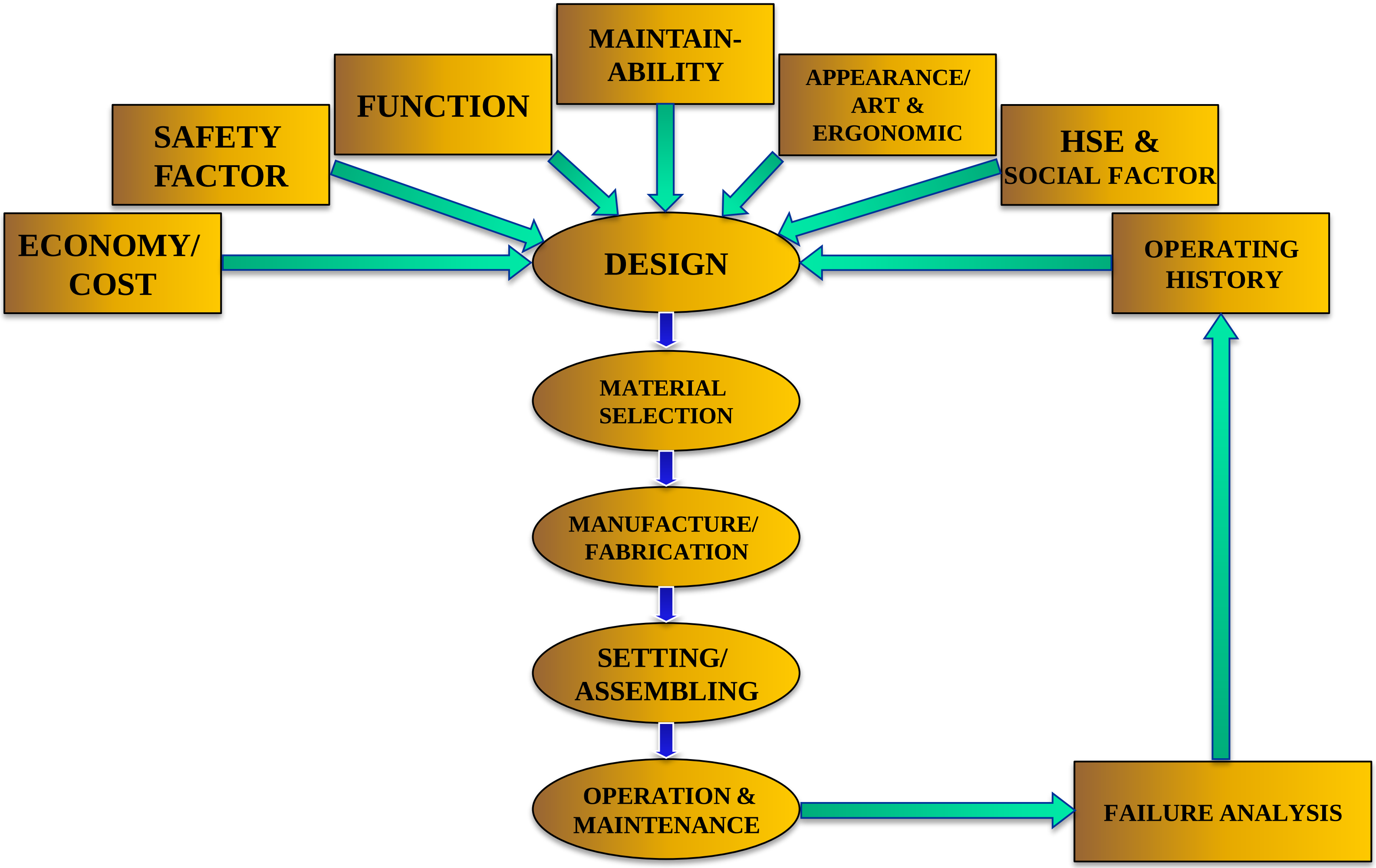
I. ROOT CAUSE FAILURE ANALYSIS (RCFA)

EMAS's team of experts is skilled at investigating the proximate cause of failure in static and rotating plant equipment. Our staff employ a multidisciplinary approach to examining the full spectrum failure causes including design issues, materials of construction and manufacture, operational and maintenance regimes.

Following a failure analysis investigation we will make recommendations aimed at preventing further failures and can assist clients with implementing corective procedures.

I. ROOT CAUSE FAILURE ANALYSIS (RCFA)

FACTORS AFFECTING EQUIPMENT FAILURE



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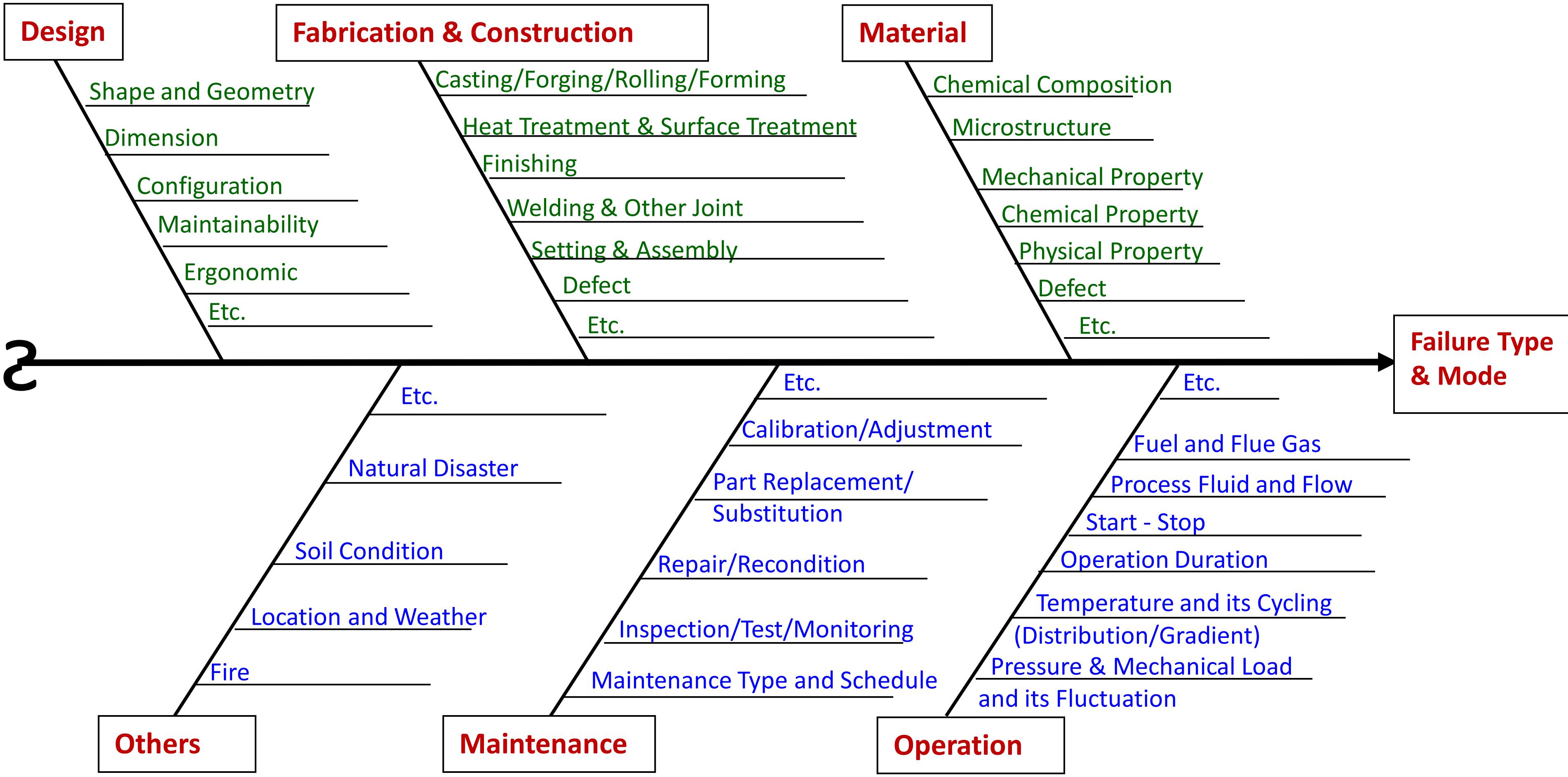
CLASSIFICATION OF FACTORS AFFECTING FAILURE



TYPES OF DAMAGE AND MECHANISM OF BOILER COMPONENTS (According to EPRI*)

- **Corrosion (General)**
- **Gas-Side Mechanisms**
  - Fireside Corrosion
  - Water-Wall Wastage with Low-NOX Combustion
- **Flow-Accelerated Corrosion (FAC)**
  - Single-Phase FAC
  - Two-Phase FAC
- **Corrosion (Under-Deposit and Pitting)**
  - Acid Phosphate Corrosion (Phosphate Hideout and Return)
  - Caustic Gouging
  - Chemical Cleaning Damage
  - Hydrogen Damage
  - Pitting
- **Fatigue**
  - Corrosion-Fatigue
  - Thermal Fatigue

*** EPRI : *Electric Power Research Institute (USA)***

TYPES OF DAMAGE AND MECHANISM OF BOILER COMPONENTS (According to EPRI), continued.

❑ Fireside Erosion and Wear

- Coal Particle Erosion
- Fly Ash Erosion
- Rubbing/Fretting
- Soot-Blower Erosion

❑ Microstructure Damage

- Graphitization
- Softening (Spheroidization)

❑ Fabrication Flaws

- Material Flaws
- Welding Flaws

❑ Overheating

- Creep (Long-Term Overheating)
- Short-Term Overheating
- Supercritical Water-Wall Cracking

GENERAL DAMAGE MECHANISMS – ALL INDUSTRIES

(According to API RP 571)

A. Mechanical and Metallurgical Failure

B. Uniform or Localized Loss of Thickness

C. High Temperature Corrosion

D. Environment Assisted Cracking

GENERAL DAMAGE MECHANISMS – ALL INDUSTRIES

(According to API RP 571)

A. Mechanical and Metallurgical Failure Mechanisms

- Graphitization
- Softening (Spheroidization)
- Temper Embrittlement
- Strain Aging
- 885^0F Embrittlement
- Sigma Phase Embrittlement
- Brittle Fracture
- Creep / Stress Rupture
- Thermal Fatigue
- Short Term Overheating – Stress Rupture
- Steam Blanketing
- Dissimilar Metal Weld (DMW) Cracking
- Thermal Shock
- Erosion / Erosion-Corrosion
- Cavitation
- Mechanical Fatigue
- Vibration-Induced Fatigue
- Refractory Degradation
- Reheat Cracking

GENERAL DAMAGE MECHANISMS – ALL INDUSTRIES

(According to API RP 571)

(Continued)

B. Uniform or Localized Loss of Thickness

- Galvanic Corrosion
- Atmospheric Corrosion
- Corrosion Under Insulation (CUI)
- Cooling Water Corrosion
- Boiler Water Condensate Corrosion
- CO_2 Corrosion
- Flue Gas Dew Point Corrosion
- Microbiologically Induced Corrosion (MIC)
- Soil Corrosion
- Caustic Corrosion
- Dealloying
- Graphitic Corrosion

GENERAL DAMAGE MECHANISMS – ALL INDUSTRIES

(According to API RP 571)

(Continued)

C. High Temperature Corrosion [400^{0}F (204^{0}C)]

- Oxidation
- Sulfidation
- Carburization
- Decarburization
- Metal Dusting
- Fuel Ash Corrosion
- Nitriding

D. Environment-Assisted Cracking

- Chloride Stress Corrosion Cracking (Cl–SCC)
- Corrosion Fatigue
- Caustic Stress Corrosion Cracking (Caustic Embrittlement)
- Ammonia Stress Corrosion Cracking
- Liquid Metal Embrittlement (LME)
- Hydrogen Embrittlement (HE)

METHODOLOGY AND SCOPE OF WORK

- **Data Collection (Design, Dimension, Material Specification, Operation Condition and Maintenance and Inspection Records).**
- **Preliminary Examination of the Failed Part such as:**
  Visual Examination and Record Keeping, Dimensional Measurement, and/or Non-Destructive Tests (PT, MPI, UT, RT, ECT).
- **Preparation of Samples for Laboratory Examination.**
- **Macroscopic Examination on Damaged/Fracture Surface by a Stereomicroscope.**
- **Chemical Analysis using an Optical Spark Emission Spectrometer.**
- **Metallographic Examination using an Optical Light Microscopy.**

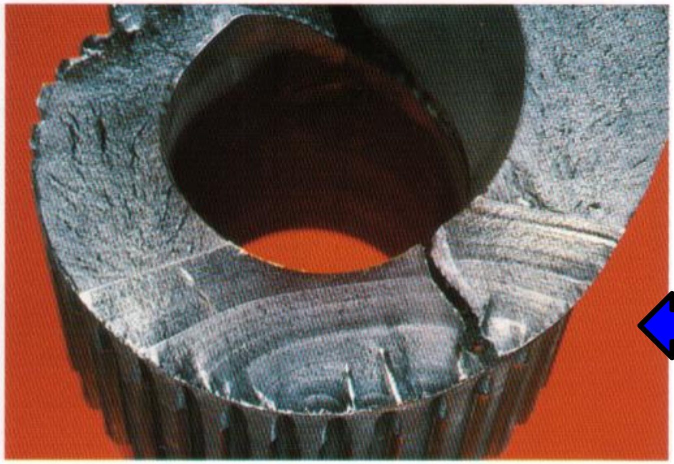
METHODOLOGY AND SCOPE OF WORK, continued

- **Hardness Test using Vickers Method or Other Methods.**
- **Other Mechanical Tests if required (Tensile Test, Bend Test, Charpy V-Notch Test, Fatigue Test, Creep Test, etc).**
- **Microfractographic Examination on Damaged/Fracture Surfaces by SEM (Scanning Electron Microscopy)**
- **EDS (Energy Dispersive Spectroscopy) Analysis on Damaged/Fracture Surface Deposit to detect the presence of any corrosion by products or others.**
- **Other Tests and Measurements (Stress/Fracture Mechanics Analysis, Corrosion Test, Vibration Measurement and Analysis, etc).**
- **Analysis of All Data or Evidence, Formulation of Conclusions and Writing the Report (Including Recommendations).**

MACROSCOPIC EXAMINATION

Fracture surface of a broken impeller shaft due to a high and sudden single torsion overload.

Cavitations erosion on an outlet LP evaporator elbow tube showing typical honeycomb pattern.



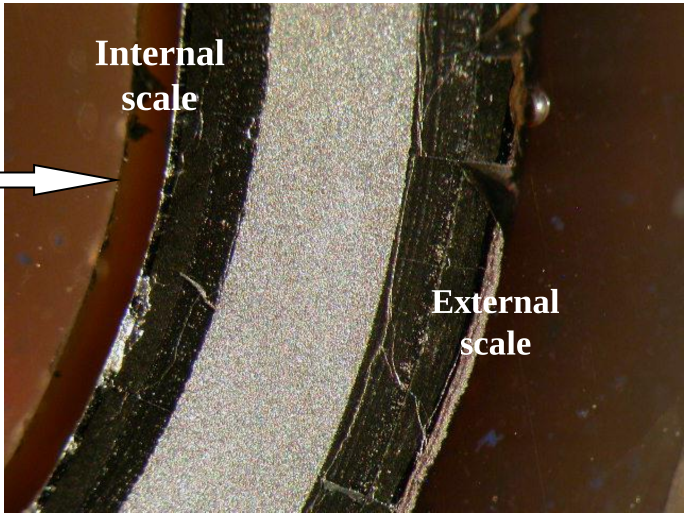
A splined shaft that had experienced fatigue fracture

MACROSCOPIC EXAMINATION

Cavitations erosion.

MACROSCOPIC EXAMINATION

A ruptured boiler tube due to long-term overheating



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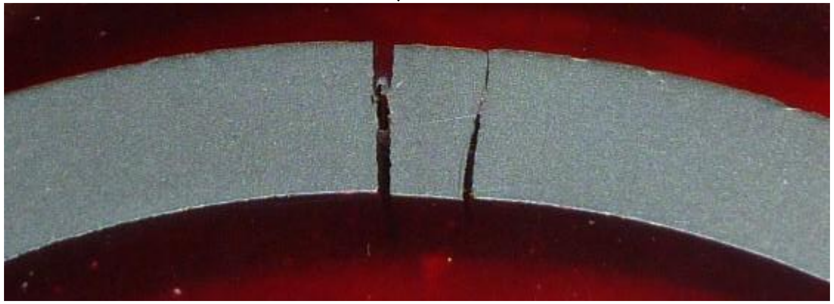
FAILURE ANALYSIS OF CAGE SUPERHEATER BOILER TUBE



Tube failure due to stress-corrosion cracking (SCC)

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SAMPLE PREPARATION FOR METALLOGRAPHIC EXAMINATION

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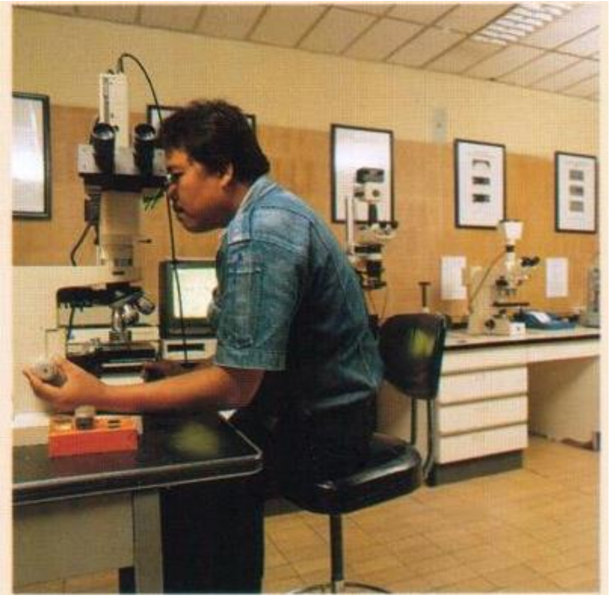
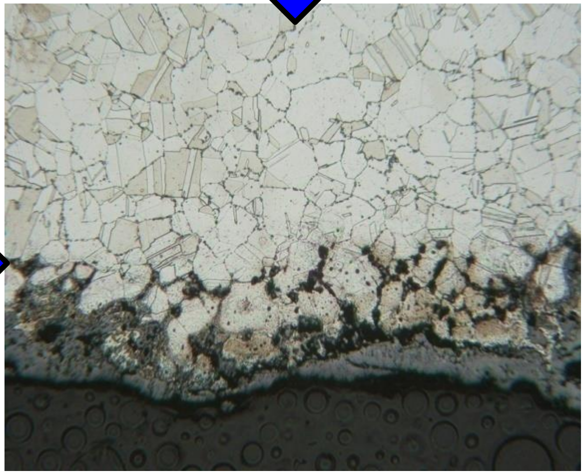
METALLOGRAPHIC EXAMINATION



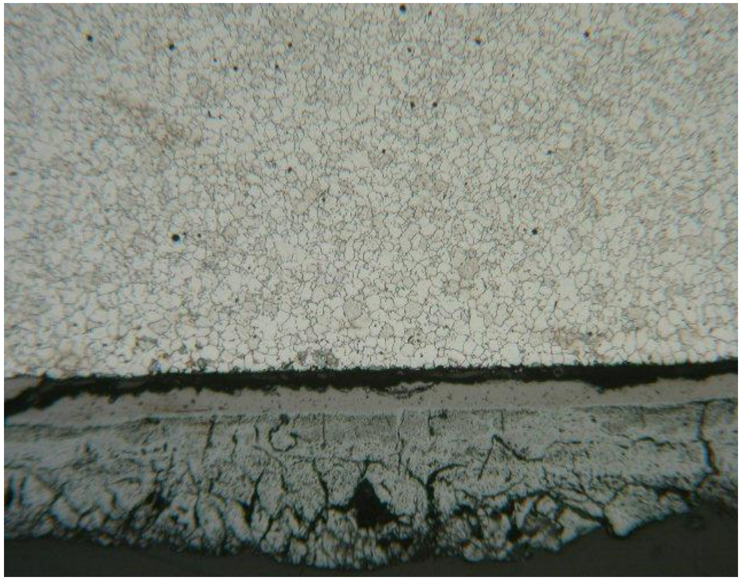
Metallographic examination using an optical light microscope

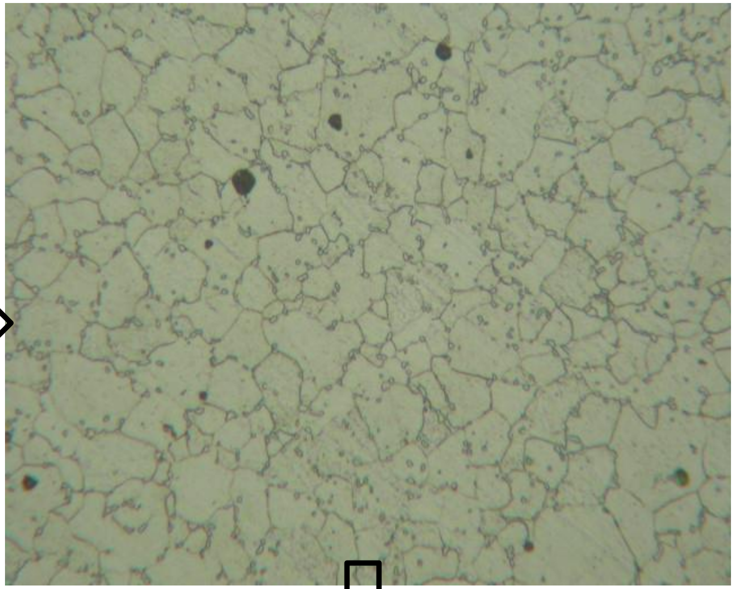
A ruptured boiler tube due to short term overheating

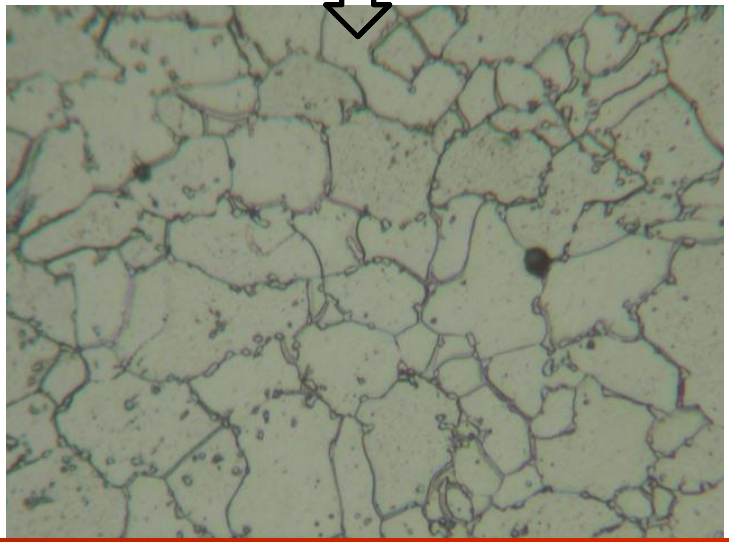


High temperature corrosion related failure of a burner nozzle.

METALLOGRAPHIC EXAMINATION







A damaged boiler tube due to long-term overheating, showing spheroidization of carbide and graphitization

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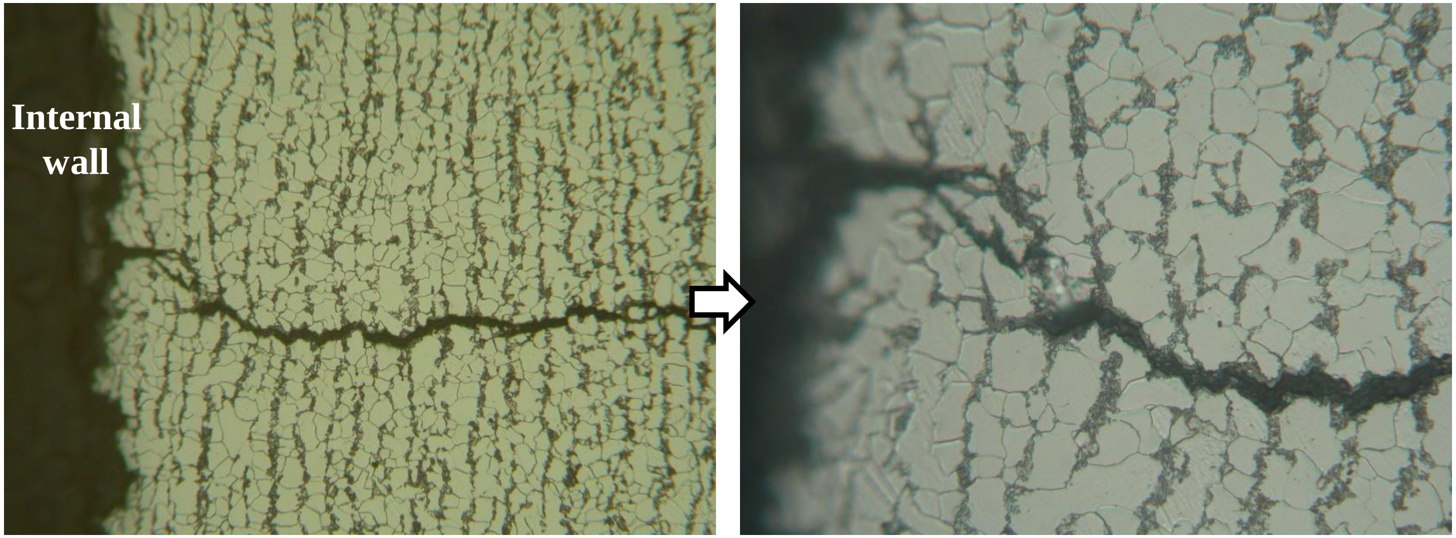
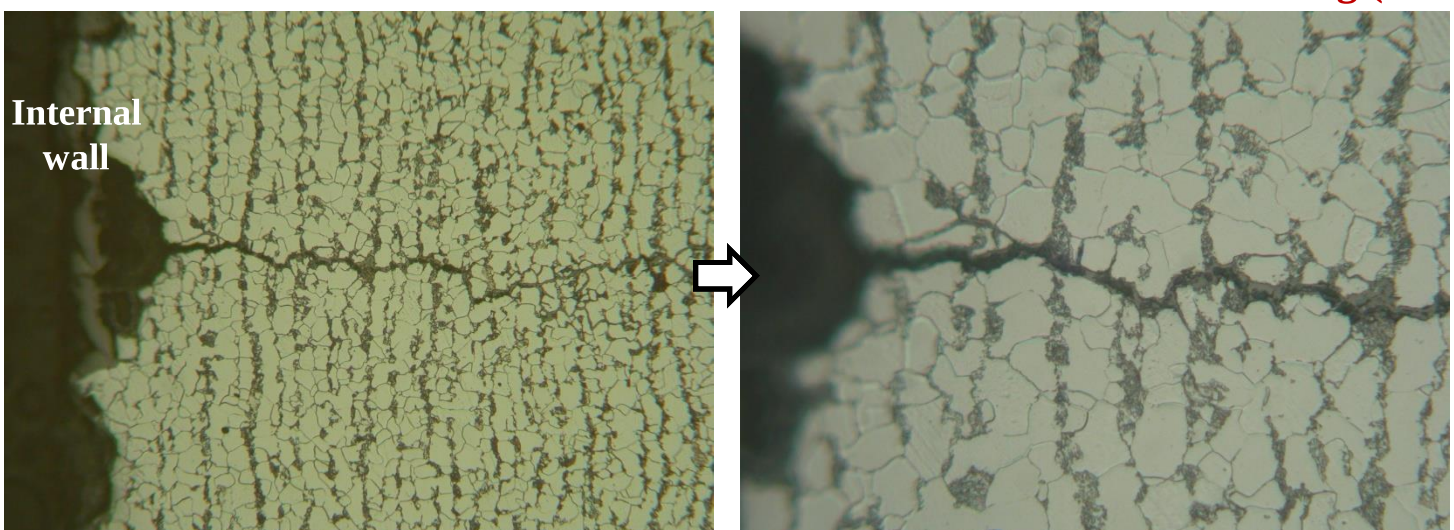
FAILURE ANALYSIS OF CAGE SUPERHEATER BOILER TUBE



Microstructures of failed boiler tube due to caustic stress-corrosion cracking (SCC)



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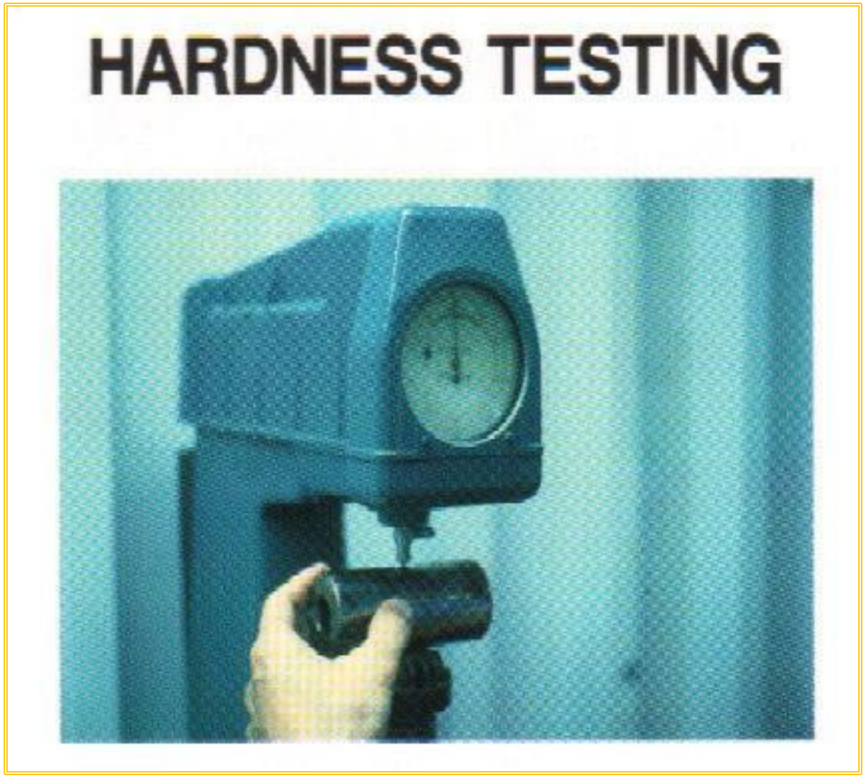
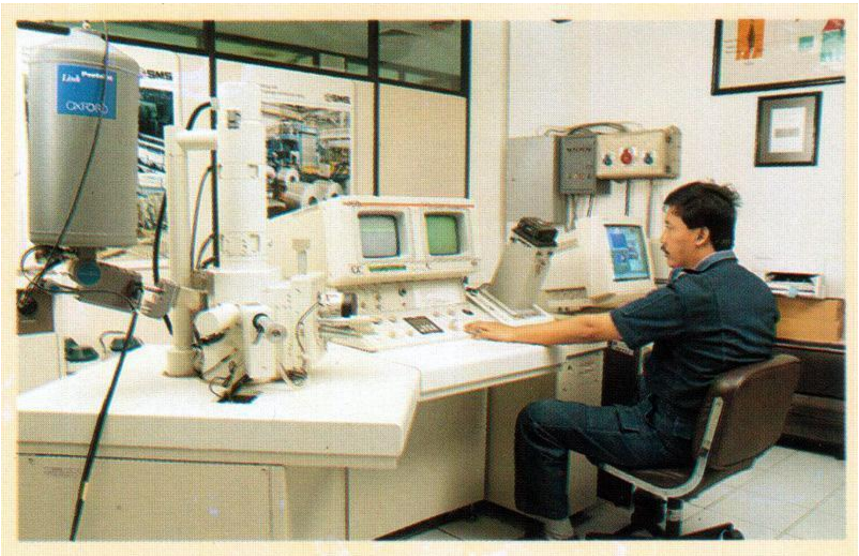
HARDNESS TESTING

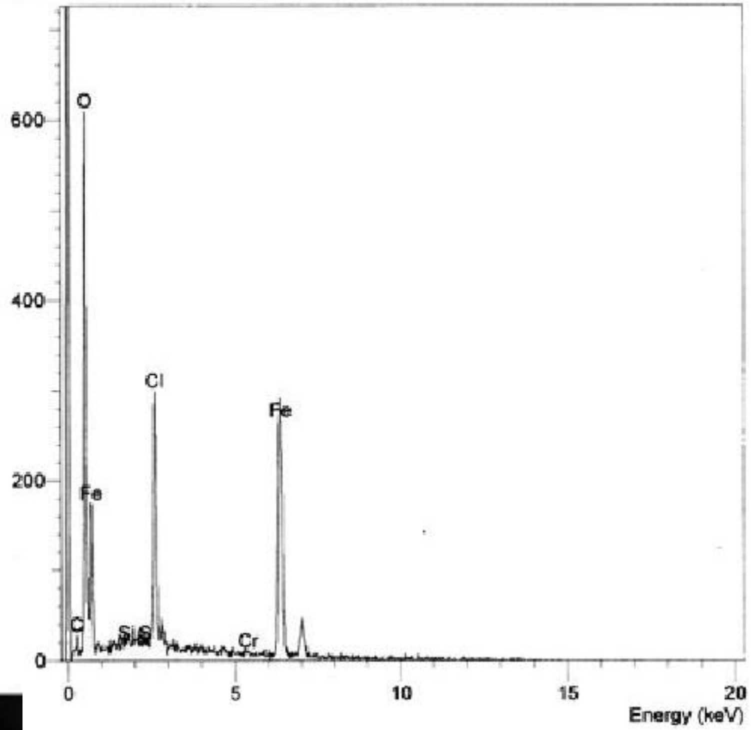
Vickers Hardness Method

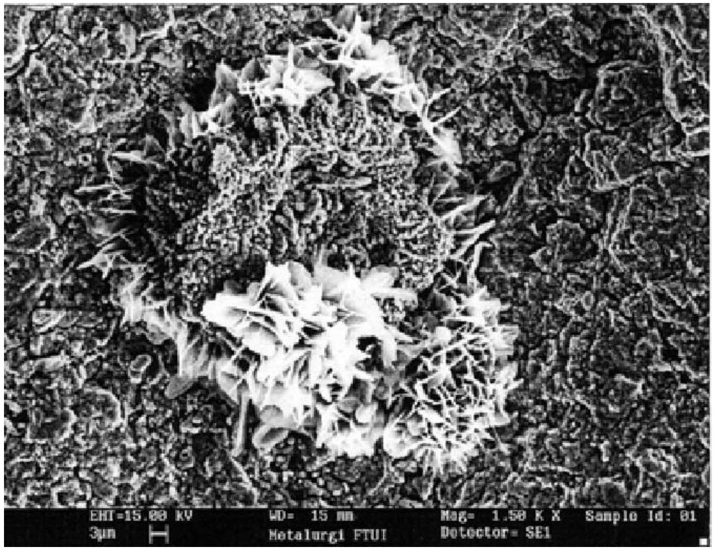


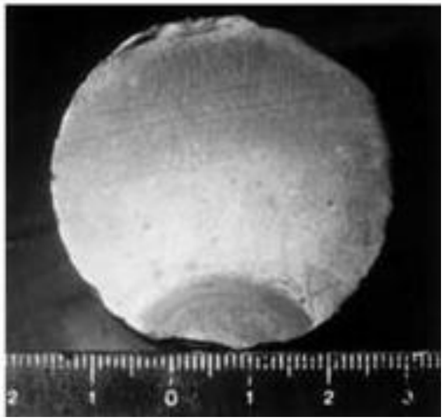
Rockwell Hardness Method

SCANNING ELECTRON MICROSCOPY (SEM) EQUIPPED WITH EDS (ENERGY DISPERSIVE SPECTROSCOPY)









SEM fractrograph and EDS spectrum of elements obtained from an area close to the corrosion fatigue crack origin of a broken cylinder head bolt of a diesel power generating unit.

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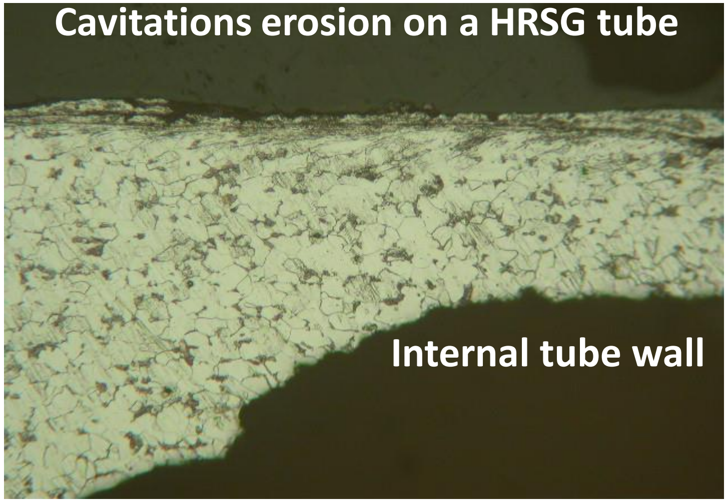
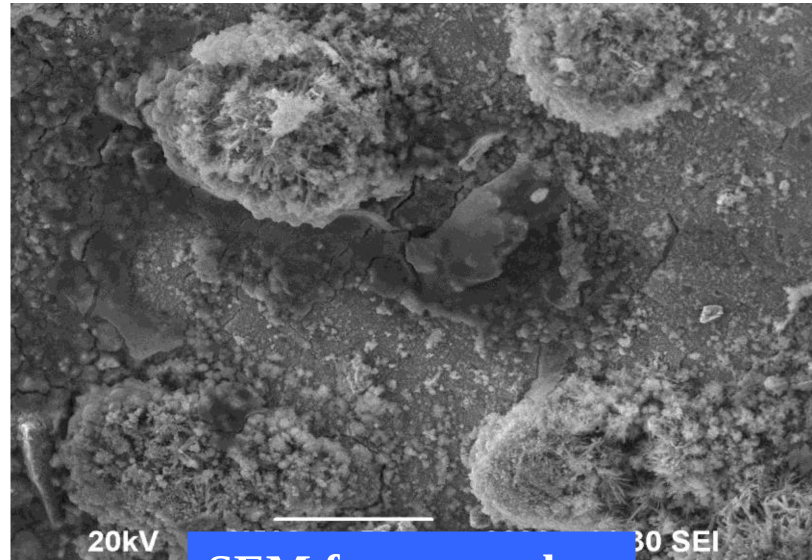
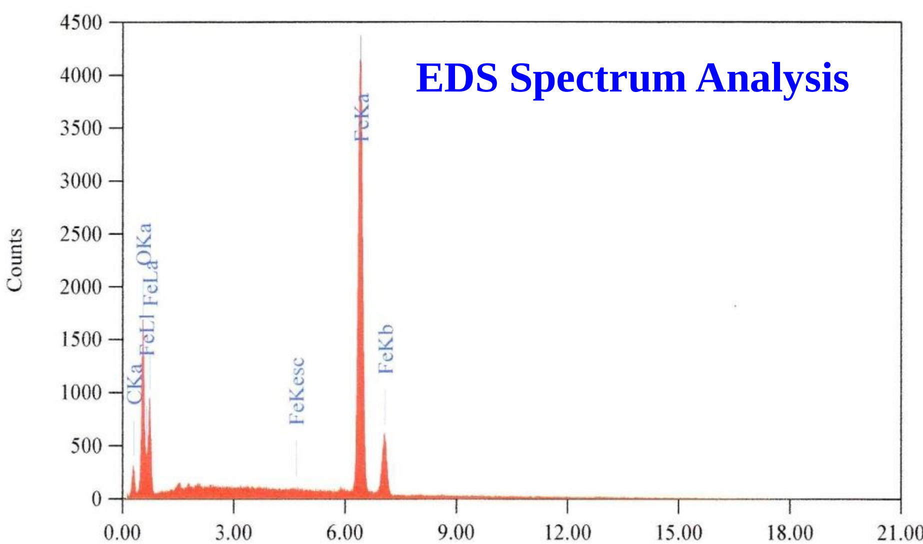
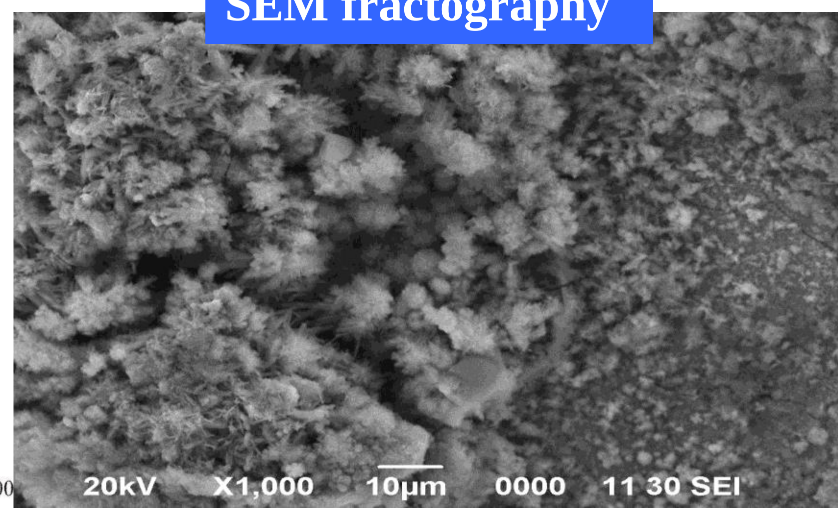
MICROFRACTOGRAPHIC EXAMINATION



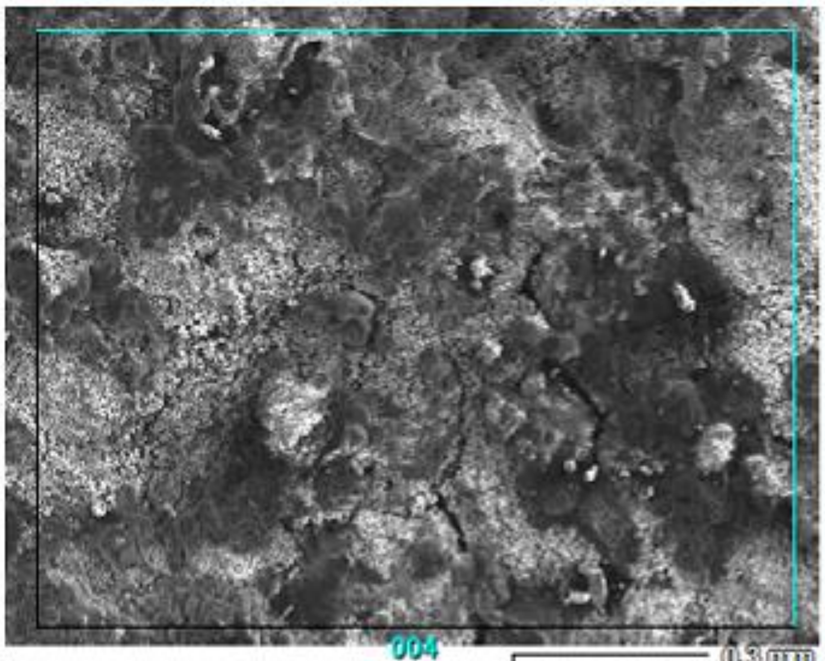


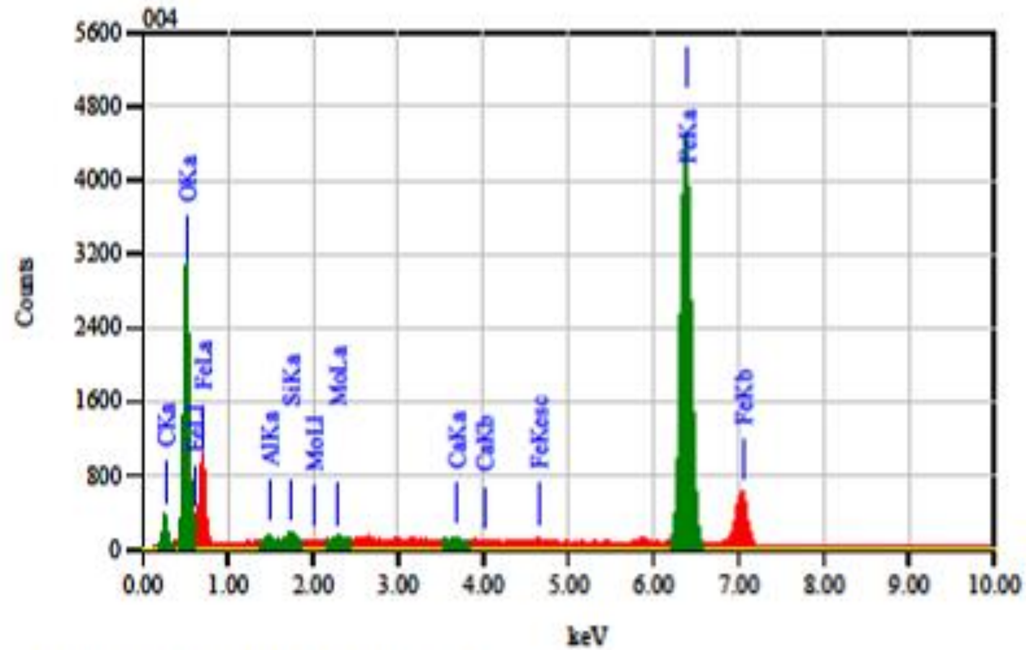
SEM fractography





EDS Spectrum Analysis on Boiler Tube Deposits





ZAF Method Standardless Quantitative Analysis
Fitting Coefficient : 0.2890

Element	(keV)	Mass%	Error%	Atom%	Compound	Mass%	Cation	K
C K	0.277	6.59	0.17	16.13				1.5619
O K	0.525	26.22	0.19	48.17				32.4855
Al K	1.486	0.37	0.24	0.40				0.1711
Si K	1.739	0.34	0.21	0.36				0.2109
Ca K	3.690	0.14	0.21	0.10				0.1659
Fe K	6.398	65.94	0.46	34.71				65.1001
Mo L	2.293	0.40	0.44	0.12				0.3047
Total		100.00		100.00				

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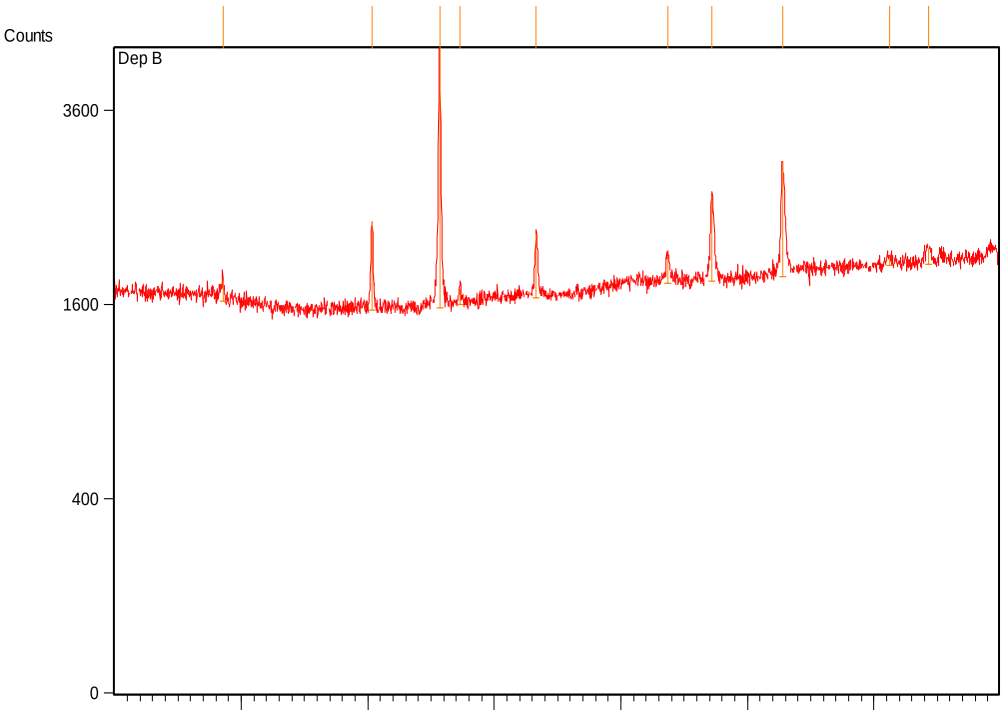
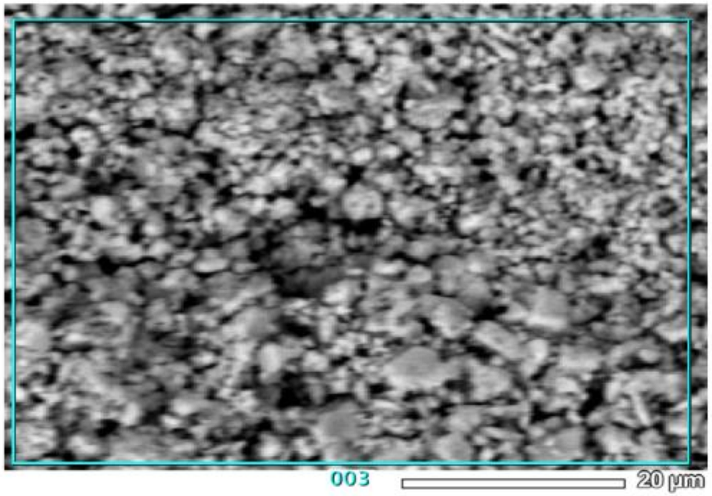
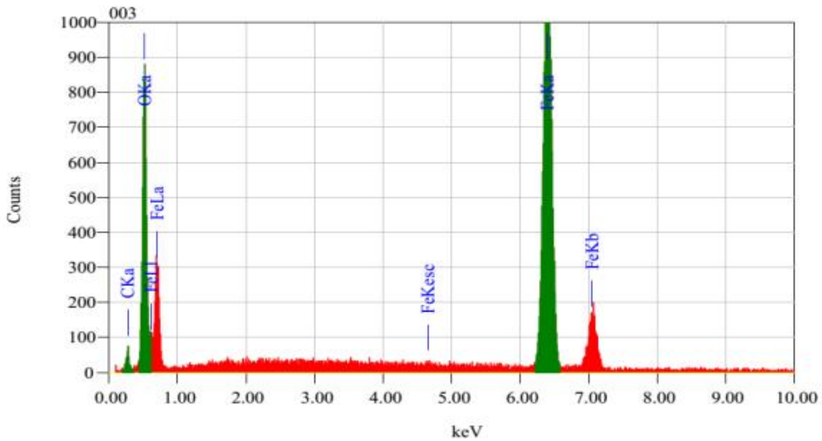
SCALE/DEPOSIT CHARACTERIZATION AND ANALYSIS BY XRD (X-RAY DIFFRACTION) AND EDS (ENERGY DISPERSIVE SPECTROSCOPY)

SCALE/DEPOSIT CHARACTERIZATION AND ANALYSIS BY XRD (X-RAY DIFFRACTION) AND EDS (ENERGY DISPERSIVE SPECTROSCOPY)







ZAF Method Standardless Quantitative Analysis
Fitting Coefficient : 0.1658

Element	(keV)	Mass%	Error%	Atom%	Compound	Mass%	Cation	K
C K	0.277	4.33	0.06	11.32				0.9845
O K	0.525	24.92	0.06	48.90				31.7810
Fe K	6.398	70.76	0.17	39.78				67.2345
Total		100.00		100.00				

ROOT CAUSE FAILURE ANALYSIS ON FRACTURED GAS TURBINE BUCKET

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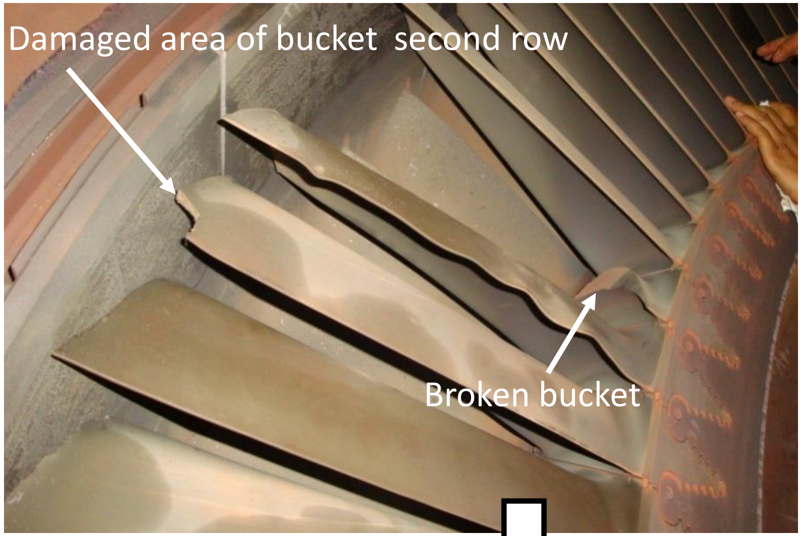
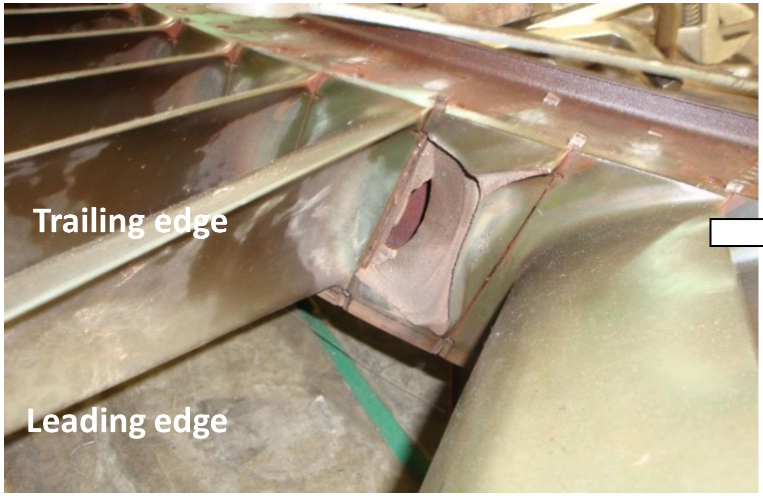


ROOT CAUSE FAILURE ANALYSIS ON FRACTURED GAS TURBINE BUCKET (continued)



Fatigue Fracture Surface

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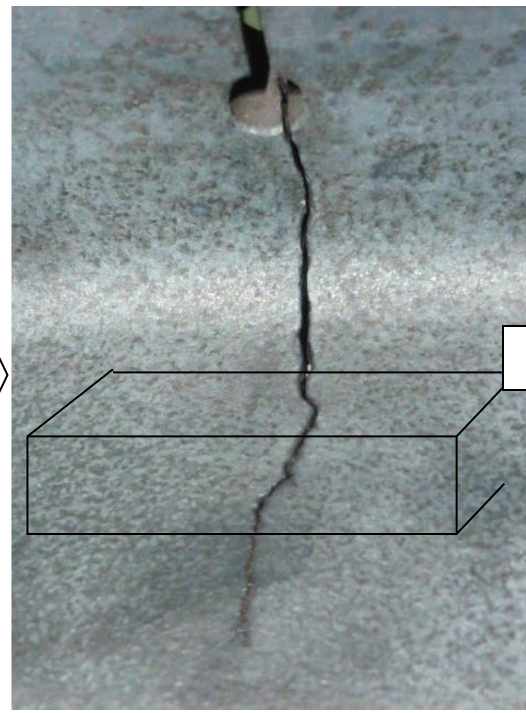
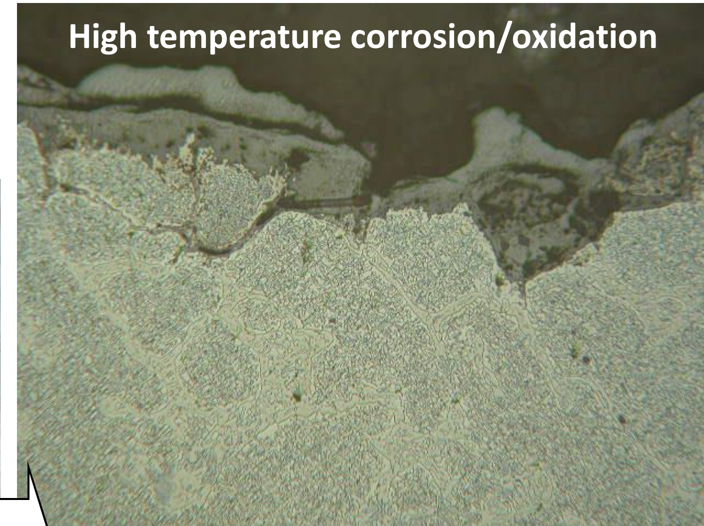
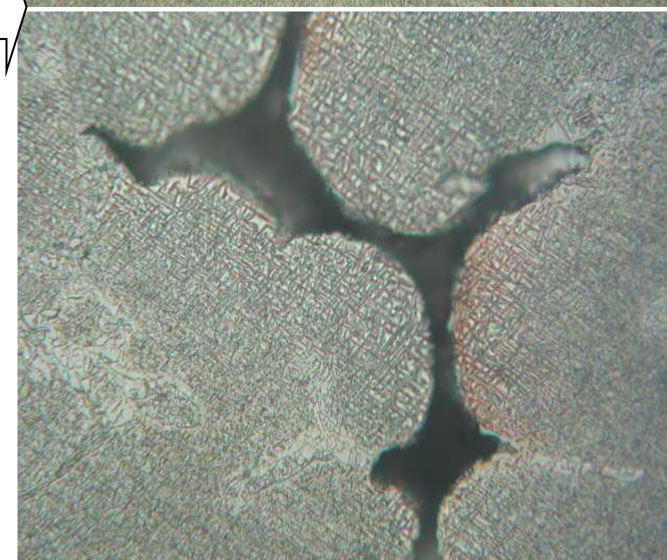
ROOT CAUSE FAILURE ANALYSIS ON CRACKED GAS TURBINE SHROUD

Thermal fatigue crack and overheating







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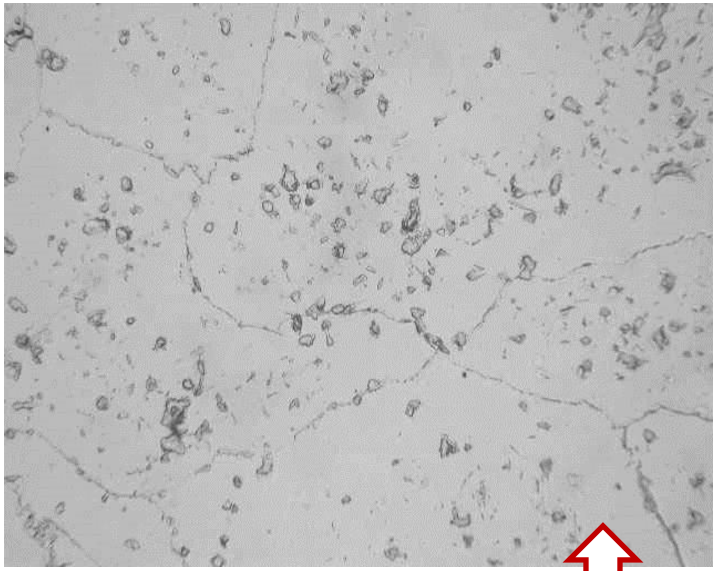
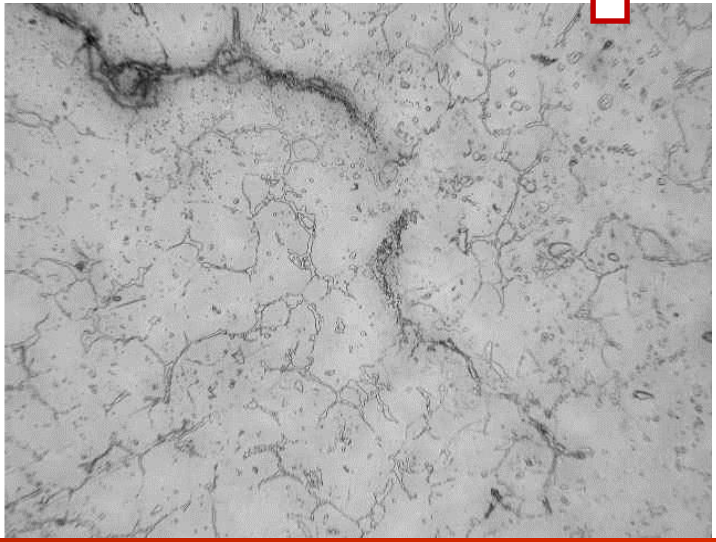
ROOT CAUSE FAILURE ANALYSIS ON CRACKED GAS TURBINE NOZZLES





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ROOT CAUSE FAILURE ANALYSIS ON DAMAGED GAS TURBINE ACCESSORY GEAR

Fatigue Fracture Surface

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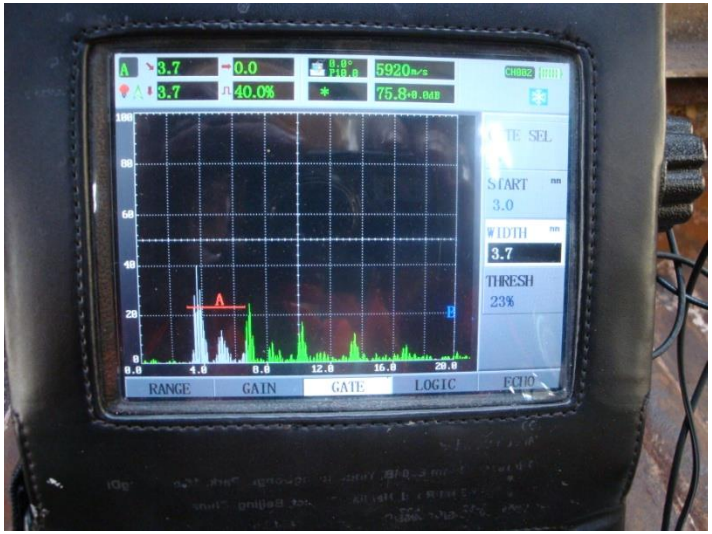
DYE-PENETRANT TEST, ULTRASONIC TESTING AND MAGNETIC PARTICLE INSPECTION ON CRACKED EVAPORATOR BOILER TUBES



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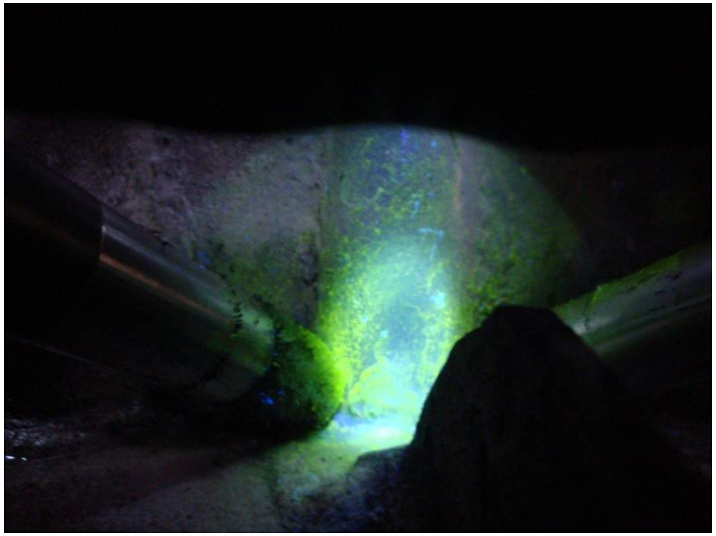
DYE-PENETRANT TEST, ULTRASONIC TESTING AND MAGNETIC PARTICLE INSPECTION ON CRACKED EVAPORATOR BOILER TUBES



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FACTORS AFFECTING COMPONENT LIFE

A. Factors that are time independent

- Design
- Material
- Manufacture

B. Factors that are time dependent

- Creep
- Fatigue (HCF & LCF)
- Creep-Fatigue Interaction
- Thermal Aging (Softening or Embrittlement)
- Corrosion
- Wear & Erosion

- Loading and Operating Condition
- Operating Hours
- Number and Type of Start-Stop
- Maintenance Condition

II. CONDITION AND REMAINING LIFE ASSESSMENT (RLA)

CONDITION ASSESSMENT

Aging Equipment

Newly in Service Equipment

- **Availability & Reliability**
- **Life Extension**
- **Re-Engineering**

On-going task that should be performed periodically and not a one-time activity

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OBJECTIVE

- To determine and evaluate the current condition and degree of any damage that may have occurred on the component / equipment from the previous operation.
- To plan and execute the appropriate test and inspection methods on plant equipment based on the risk assessment.
- To analyze of all test and inspection results and evidence obtained and evaluate the remaining useful life of the equipment that could maintain its mechanical integrity and provide reliable and safe operation.
- To provide planning for maintenance strategy and other risk mitigation activities that may be required based on the recommendations as whether the equipment may still be serviceable, repairable or even subjected to possible replacement.

DESIGN LIFE OF COMPONENT

- **T operating < T creep**

  (Deformation & fracture: time independent)

  Design approach:

  - Yield Strength
  - Tensile Strength
  - Fatigue Strength

  By introducing safety factor ,

  Undamaged criteria: Applied stress < Design stress

  (but many factors may reduce the useful life)

- **T operating ≥ T creep**

  (Deformation & fracture: time dependent)

  Damage or rupture criteria : design life is made based on the allowable creep strain (e.g: 10^5 hrs)

  (but many factors may increase or reduce the useful life).

THRESHOLD TEMPERATURES FOR CREEP

Material	Threshold Temperature
Carbon Steel	700 ºF (370ºC)
C-1/2 Mo	750 ºF (400ºC)
1 1/4Cr-1/2Mo	800 ºF (425ºC)
2 1/4Cr-1Mo	800 ºF (425ºC)
5Cr-1/2Mo	800 ºF (425ºC)
9Cr-1Mo	800 ºF (425ºC)
304H SS	900 ºF (480ºC)
347H SS	1000 ºF (540ºC)

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Favorable and adverse factors affecting the useful life of components

ACTUAL LIFE

Life extension ↑

- Use of minimum properties in design
- Factor of safety in design
- Conservative operation of unit
- Inaccuracies in data extrapolation
- Overestimation of oxidation effects

DESIGN LIFE

Forced outage or premature retirement ↓

- Unanticipated stresses – e.g., residual, systems stresses
- Operation outside design limits – e.g., excessive temperatures, load cycling of base load units
- Operation and Environmental effects
- Degradation of material properties in service – e.g., temper embrittlement, softening

ACTUAL LIFE

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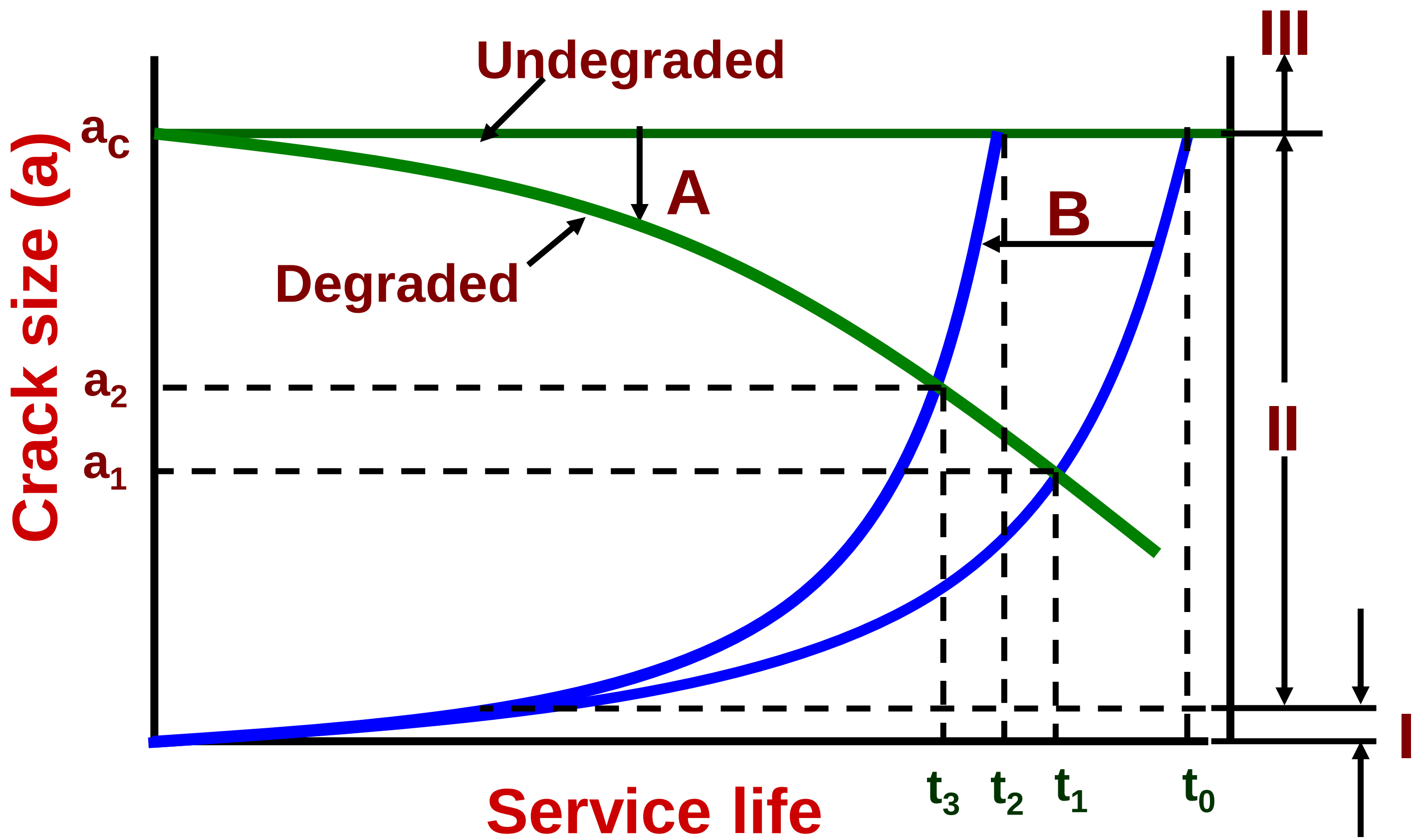
Illustration of remaining-life assessment procedure for a common failure scenario involving crack initiation and propagation, and final fracture



A-*embrittlement phenomena.* **B**-*unanticipated factors (excess cycling, temperature excursions, corrosion, metallurgical degradation, improper material, excessive stresses)*

Note:

a_c: critical crack length

Stage I : incipient failure (crack initiation)

Stage II : crack propagation

Stage III : final / fast fracture

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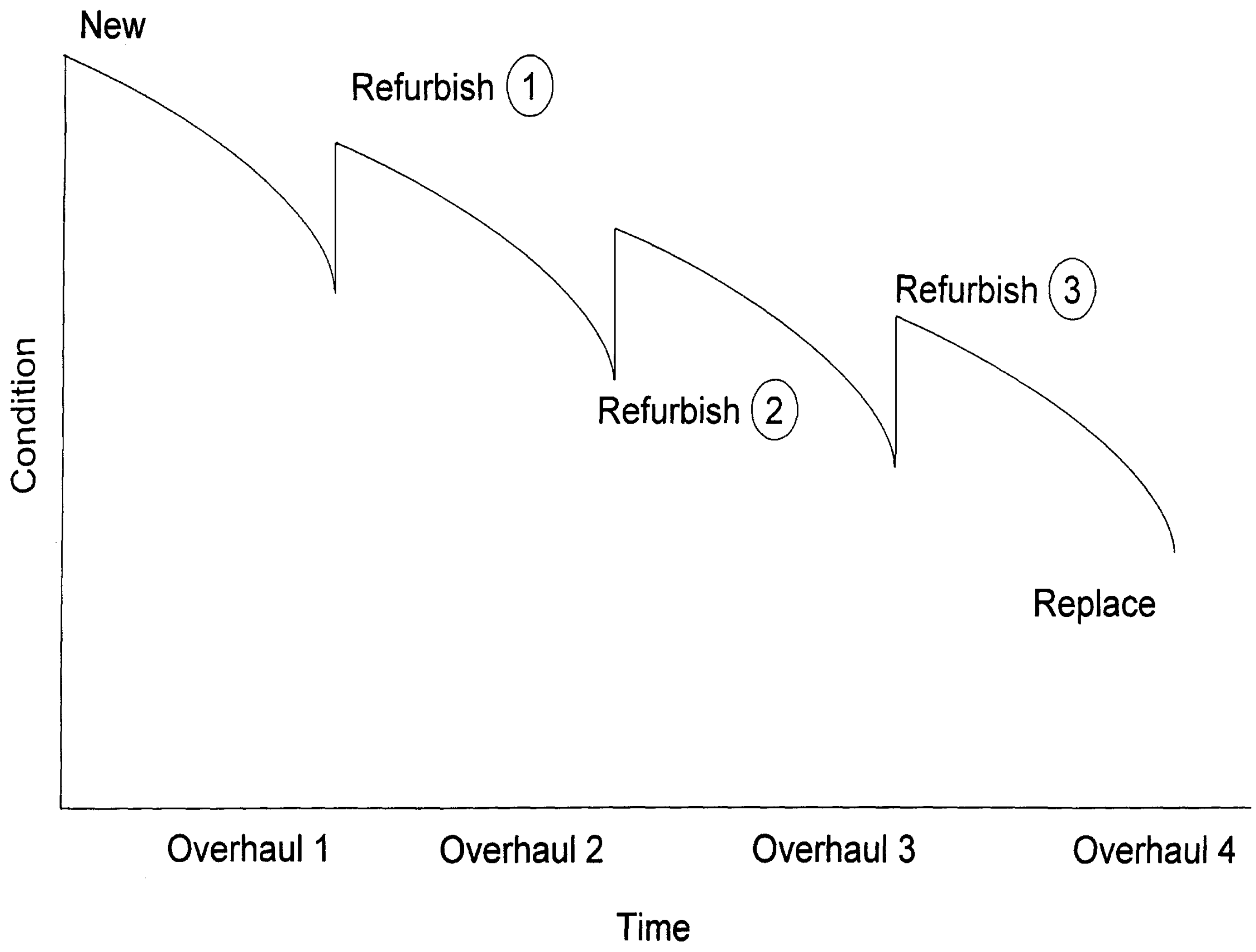
COMPONENT DEGRADATION TRENDS



PROCEDURAL ROUTE OF RLA

IDENTIFY CRITICAL COMPONENTS

↓

DEFINE LIFE-LIMITING FACTORS

↓

FORMULATE “ON-LINE” OR “OFF-LOAD” ASSESSMENT METHODOLOGY

↓

RECOMMENDED RETIREMENT, REPAIR OR INSPECTION STRATEGY

Implementation of RLA Procedures

Level I : assessments are performed using plant records, design stresses and temperatures, and minimum values of material properties from the literature/standard.

Level II : involves actual measurement of dimension and temperatures, simplified stress calculation, and inspection, coupled with the use of the minimum material properties from the literature/standard.

Level III : involves in-depth inspection, stress analysis, plant monitoring, and generation of actual material data from samples removed from the component.

(The level of detail and accuracy of the results increase from level I to level III, but at the same time the cost of life assessment also increases)

DAMAGE AND LIFE ASSESSMENT OF COMPONENTS

CONDITION ASSESSMENT

OPERATING EXPERIENCE

FAILURE ANALYSIS

→ IDENTIFICATION OF CRITICAL / VITAL COMPONENTS (with finite lives)

↓

TESTING & DATA COMPILATION

- Non-Destructive tests
- Metallographic replication
- Strain/stress measurement
- Temperature measurement
- Destructive test (tube samples or boat samples
- Etc.

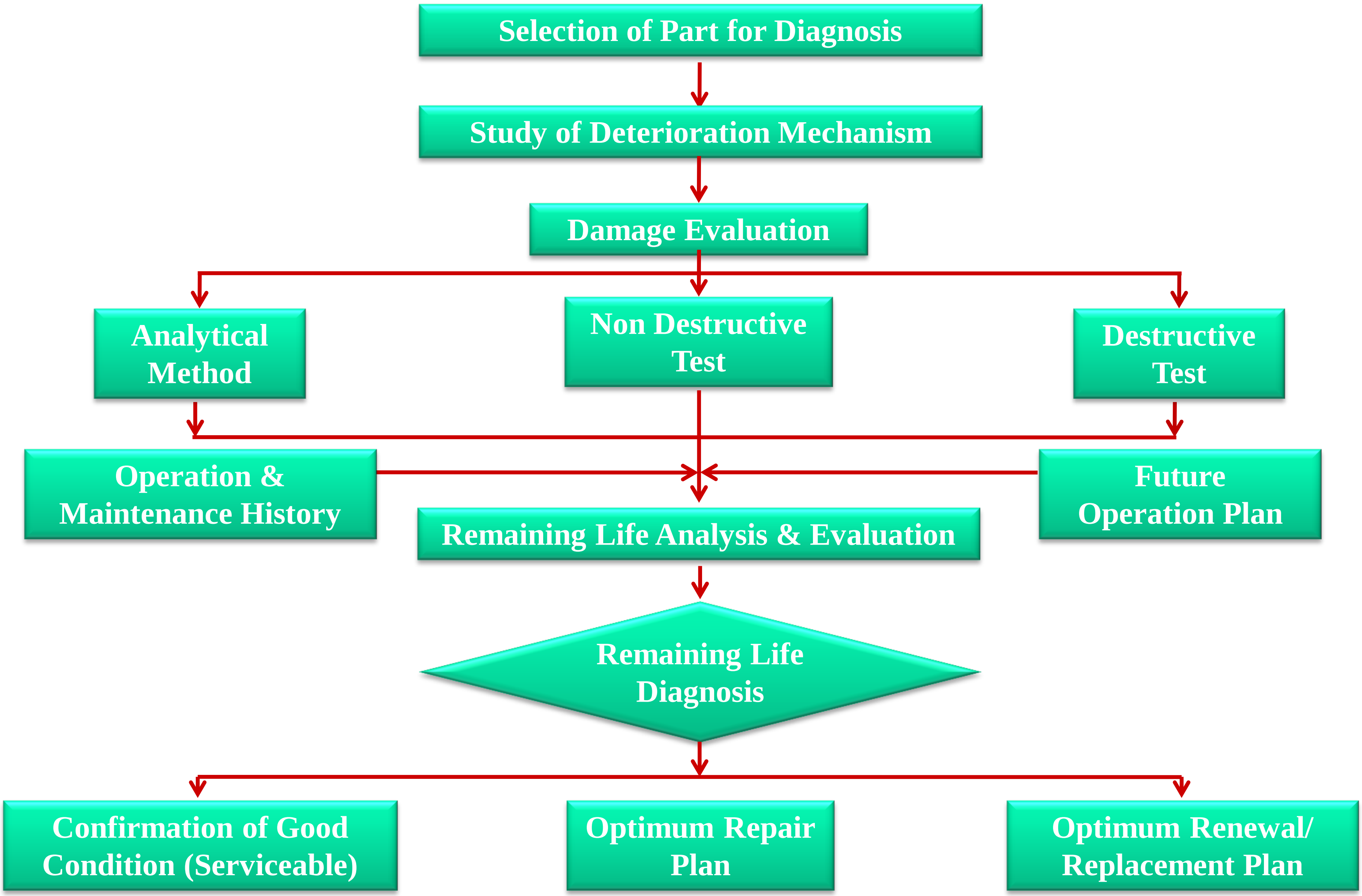
↓

ANALYSIS TECHNIQUES

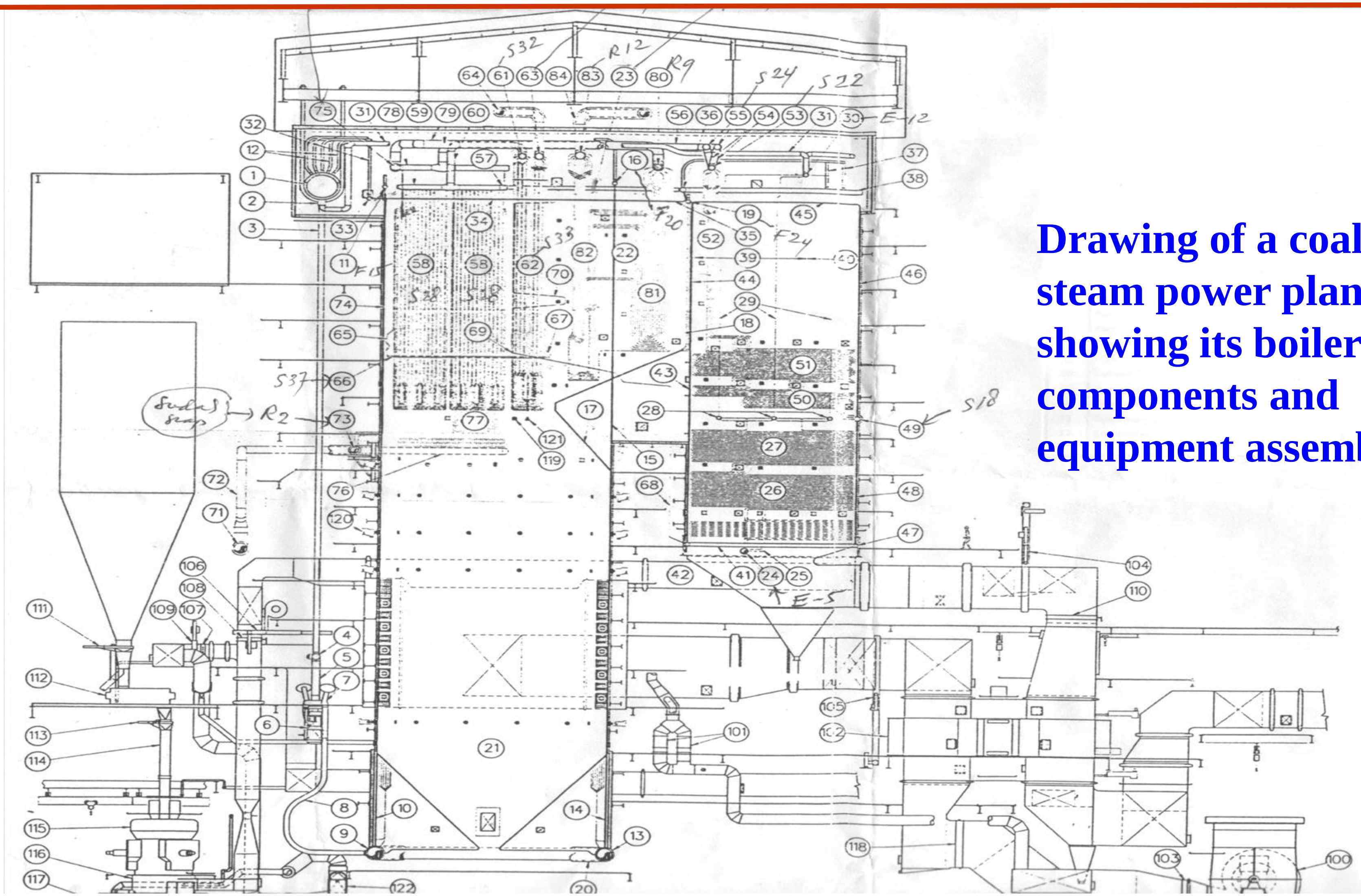
↓

REPAIR, REPLACE, OR RE-INSPECT

RLA METHODOLOGY



BOILER CONDITION ASSESSMENT



Drawing of a coal-fired steam power plant showing its boiler components and equipment assemblies .

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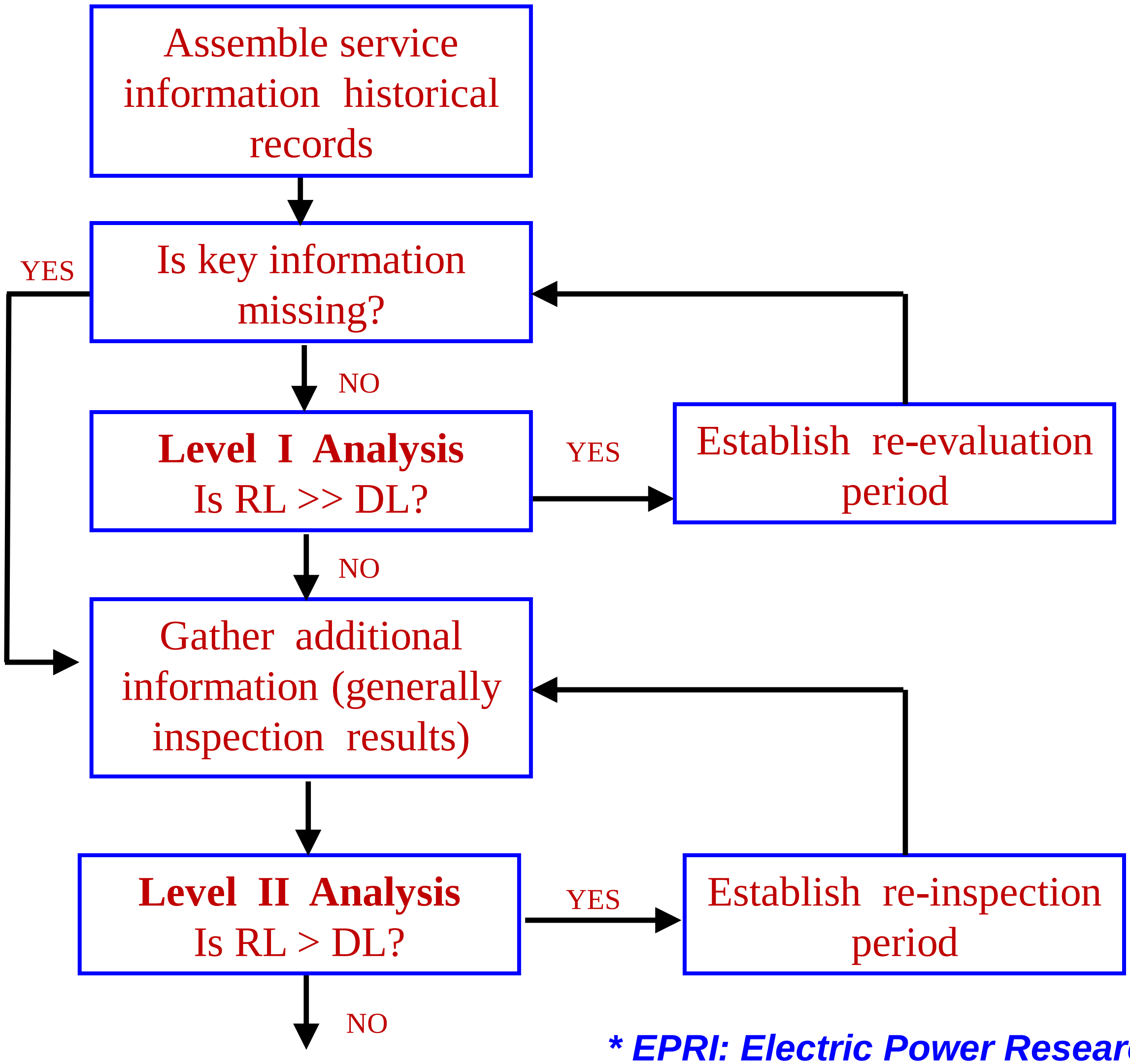
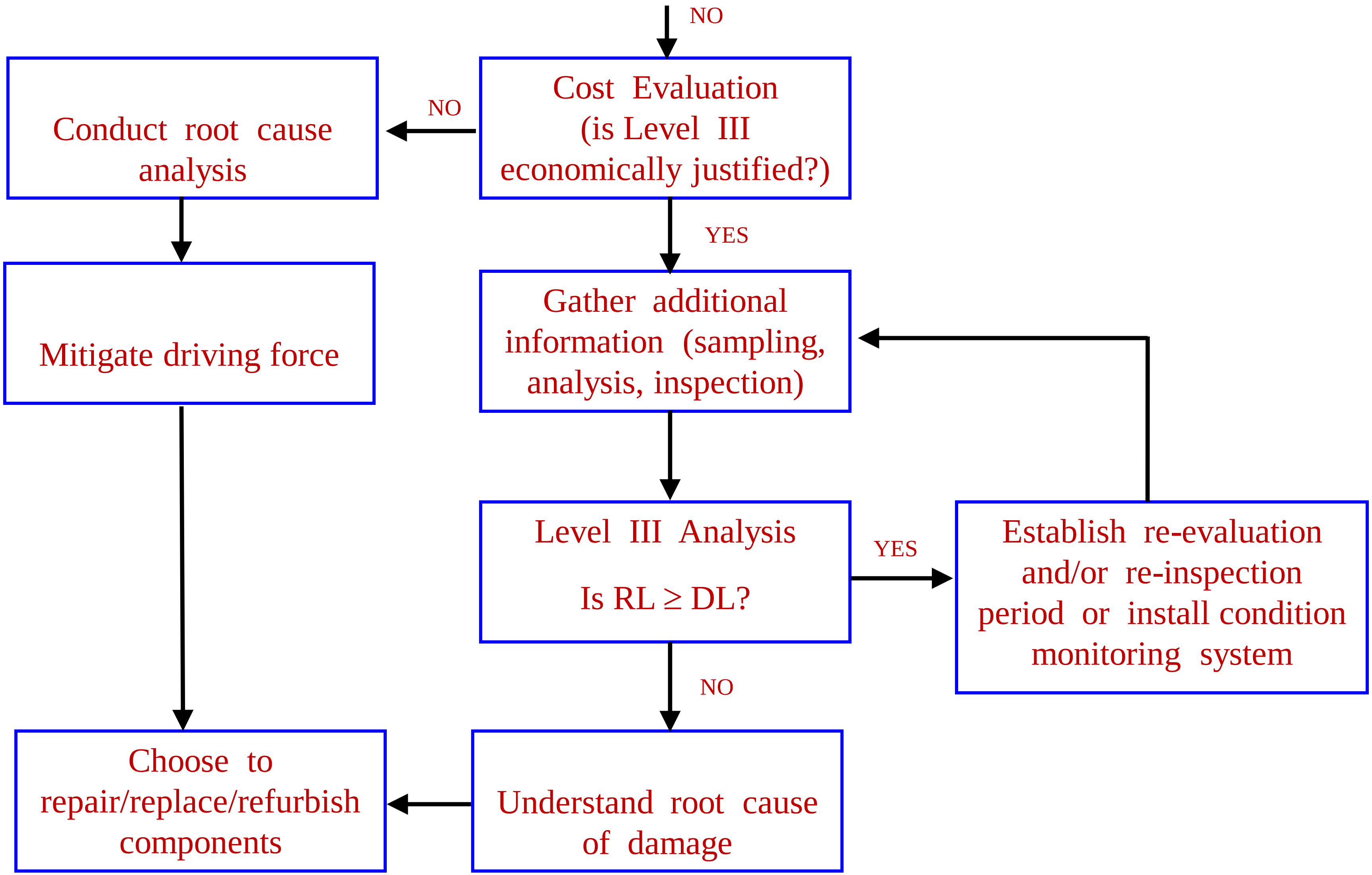
General Procedure for Boiler Component Life Assessment (according to EPRI*)



**** EPRI: Electric Power Research Institute (USA)***

General Procedure for Boiler Component Life Assessment (according to EPRI), continued



Key Boiler Components and Applicable Classes of Damage (according to EPRI)

Component	Damage Mechanism					
	Creep	Fatigue	Corro-sion	Internal Erosion/ FAC	External Erosion/ Corr'n	Thermal/ Mech'l Deform'n
Waterwall Tubing	x	x	x	x	x	x
Superheater (SH) and Reheater (RH) Tubing	x	x	x		x	x
Economizer Tubing		x	x	x	x	x
Superheater Headers	x	x	x			x
Reheater Headers	x	x	x			x
Steam and Lower Drums		x	x	x		x
Waterwall Headers		x	x	x		x
Downcomers		x	x	x		x

Key Boiler Components and Applicable Classes of Damage (according to EPRI), continued

Component	Damaged Mechanism					
	Creep	Fatigue	Corro-sion	Internal Erosion/ FAC	External Erosion/ Corr'n	Thermal/ Mech'l Deform'n
Economizer Inlet Headers		x	x	x		x
Main Steam Piping	x	x				x
Hot Reheat Piping	x	x				x
Superheater Crossover Piping		x	x			x
Cold Reheat Piping		x	x	x		x
Attemperators	x	x	x	x		x
Valves		x	x	x		x
Deaerators		x	x	x		x
Feedwater Heaters		x	x	x		x
Blowdown Vessels		x	x	x		

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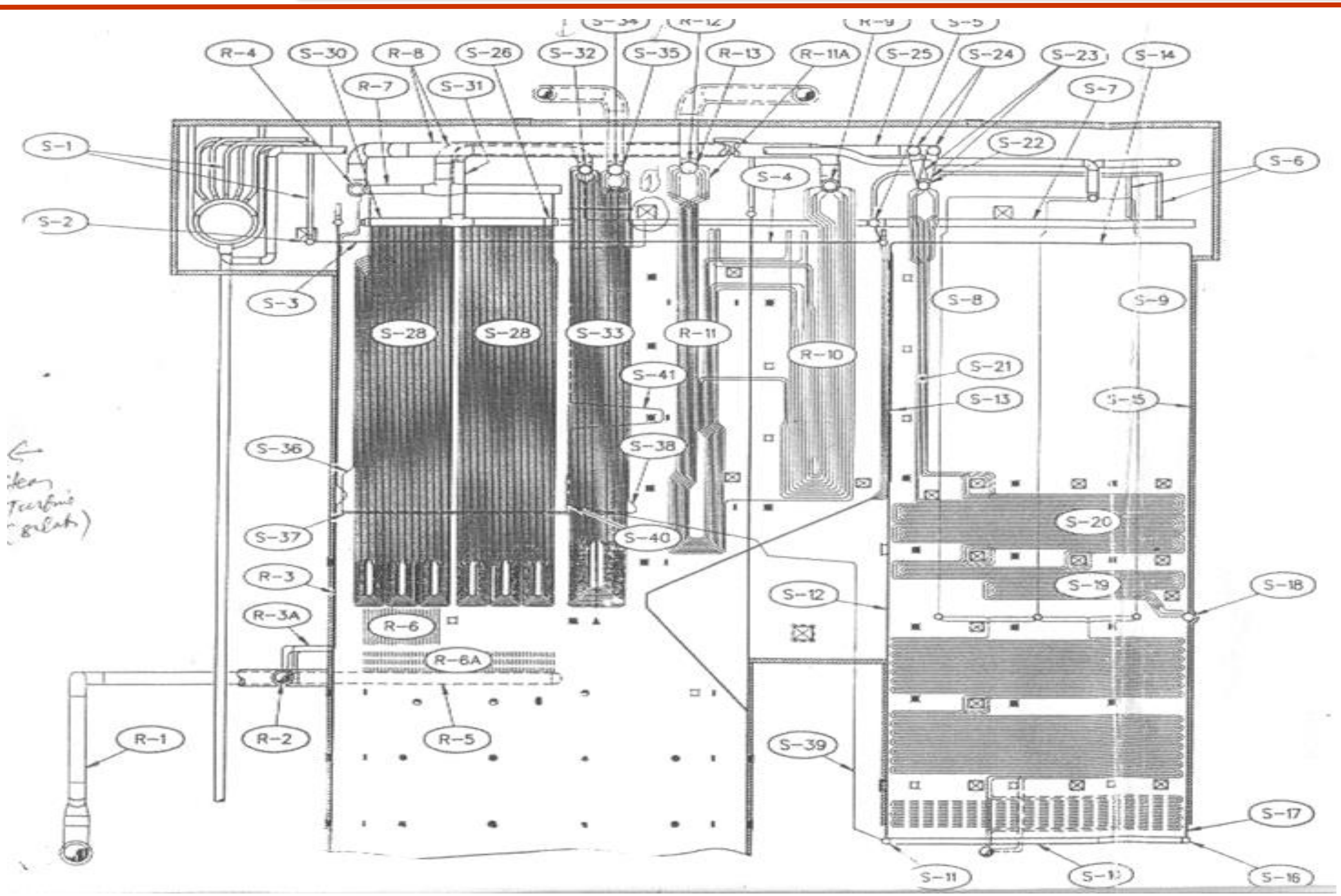
REHEATER AND SUPERHEATER BOILER TUBES CONDITION ASSESSMENT



Headers and tube assemblies of reheater and superheater of a coal-fired steam power plant

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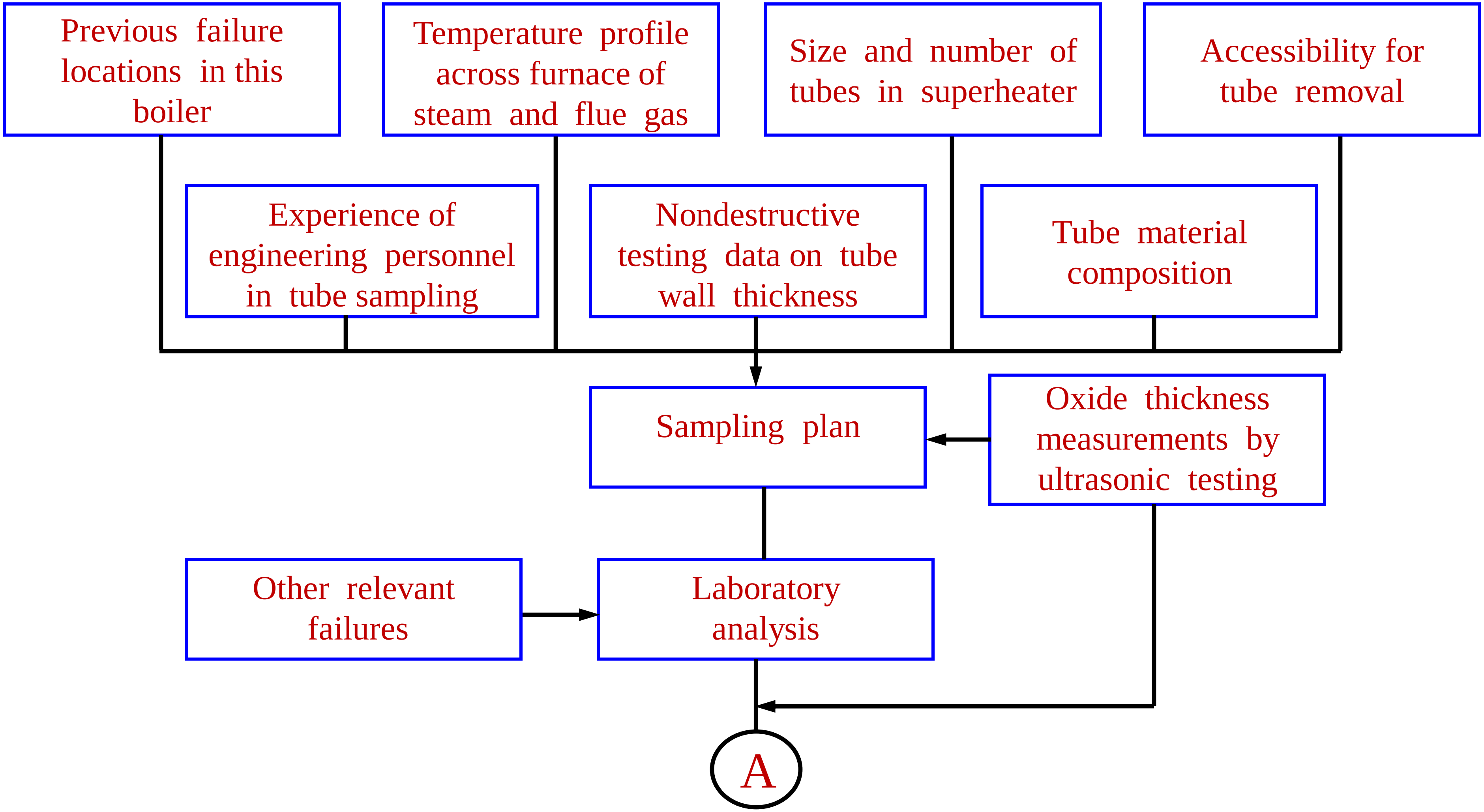
Strategic approach flow diagram for general tube sampling and life-assessment plan for superheater and reheater boiler tubes (according to EPRI)



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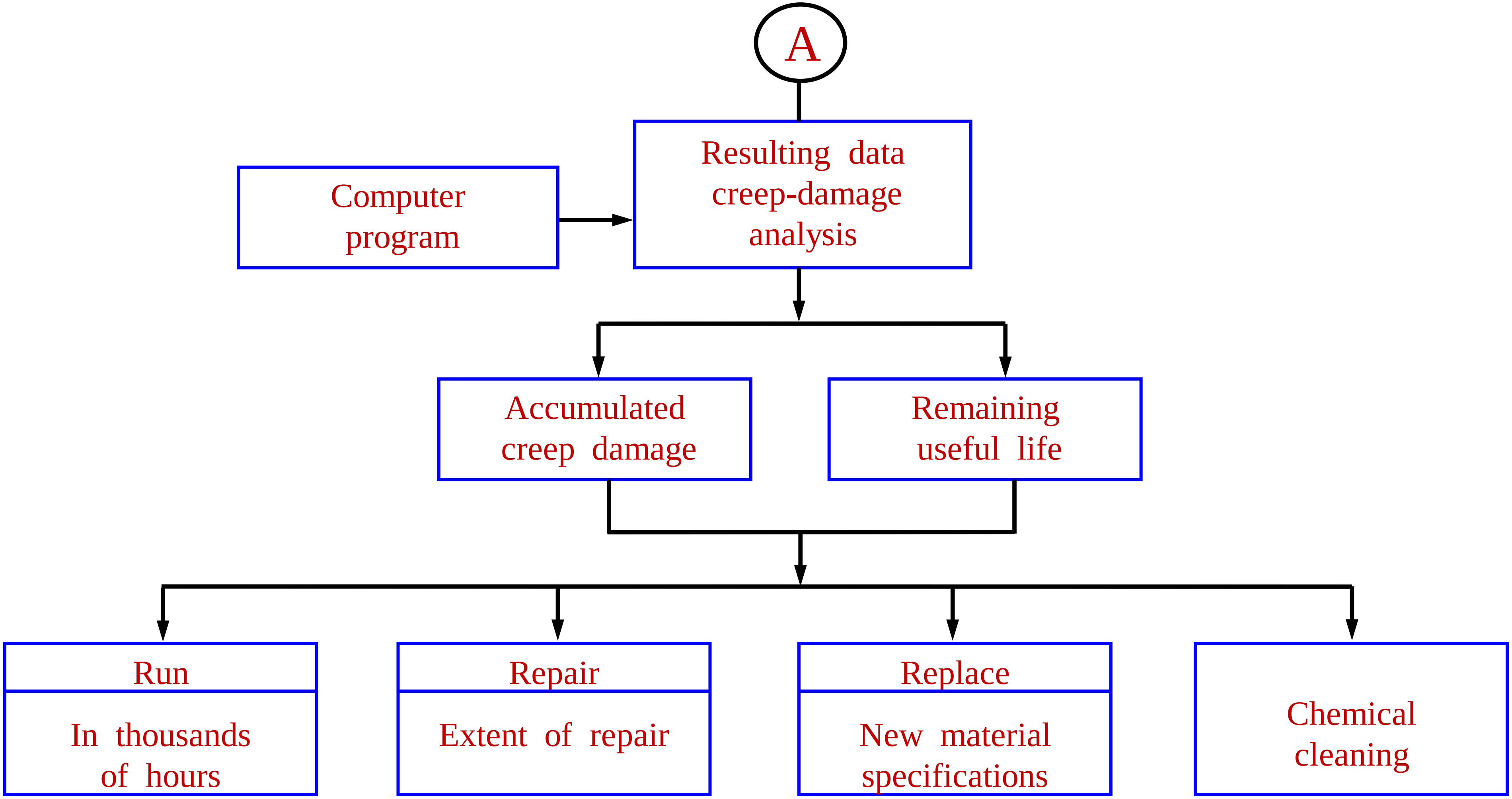
Strategic approach flow diagram for general tube sampling and life-assessment plan for superheater and reheater boiler tubes (according to EPRI), continued



METHODOLOGY AND SCOPE OF WORK

- Data collection and requirements (design & dimension including P&ID, PFD, drawing, etc), material specification, process data/operation condition / operational history, maintenance history, inspection records and failure data/failure investigation report, management of change records, etc.
- Preliminary examination on-site (visual tests and record keeping)
- Identifying deterioration mechanisms and failure modes that may have occurred on the component /equipment.

II. REMAINING LIFE ASSESSMENT (RLA) METHODOLOGY AND SCOPE OF WORK, continued

- Selection of test spot on-site as representative of the component/equipment (based on criticality and anomalies such as deformation/distortion/bulging, texture change due to oxidation/hot spot, corrosion (deposit/scale formation or pitting), surface damage (erosion, abrasion, fretting), crack, etc.
- Collection of some deposit/scale or corrosion by-product from the component external surface.
- Non-destructive inspection/examination on-site (if required, such as: PT, MPI, UT, RT, ECT, Borescope Inspection, Leak/Hydrostatic Testing, etc).

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II. REMAINING LIFE ASSESSMENT (RLA) METHODOLOGY AND SCOPE OF WORK, continued

- Dimension measurement (diameter, thickness, diametral strain due to ovality change, etc)
- Positive material identification by portable chemical analyzer (if required).
- In-situ metallographic examination by replica technique.
- In-situ hardness test using a portable hardness tester.

II. REMAINING LIFE ASSESSMENT (RLA) METHODOLOGY AND SCOPE OF WORK, continued

- Destructive tests on post-service component in the laboratory (if required, such as: metallographic examination, hardness test, tensile test, Charpy V-notch test, accelerated creep rupture test to determine the Larson-Miller parameter, and SEM (scanning electron microscopy) on the fracture or damaged surface equipped with EDS analysis (energy dispersive spectrometer) on the deposit/scale obtained from the component.
- Other tests and measurements if required such as: stress measurement and analysis, corrosion test, vibration analysis, special test, etc.

II. REMAINING LIFE ASSESSMENT (RLA) METHODOLOGY AND SCOPE OF WORK, continued

- Assessment techniques and acceptance criteria based on standard and code such as: EPRI, ASME Boiler & PV Code, API 579-1/ASME FFS-1, API 530, etc for different damages or failure modes that may have occurred.
- Remaining life analysis and evaluation, formulation of conclusions and writing the report (including recommendations as whether the component is serviceable, repairable or even subjected to replacement), and remediation action required such as future maintenance & inspection strategy and other risk mitigation activities in order to extent the component/ equipment life with reliable and safe operation.

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II. REMAINING LIFE ASSESSMENT (RLA) BY WALL THICKNESS MEASUREMENT

From the ASME Boiler and Pressure Vessel Code Section I and II, the wall thickness formula for a tube under internal pressure is given as follows:

$$t = \frac{P\,.\,d}{2\,S + P} + 0.005d$$

where:

t : calculated minimum wall thickness

P : design pressure or maximum allowable working pressure

d : outside diameter of tube

S : maximum allowable stress at design temperature

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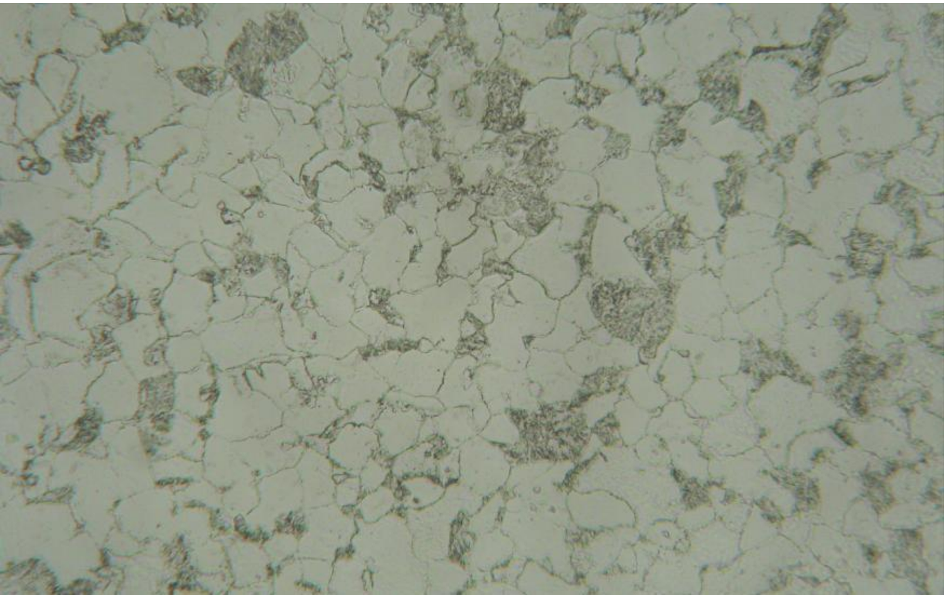
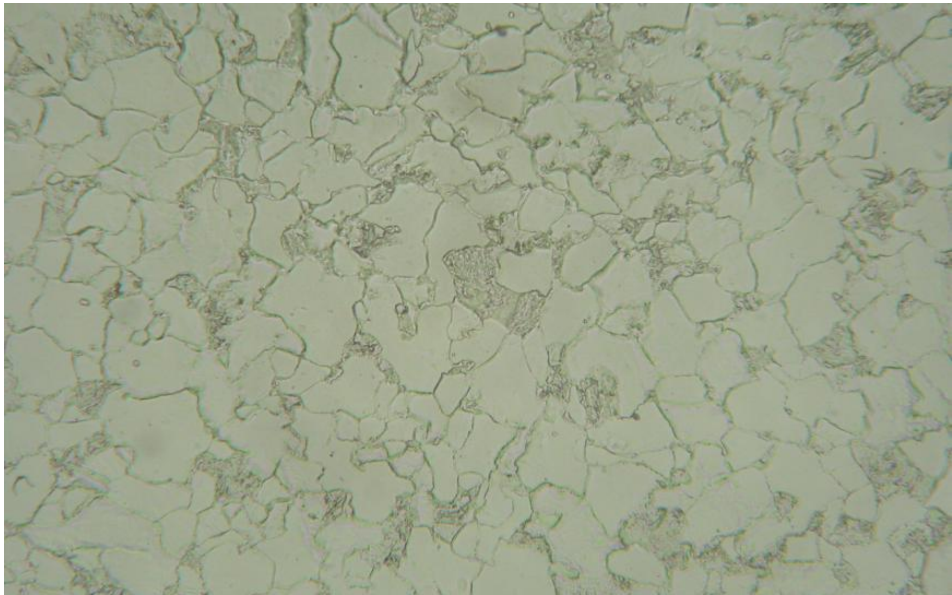
II. REMAINING LIFE ASSESSMENT (RLA) BY WALL THICKNESS MEASUREMENT

Wall thickness measurement on elbow main steam pipe using an ultrasonic thickness meter.

IN-SITU METALLOGRAPHY AND HARDNESS TEST ON SUPERHEATER OUTLET HEADER





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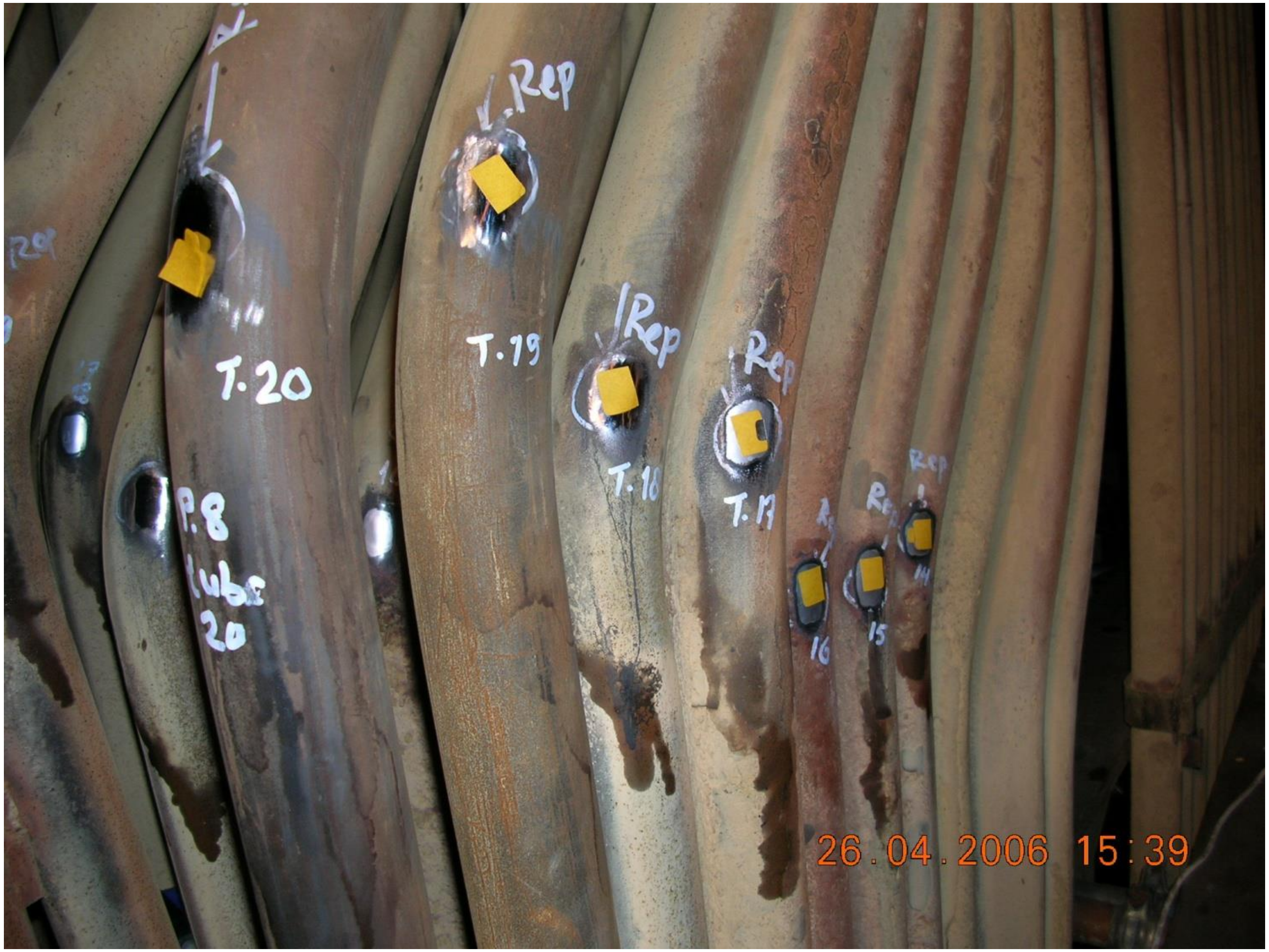
IN-SITU METALLOGRAPHY AND HARDNESS TEST ON BOILER TUBES PANEL

IN-SITU METALLOGRAPHY AND HARDNESS TEST ON REHEATER BOILER TUBES



Replication test performed on several reheater boiler tubes.

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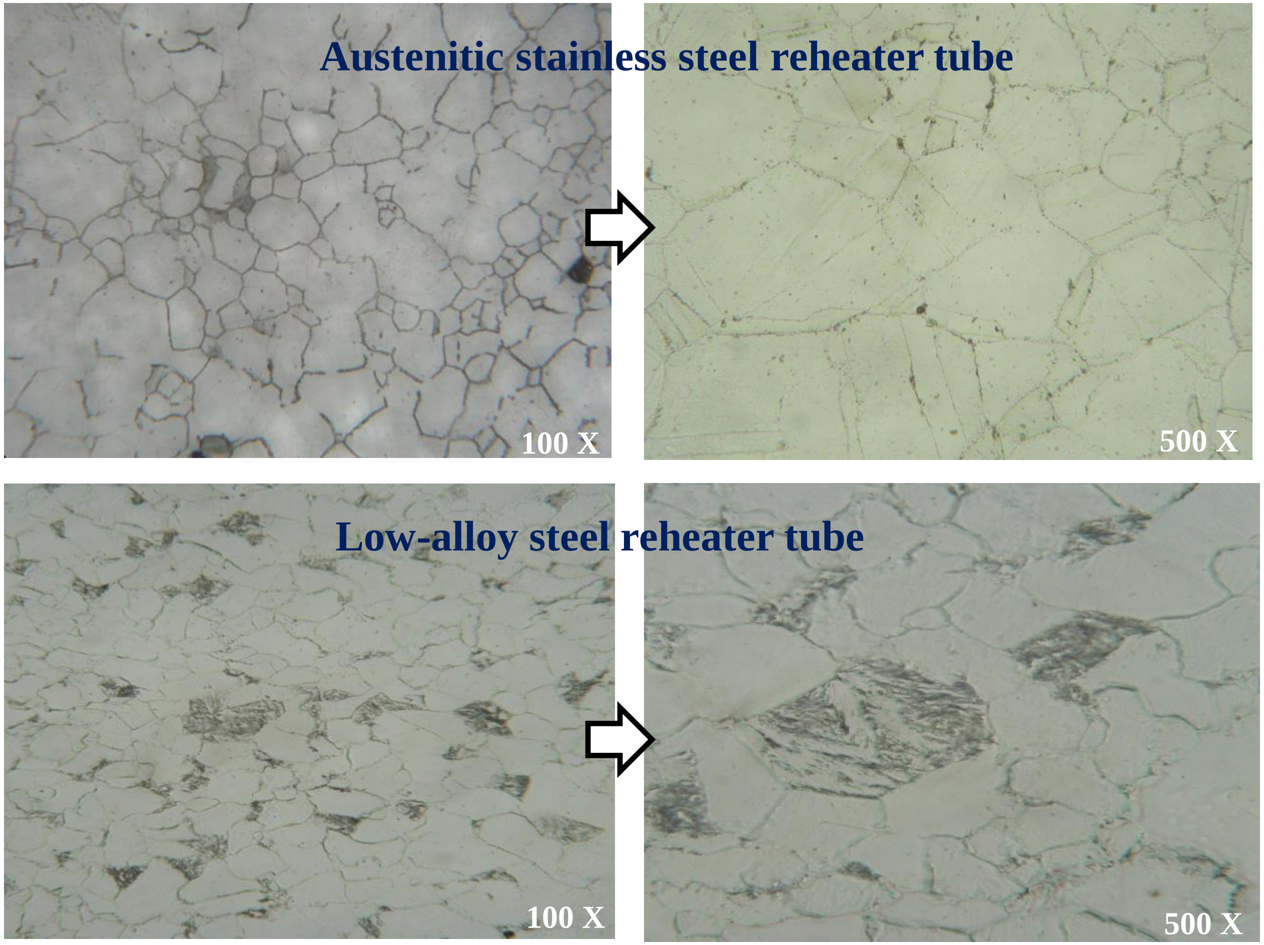
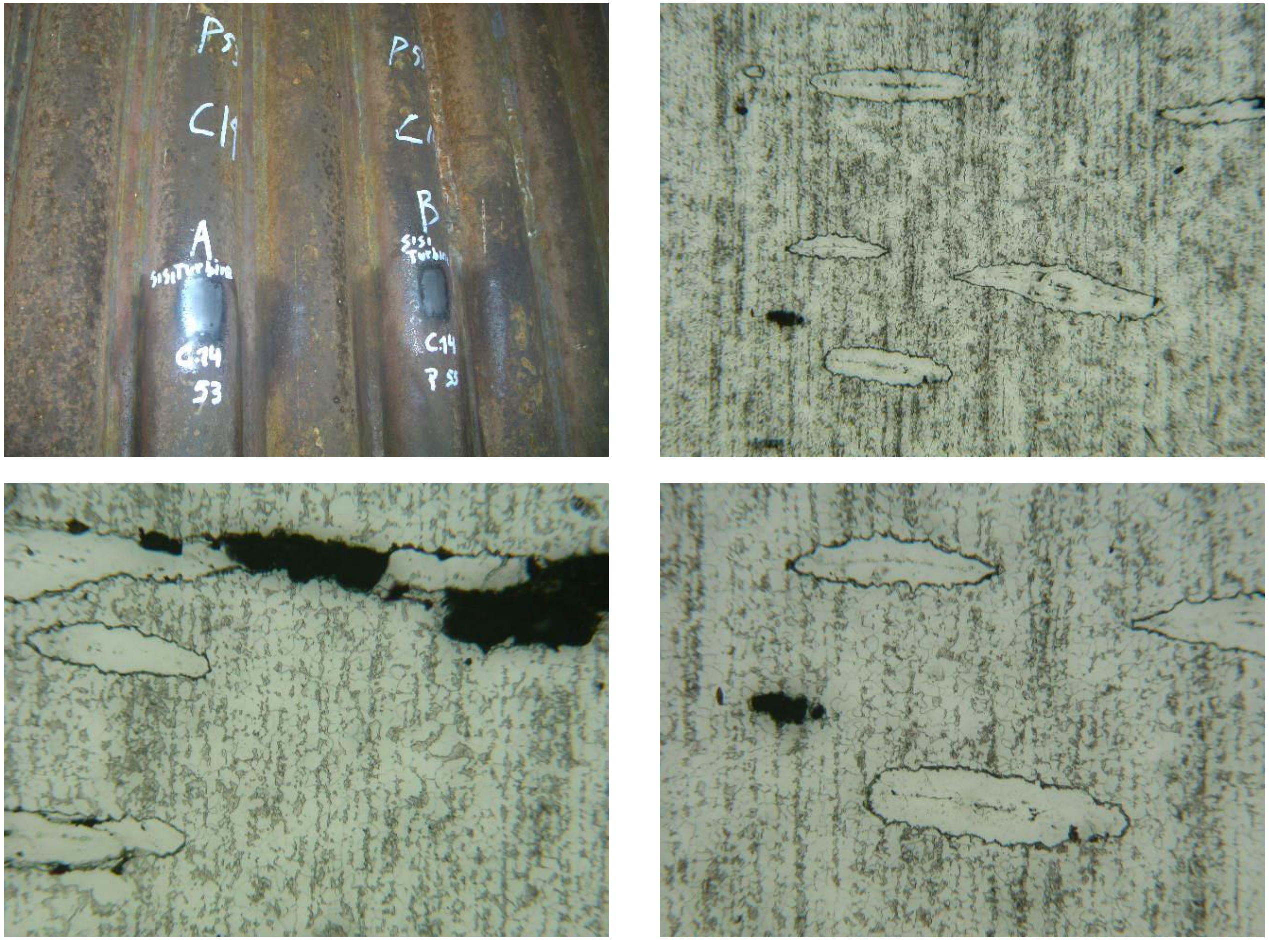
IN-SITU METALLOGRAPHY AND HARDNESS TEST



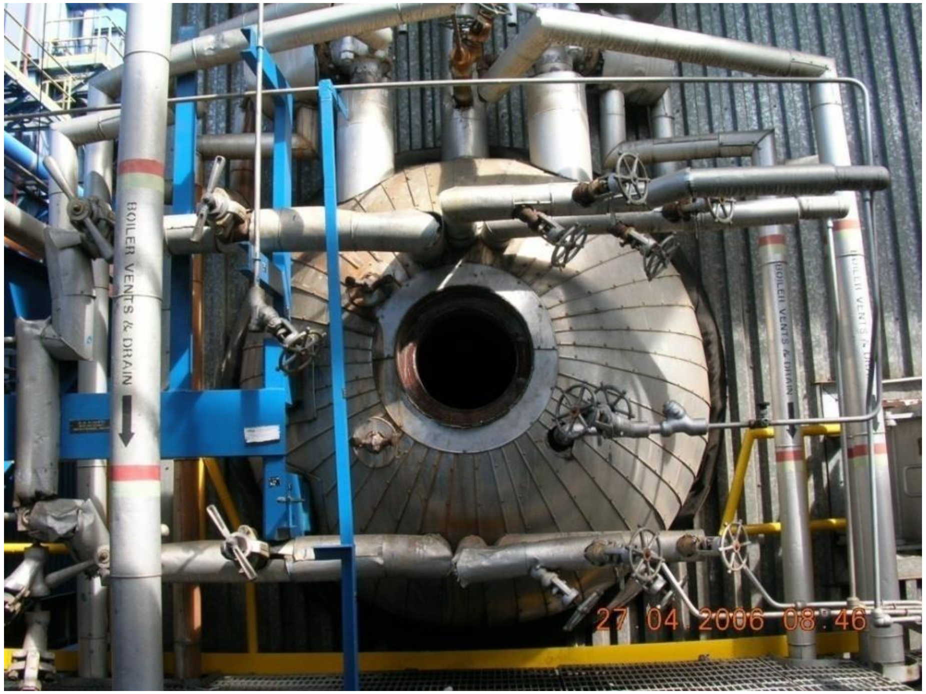
Microstructures obtained from in-situ metallographic examination on reheater tubes of a coal-fired steam power plant boiler

IN-SITU METALLOGRAPHY AND HARDNESS TEST

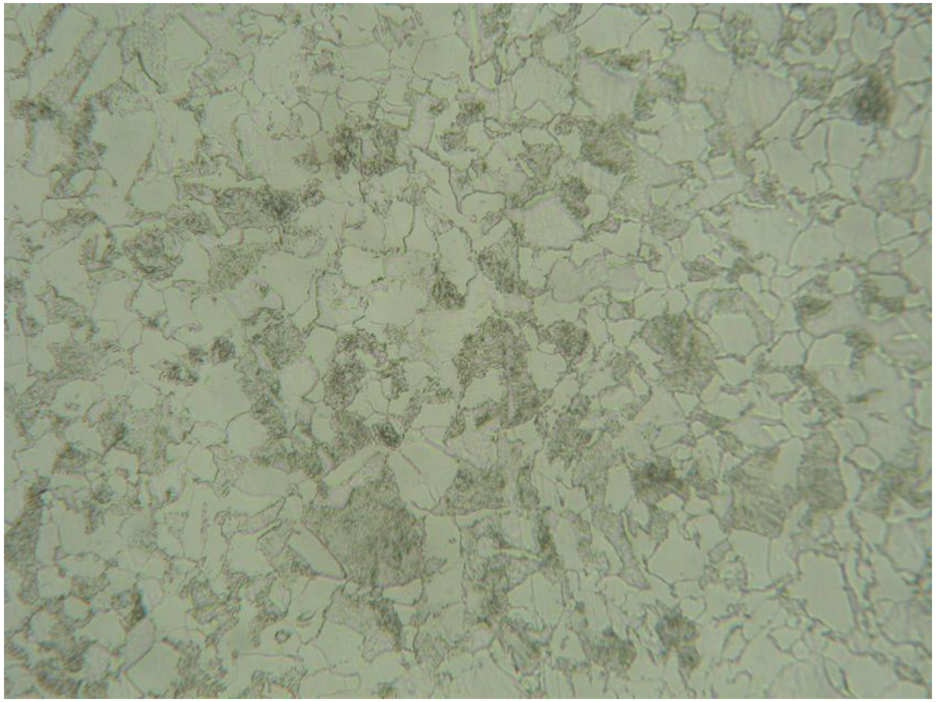


Microstructures obtained from in-situ metallographic examination on furnace front wall tube of a power plant boiler that had experienced corrosion fatigue

IN-SITU METALLOGRAPHY AND HARDNESS TEST ON STEAM DRUM



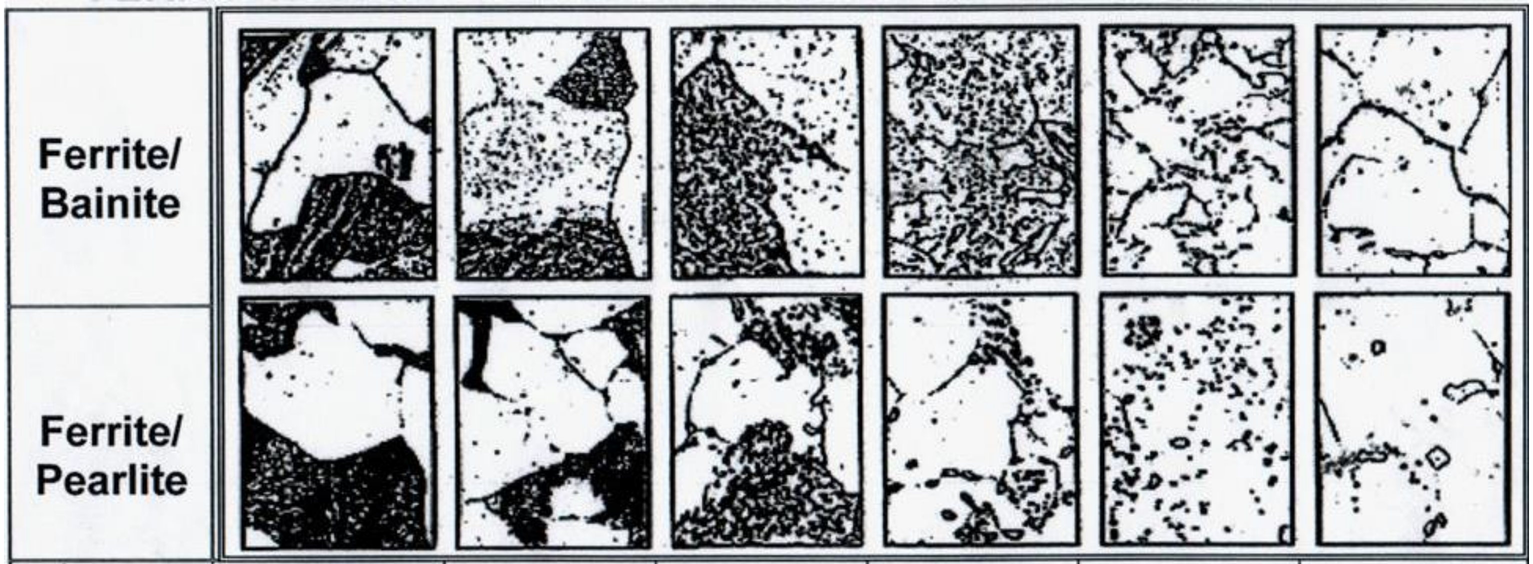
Steam drum of a boiler power plant



Microstructures obtained from the in-situ metallographic examination on some internal wall of the steam drum shown at left

MICROSTRUCTURAL CONDITION CLASSIFICATION FOR FERRITE/PEARLITE & FERRITE/BAINITE

For Low/Medium Carbon Steel and Low-Alloy Cr-Mo Steel



Class/Stadium	A	B	C	D	E	F
Approx. Damage	0 %	20 %	40 %	60 %	80 %	End Of Life
Approx. Life Remaining	100 %	80 %	60 %	40 %	20 %	None
Nature	No Creep Defect, Ferrite and distinct transformation product	Incipient Spheroi-disation and isolated carbide precipitation, notably at grain boundaries	Evident Spheroi-disation of trans-formation product Ferrite and trans-formation product easily distinguish-able	Full Spheroidisa-tion of transfor-mation product. No significant carbide precipita-tion within ferrite grains	Full Spheroidisa-tion. Carbides evenly dispersed throughout grains and at grain boundaries	Full Spherodisation. Significant coalescence between carbides
Action	None	Reinspection after Approx. 100.000 servive hours	Reinspection after Approx. 50.000 servive hours	Reinspection after Approx. 35.000 servive hours	Reinspection after Approx. 10.000 servive hours	Management must be informed im-mediately grinding to determine crack depth

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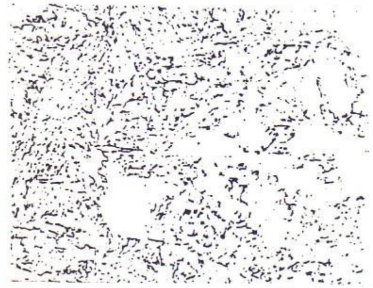
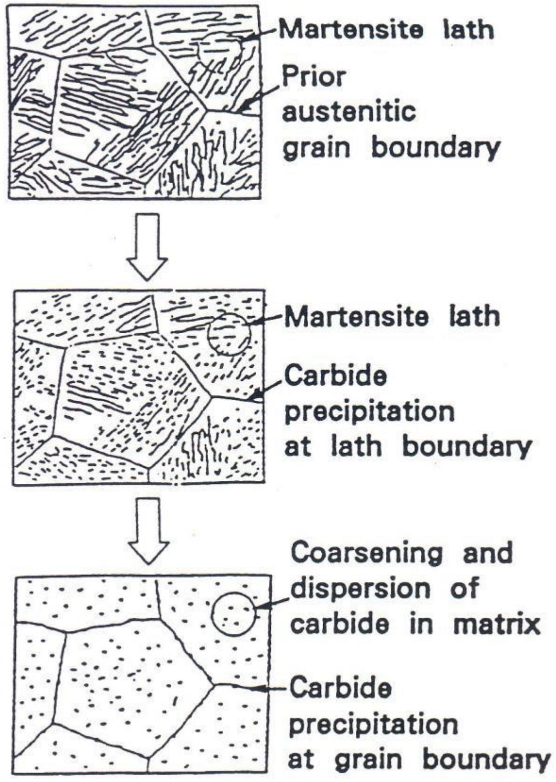
Classification of damage by microstructure (according to MHI)

For Low-Alloy Cr-Mo Steel

Classification	Life Fraction	OEM Microstructure 50 μm
I M	0~0.3	
II M	0.3~0.6	
III M	0.6~	

Feature of Structure



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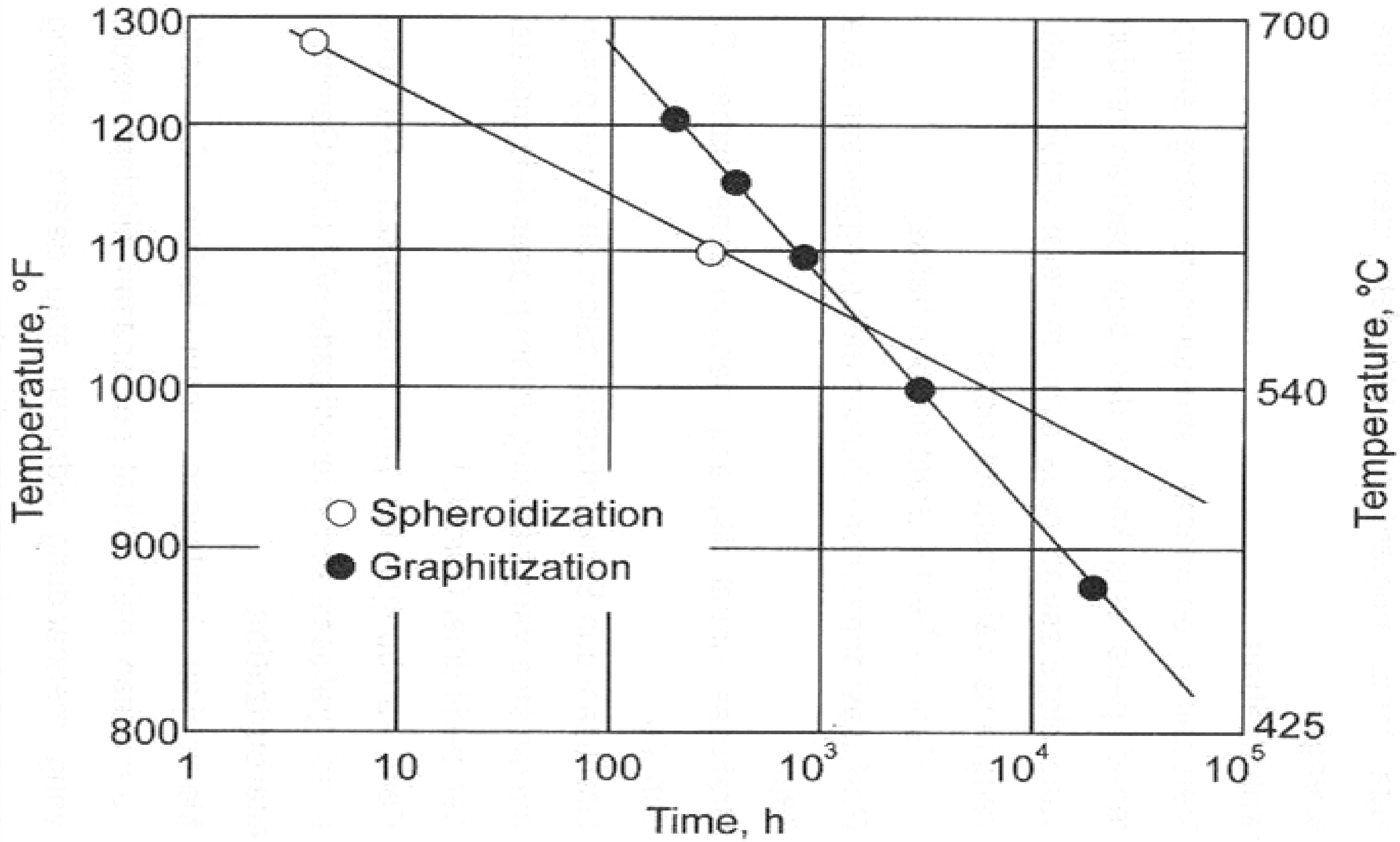
Microstructure Degradation

The influence of temperature and time to the formation of spheroidization and graphitization of carbon steel or low-alloy steel.



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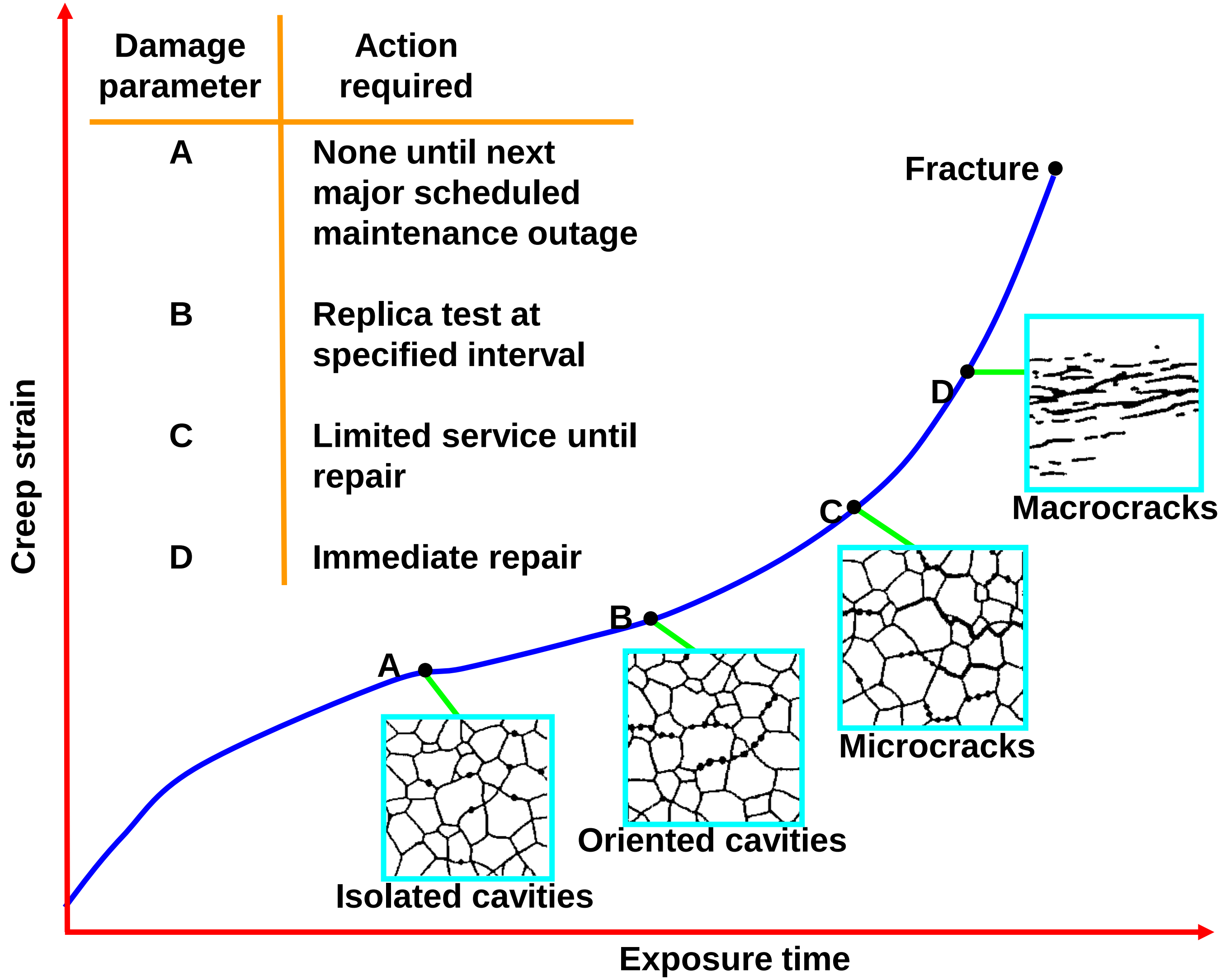
Cavitations Damages Classification and Maintenance Effort

Damage parameter	Action required
A	None until next major scheduled maintenance outage
B	Replica test at specified interval
C	Limited service until repair
D	Immediate repair



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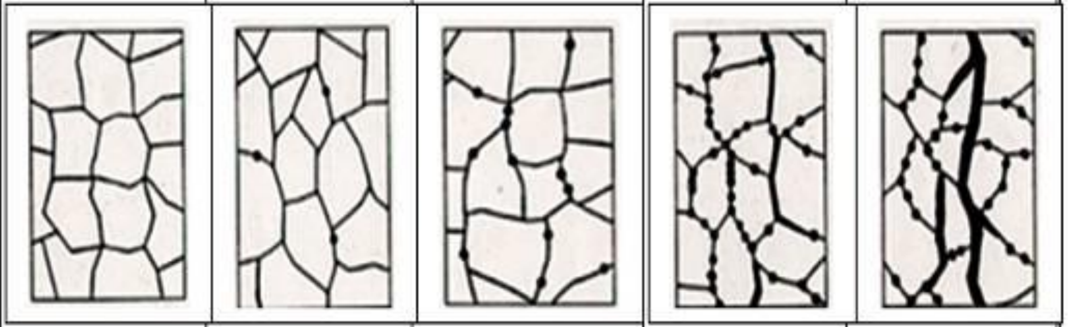
Replication-Based Cavitations Assessment (RCA) on Austenitic Stainless Steel

Class/ Stadium	Nature	Action
1	*No Creep Defect*	*None*
2	*A few Cavities*	*Reinspection after approx. 20.000 service hour*
3	*Coalescent Cavities*	*Reinspection after approx. 15.000 service hour*
4	*Creep Cracks (Micro)*	*Reinspection after approx. 10.000 service hour*
5	*Creep Cracks (Mark)*	*Management must be informed immediately grinding to determine crack depth*

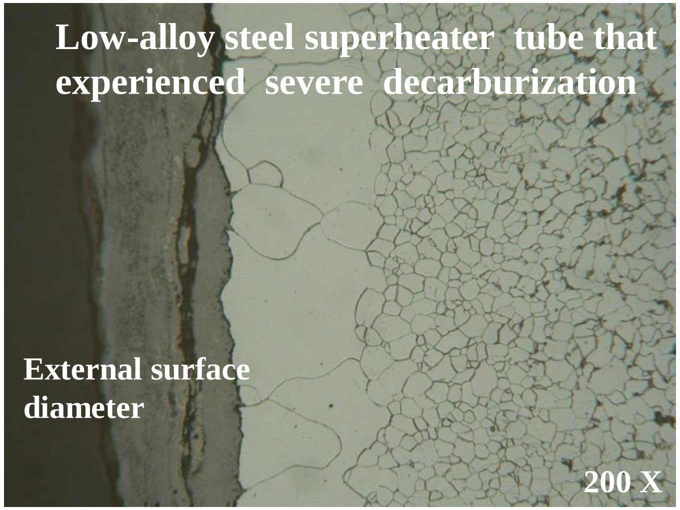
Forma-tion of Creep Cracks					
Stadium	1	2	3	4	5
Approx. Damage	0	33 %	50 %	66 %	*End of Life*
Approx. Life Remai-ning	100 %	66 %	50 %	33 %	*None*

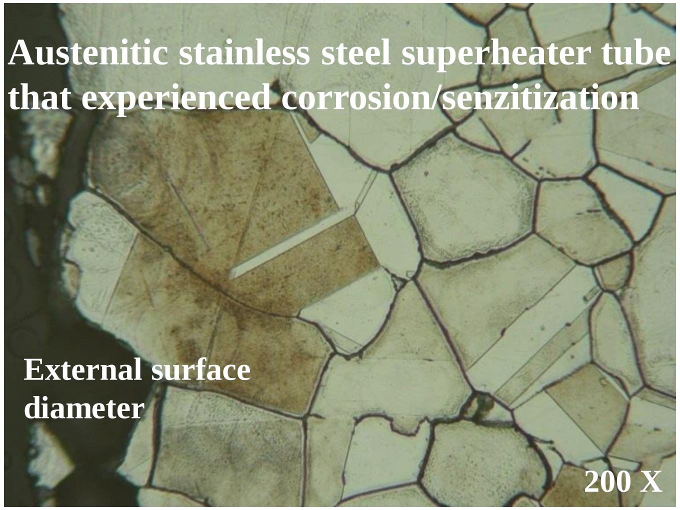
INTERNAL WALL INSPECTION OF A BOILER HEADER BY BORESCOPE TECHNIQUE

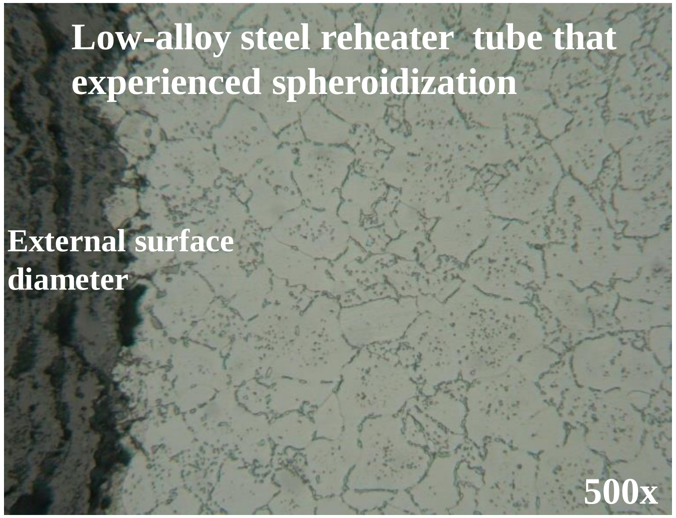
LABORATORY EXAMINATION ON POST-SERVICE BOILER TUBES

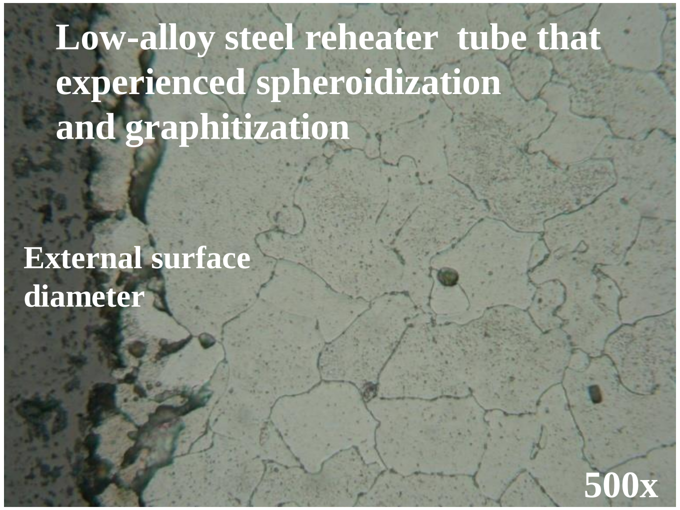
A number of post-service tubes were cut-away from a coal-fired steam power plant boiler for laboratory examination

METALLOGRAPHY AND HARDNESS TEST ON POST-SERVICE BOILER TUBES









Microstructures obtained from the cross-sectional area of some boiler tubes

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TENSILE TEST ON POST SERVICE TUBE SPECIMENS

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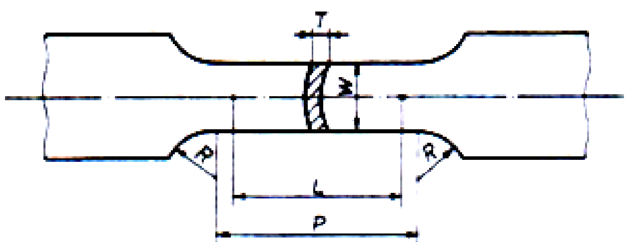

Unit : mm

Type of test piece	Width W	Gauge length L	Parallel length P	Radius of fillet R	Thickness T
12A	19	50	60 approx.	15 min.	Thickness of tube
12B	25	50	60 approx.	15 min.	Thickness of tube
12C	38	50	60 approx.	15 min.	Thickness of tube

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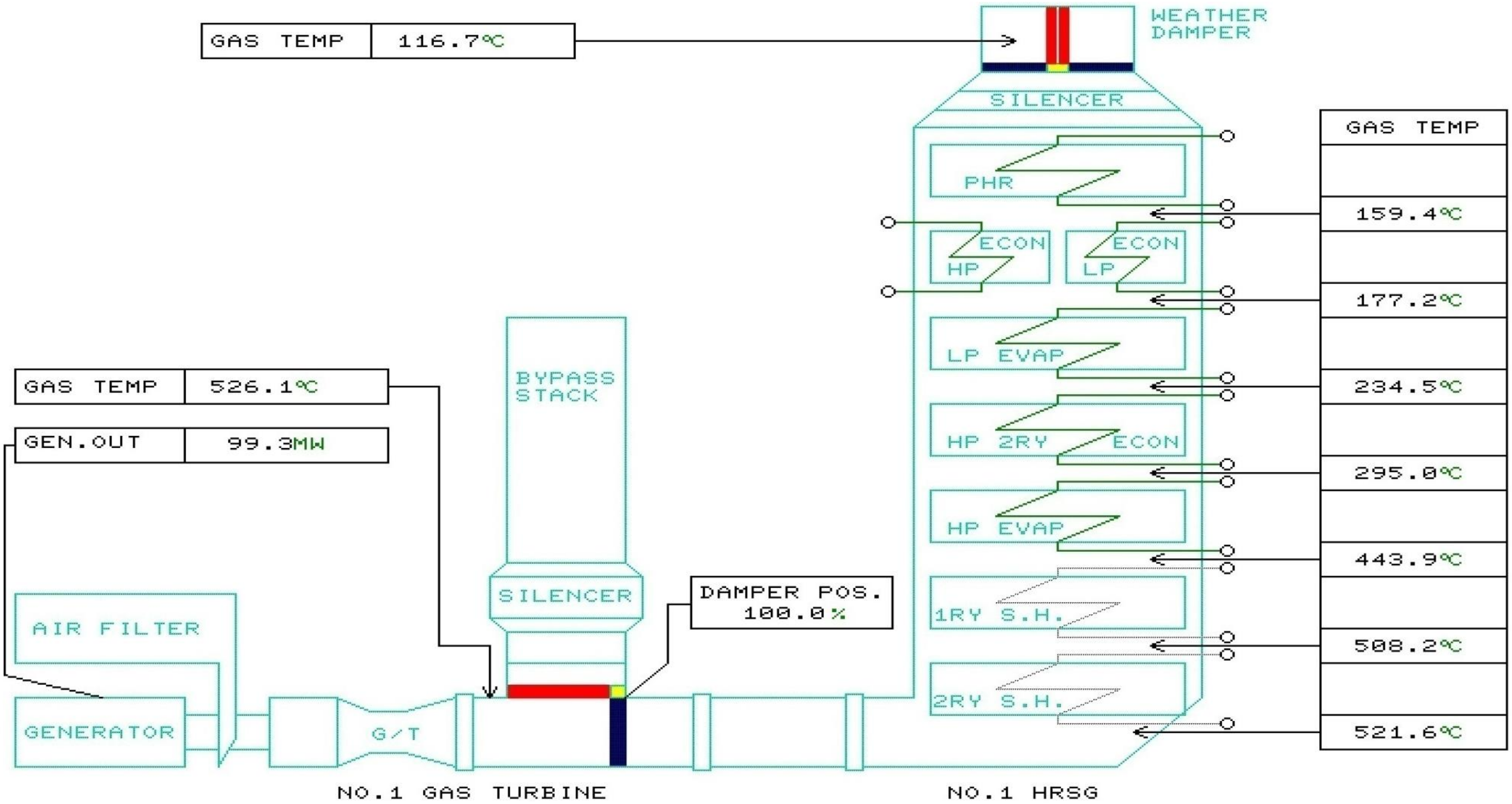
CONDITION AND USEFUL LIFE ASSESSMENT OF HRSG'S TUBES AND HEADERS



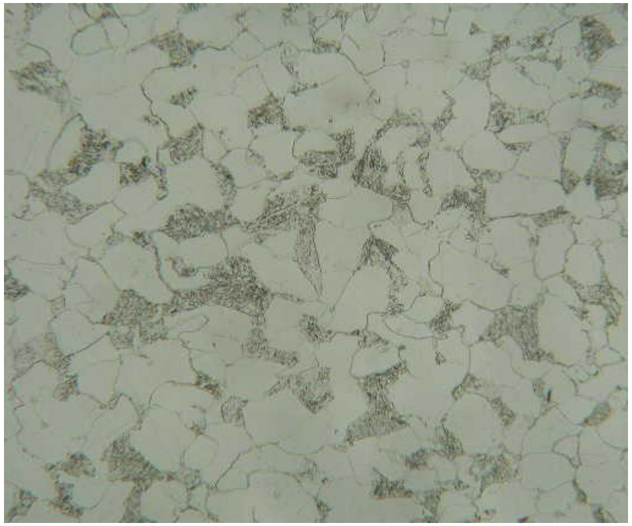
Sketch of flue gas flow from a gas turbine unit to a HRSG showing the inlet gas temperature at each of the HRSG's heat-exchanger equipment .

TEST SPOT PREPARATION FOR IN-SITU METALLOGRAPHIC EXAMINATION

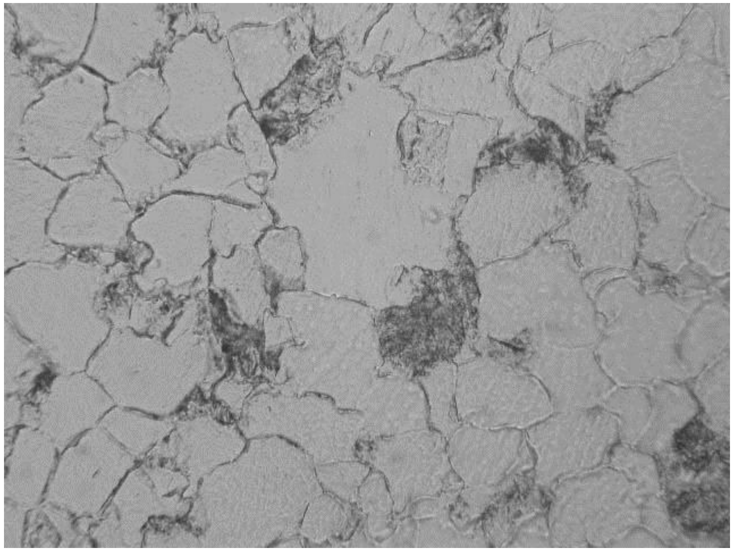
Heat Recovery Steam Generator (HRSG)'s Headers

IN-SITU METALLOGRAPHIC EXAMINATION ON HRSG'S TUBES AND HEADERS

HRSG's Header



HRSG's Lower Tube
HP Superheater-1



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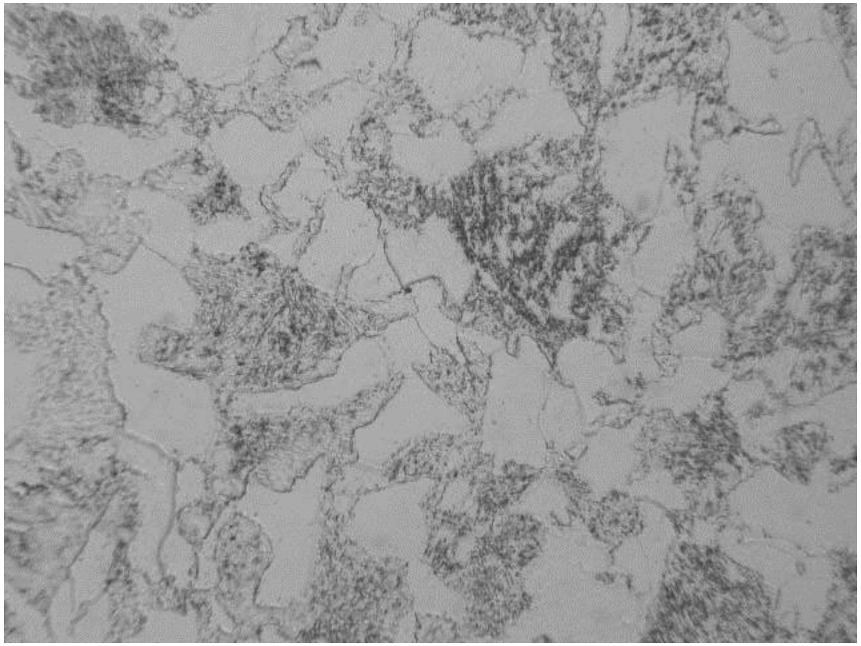
IN-SITU METALLOGRAPHIC EXAMINATION ON HRSG'S HP DRUM



HP Drum of a HRSG and the corresponding microstructures of its internal wall obtained from the in-situ metallographic examination.

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HRSG's POST SERVICE TUBES FOR RLA

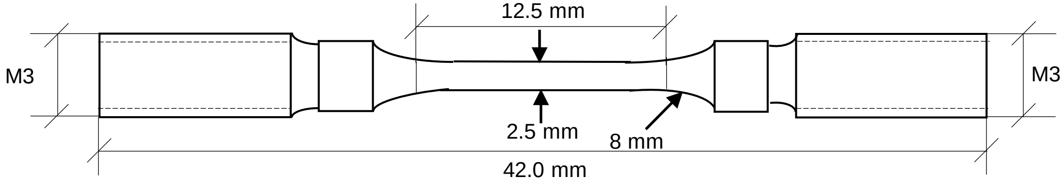
Plain Tubes

Finned Tubes

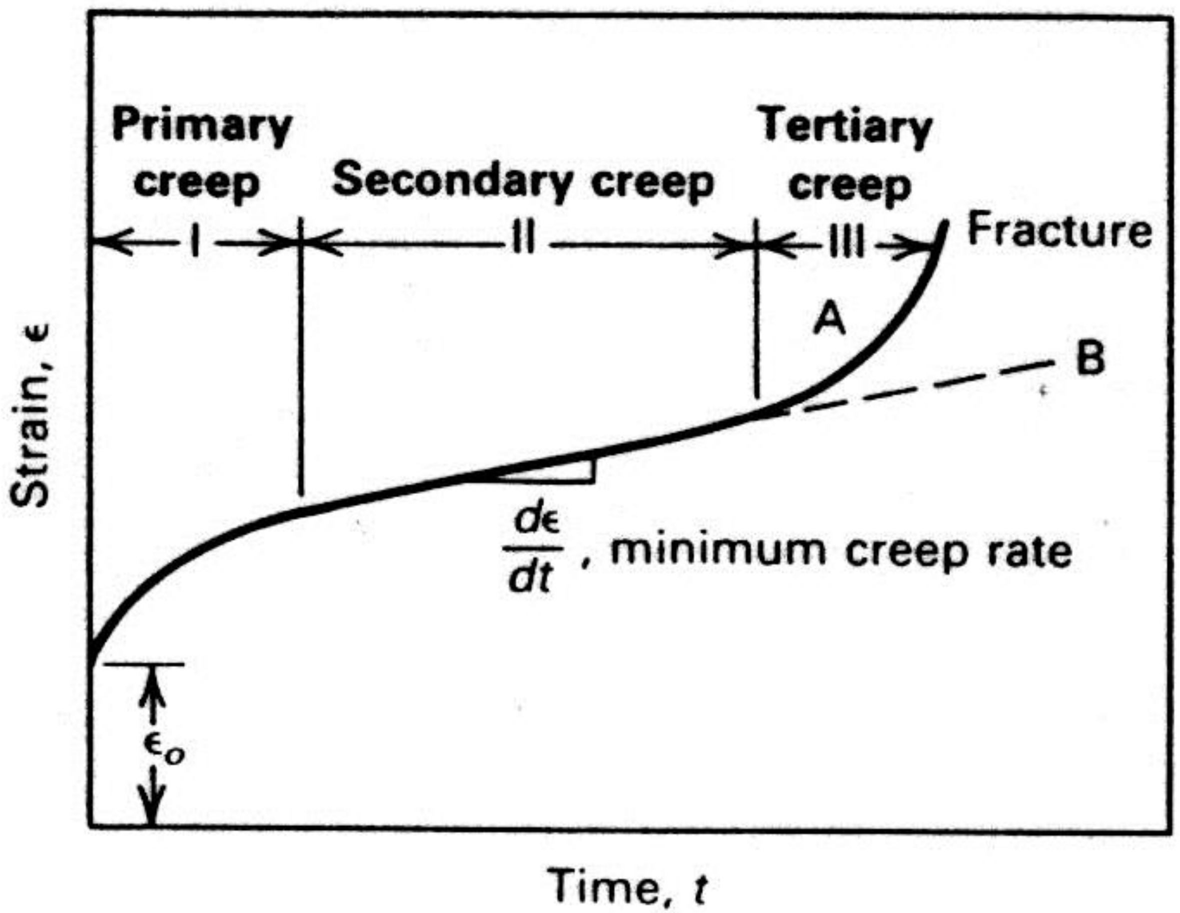
HRSG's Post Service Tubes for RLA

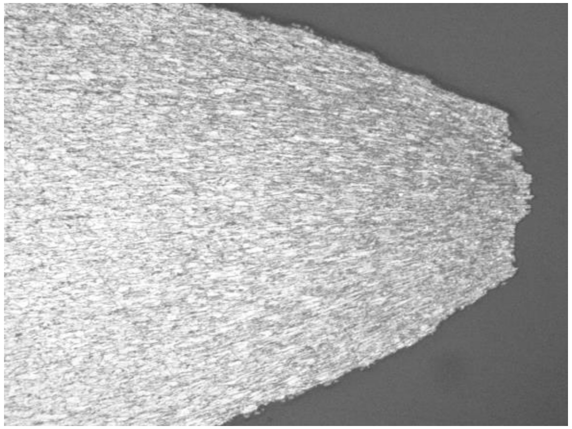
New Plain Tubes

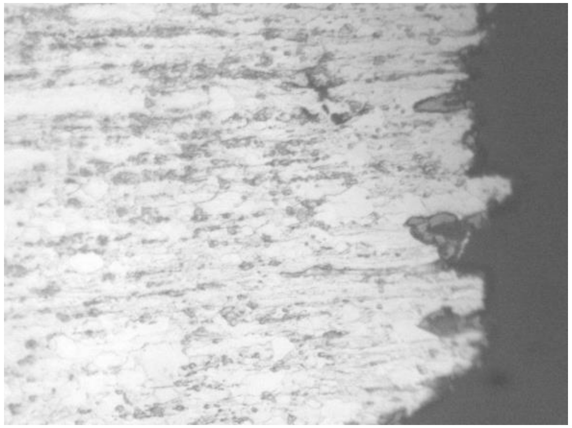
CREEP RUPTURE TEST ON POST SERVICE TUBE SPECIMENS



Typical creep curve showing the three stages of creep







Microstructure of sample after creep test

PREDICTED RUPTURE LIFE BY LARSON-MILLER PARAMETER AND CREEP RUPTURE TEST

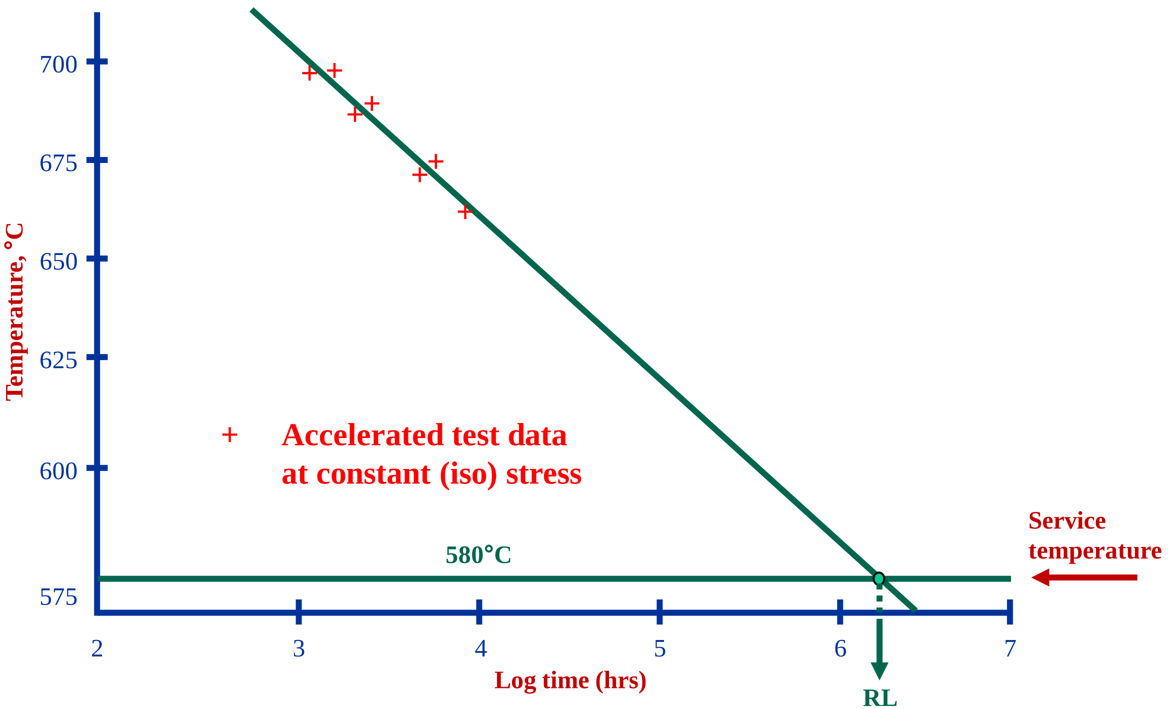
Larson-Miller Parameter (LMP) = T (C + log t_r)

where :

T = absolute temperature, i.e : T (K) = ^{0}C+273, or T(^{0}R) = ^{0}F+460

C = correlation/extrapolation constant, namely C = 20 for carbon or low-alloy steel, and C = 18 for austenitic stainless steel.

t_r = rupture time.



PREDICTED RUPTURE LIFE AT 580°C FOR 2.25 Cr-1Mo STEEL PIPE

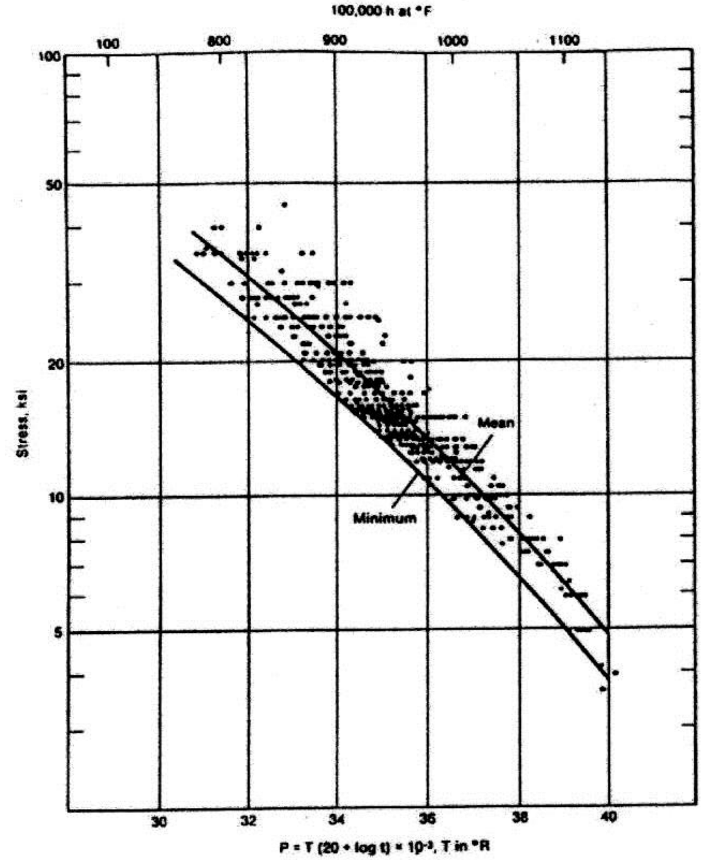


Fig. Variation of Larson-Miller rupture parameter with stress for annealed 2¼Cr-1Mo steel (Ref 30).

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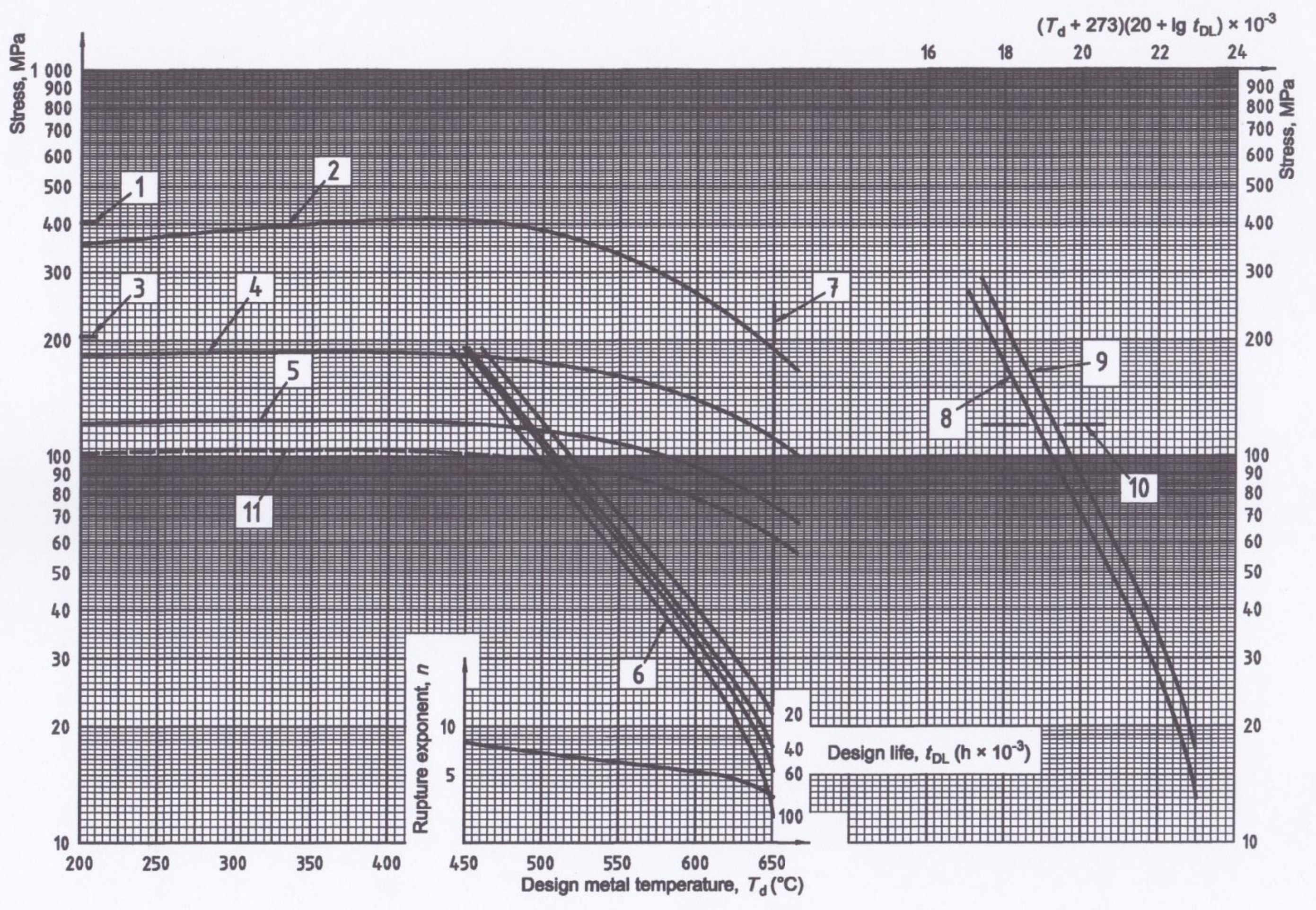
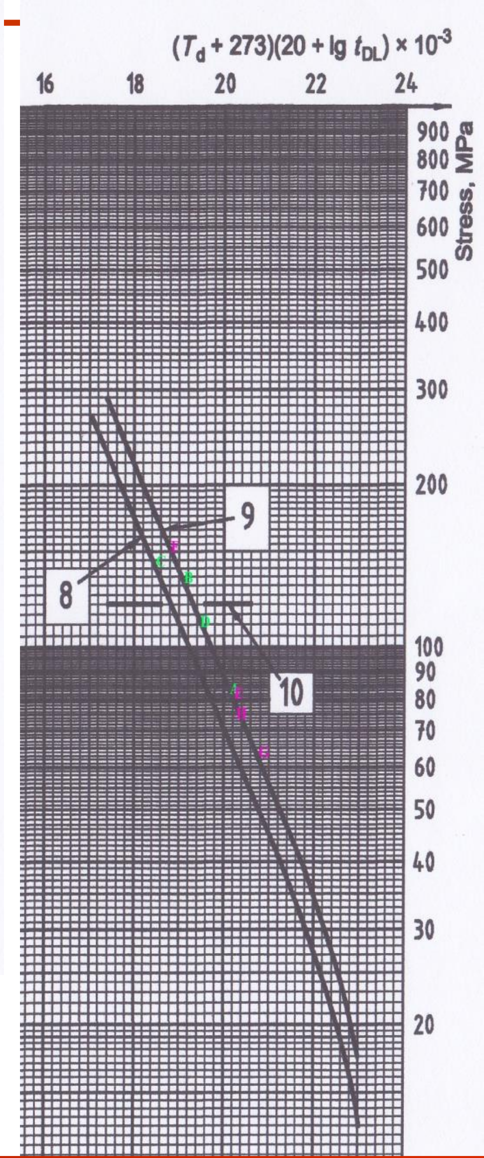
PREDICTED RUPTURE LIFE BY LARSON-MILLER PARAMETER AND CREEP RUPTURE TEST OF HRSG's SUPERHEATER TUBE





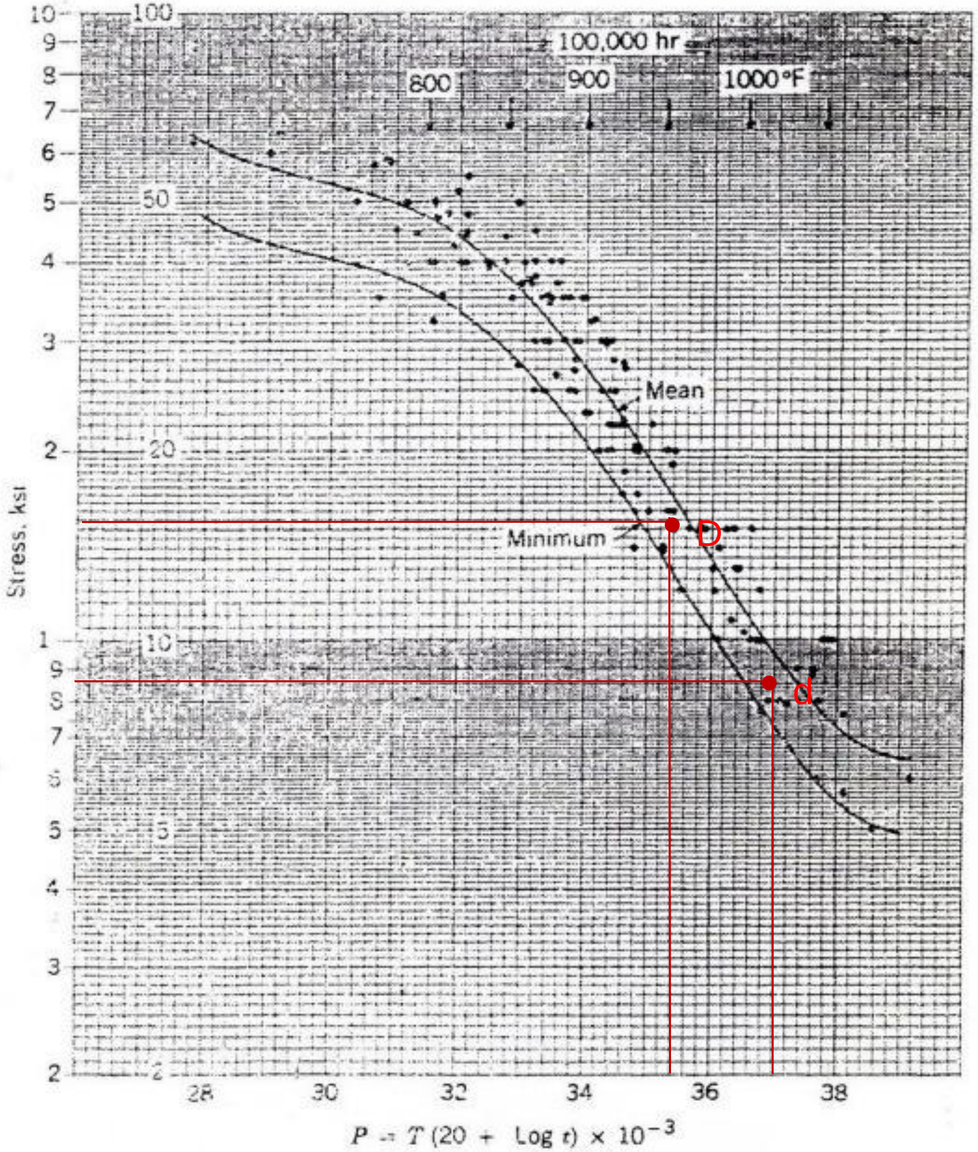
Stress curves (SI units) for ASTM A 200 T22, ASTM A 213 T22 and ASTM A 335 P22 $2^1/_4$% Cr-1 Mo steels (according to API Standard 530)

PREDICTED RUPTURE LIFE BY LARSON-MILLER PARAMETER AND CREEP RUPTURE TEST OF HRSG's HP SUPERHEATER TUBE

Creep test results obtained from HP Superheater tube material (DIN Grade 13 CrMo44, equivalent to SA 213-T12, 1Cr-0.5Mo steel)

Note:

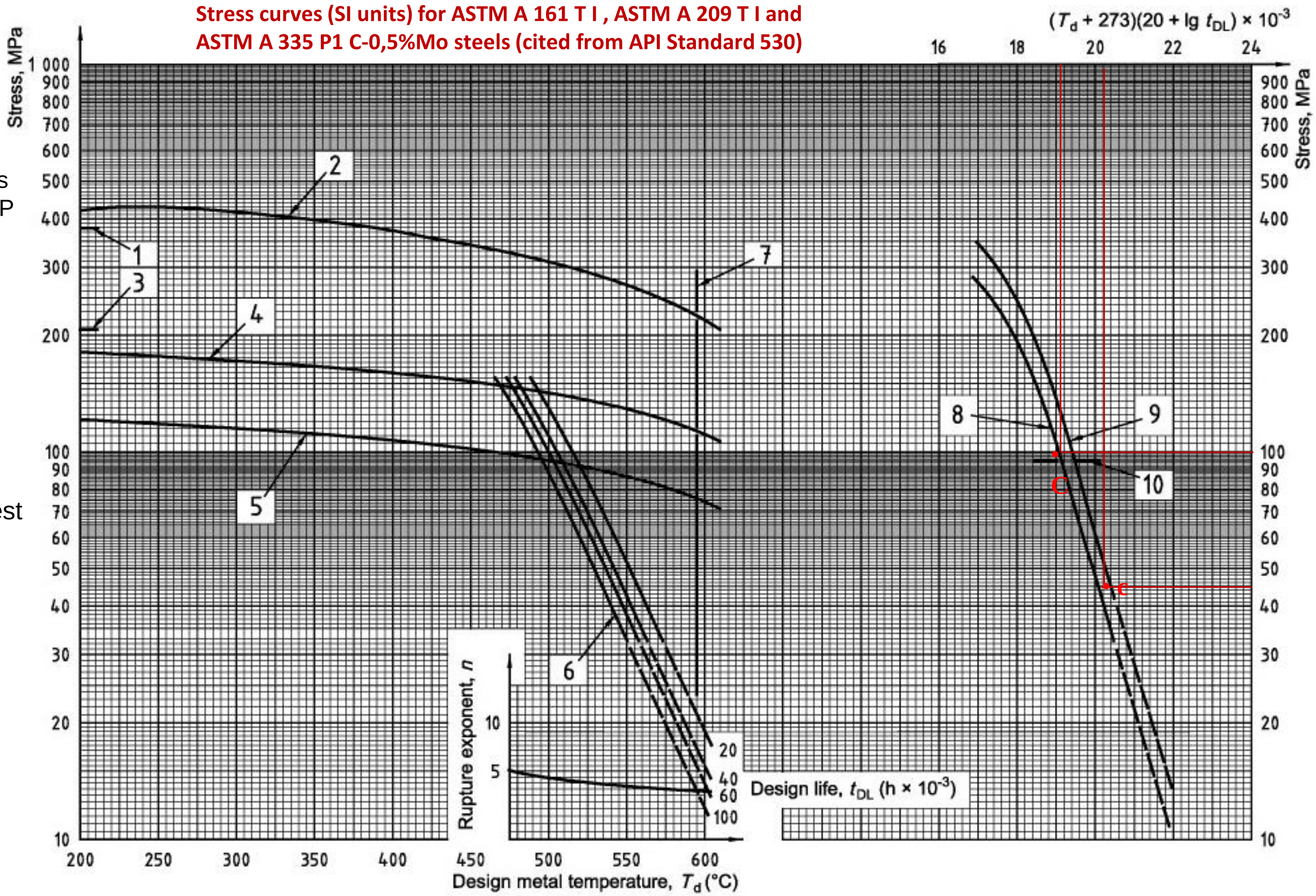
- D and d are data of creep test results



Larson-Miller Parameter chart for SA213-T12 (Smith 1973)

PREDICTED RUPTURE LIFE BY LARSON-MILLER PARAMETER AND CREEP RUPTURE TEST OF HRSG's HP EVAPORATOR TUBE

Stress curves (SI units) for ASTM A 161 T I , ASTM A 209 T I and ASTM A 335 P1 C-0,5%Mo steels (cited from API Standard 530)



Creep test results obtained from HP Evaporator tube material (DIN Grade 15 Mo3, equivalent to SA-209 T1, C-0.5Mo steels)

Note:

- C and c are data of creep test results

II. STEAM TURBINE CONDITION ASSESSMENT

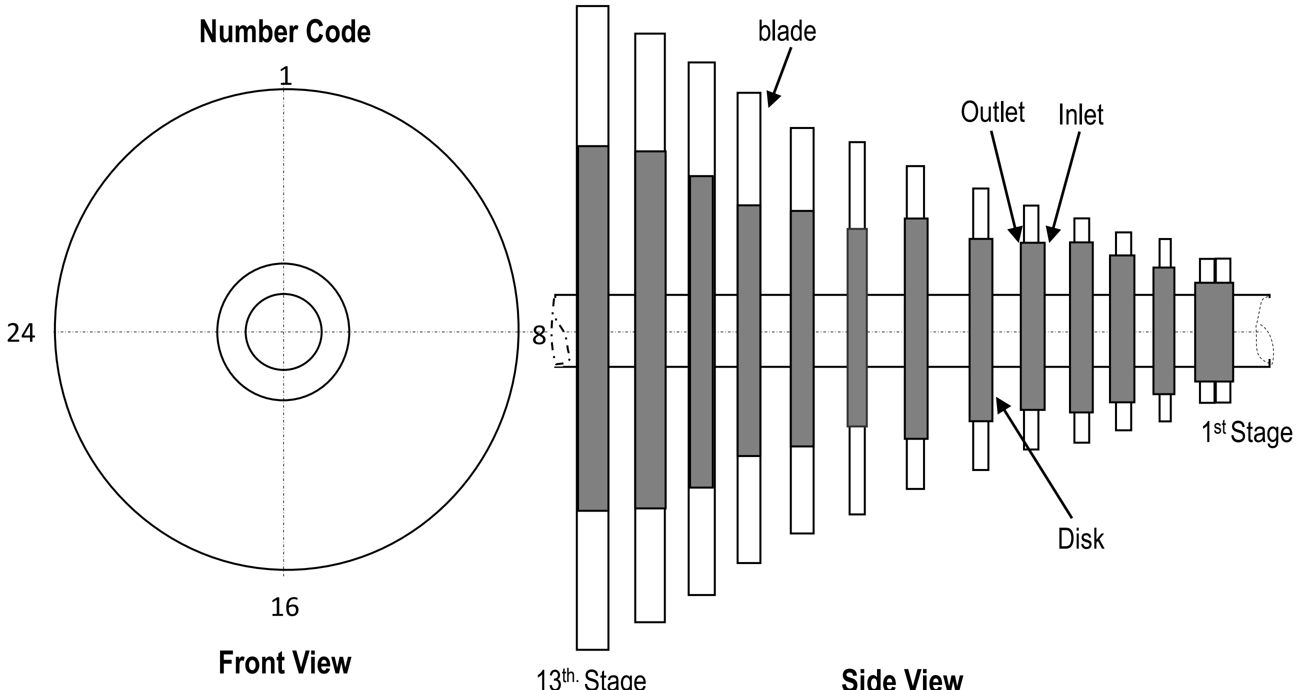
CRITICAL STEAM TURBINE COMPONENTS

- Rotor
- Blades (Buckets)
- Fixed Vanes (Nozzles)
- Housing (Casing)
- Bolts

STEAM TURBINE POWER PLANT ASSEMBLY

- High-Pressure (HP) Turbine
- Intermediate-Pressure (IP) Turbine
- Low-Pressure (LP) Turbine

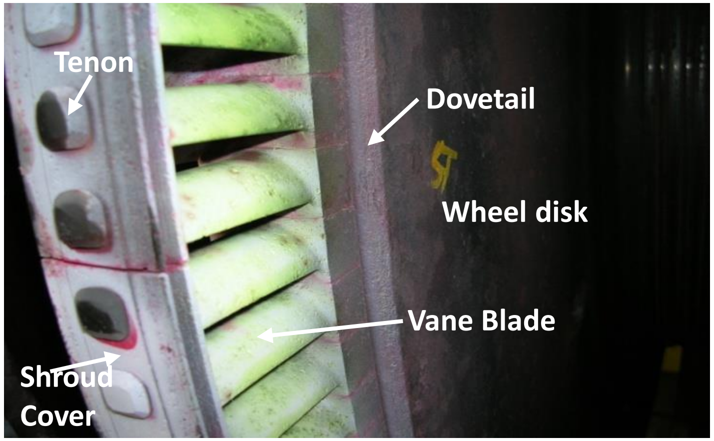
Steam turbine rotor/disk and blades



Low Pressure (LP) Turbine Rotor, 2 x 8 Stages Tandem

Intermediate Pressure (IP) Turbine Rotor (12 Stages) and High Pressure (HP) Turbine Rotor (12 Stages) with Curtis Turbine (2 Stages)

CONDITION ASSESSMENT OF STEAM TURBINE ROTOR AND BLADES



Steam Turbine Rotor and Blades

Christmas tree attachment of the blades last stage to the wheel disk rotor turbine

TYPES OF DETERIORATION OR DAMAGE OF STEAM TURBINE COMPONENTS

- CREEP
- FATIGUE (HIGH CYCLE/LOW CYCLE)
- CREEP-FATIGUE INTERACTION
- THERMAL AGING (Carbide Coarsening)
- CORROSION
- STRESS CORROSION CRACKING
- MECHANICAL DAMAGE (EROSION)

MATERIAL PROPERTY REQUIREMENT FOR STEAM TURBINE COMPONENTS

Component	Material Property Requirement
HP-IP Rotor/Disks	Creep Strength, Corrosion Resistance, Thermal Fatigue Strength, Toughness
LP Rotor/Disks	Toughness, Stress-Corrosion Resistance, Fatigue Strength
HP-IP Blading	Creep Strength, Fatigue Strength, Corrosion and Oxidation Resistance
LP Blading	Fatigue Strength, Corrosion-Fatigue Resistance, Pitting Corrosion/Stress Corrosion Resistance, Erosion Resistance
Inner Casing, Steam Chest, Valves	Creep Strength, Thermal Fatigue Strength, Toughness, Yield Strength
Bolts	Proof Stress, Creep Strength, Stress Relaxation Resistance, Toughness, Notch Ductility

DAMAGE LOCATIONS AND CAUSES FOR STEAM TURBINE COMPONENTS

Component	Position	Cause of Life Exhaustion
HP-IP rotor	Outer /wheel groove	Low cycle fatigue
	Center bore	Low cycle fatigue, creep-crack propagation, and brittle fracture
	Blade-groove shoulder/ wheel dovetail	Creep, high cycle fatigue
LP-rotor	Center bore	Fatigue, crack propagation, and brittle fracture
	Wheel groove and shaft	Fatigue, corrosion, brittle fracture
HP inner casing	Inner surface	Low cycle fatigue and creep
	Female thread	Creep

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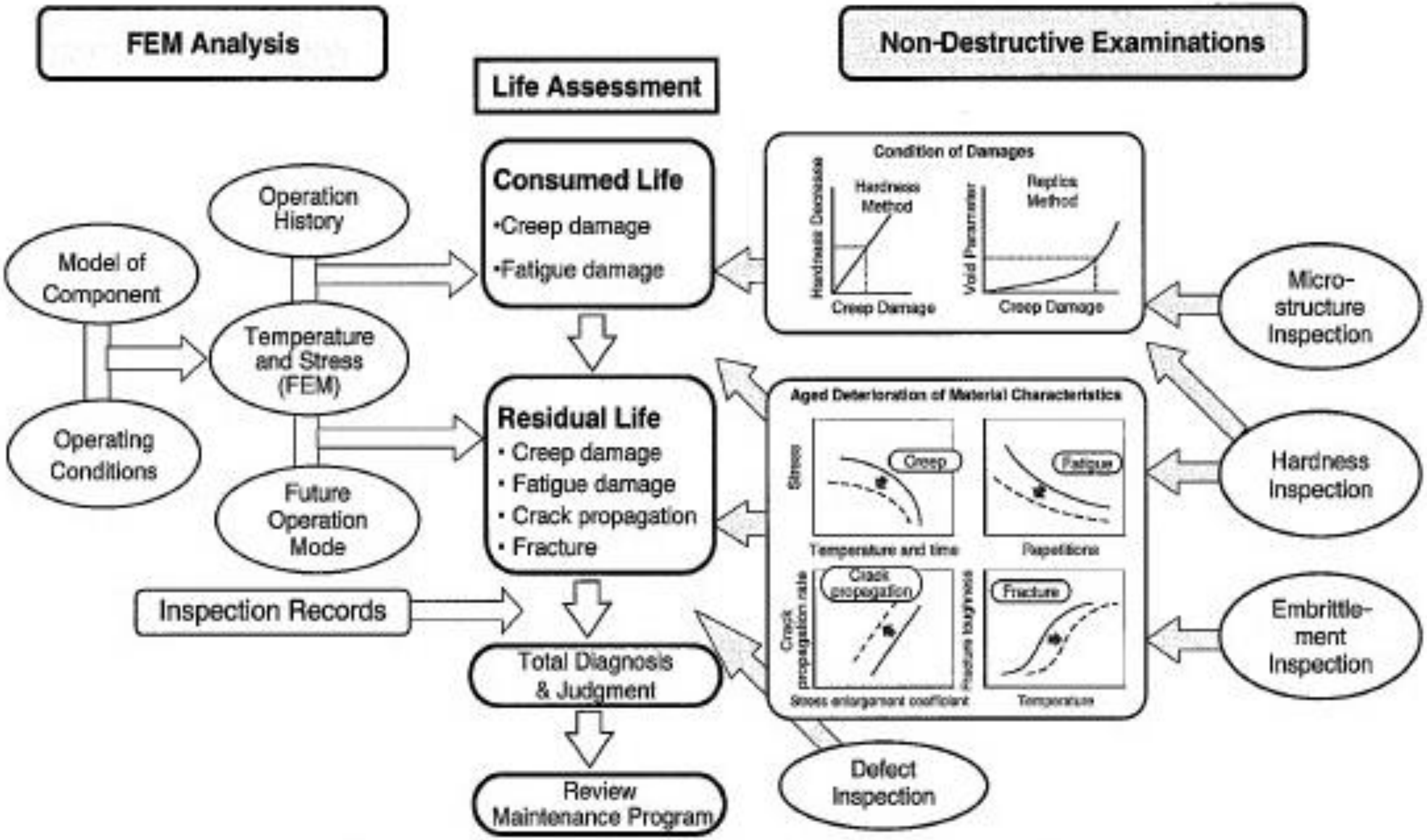
DAMAGE LOCATIONS AND CAUSES FOR STEAM TURBINE COMPONENTS, continued

Component	Position	Cause of Life Exhaustion
LP-blades	Christmas tree blade attachment, vane blade	Fatigue, corrosion, erosion, brittle fracture
Nozzle block	Diaphragm	Creep and fatigue
HP-IP blades	Tenon, shroud cover and root of blade/dovetail	Creep and high cycle fatigue
Main valves	Body Female thread	Low cycle fatigue and creep Creep
High-temperature bolts	Thread	Creep and fatigue

RLA METHODOLOGY FOR STEAM TURBINE (cited from Toshiba Corp., Japan)



TESTING AND EVALUATION METHOD FOR LIFE ASSESSMENT

- **Nondestructive Evaluation for Flaws/Cracks**
- **Metallurgical Evaluation for Material Properties Degradation**
- **Computational Method for Fracture Mechanics Analysis**

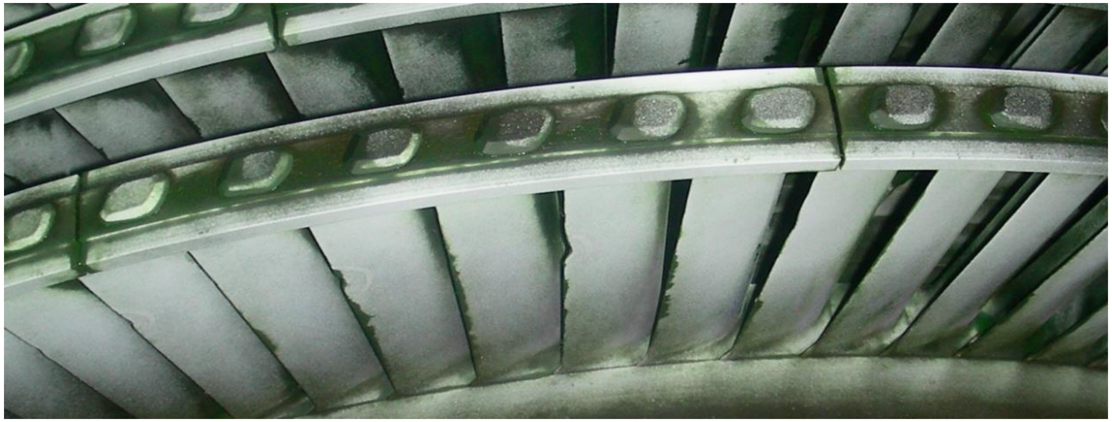
Nondestructive Evaluation (NDE) Methods

a) **Conventional Methods**
- Visual Inspection (VI)
- Penetrant Testing (PT)
- Magnetic Particle Testing (MT)
- Ultrasonic Testing (UT)
- Eddy Current Testing (ET)
- Radiography Testing (RT)

b) **Specialty Methods**
- Acoustic Thermography
- Ultrasonic Phased Array
- Rotor Bore Inspection
- High Temperature Video Inspection
- Other Methods

Some NDE results obtained from steam turbine blades and rotor

Typical pitting corrosion on 5th, 6th and 7th stage



Erosion on trailing edge stage 12, shroud 3 blade no.5 , 6 and shroud 4 blades 1 to 6 (HP/Governor Side)

Some NDE results obtained from steam turbine blades and rotor

Magnetic Particle Inspection on stage 13th *(Christmas tree area)*

Inspection on christmas tree Stage 13th by Magnetic Particle Testing

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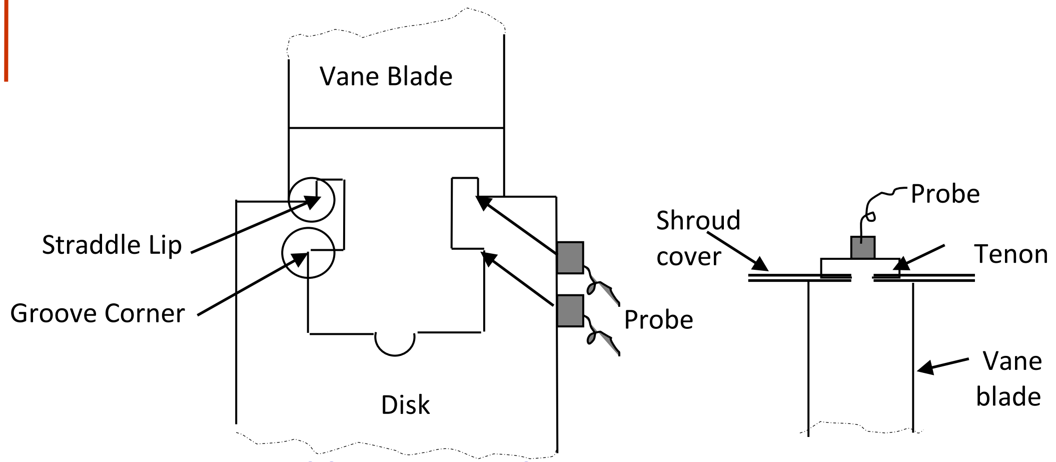
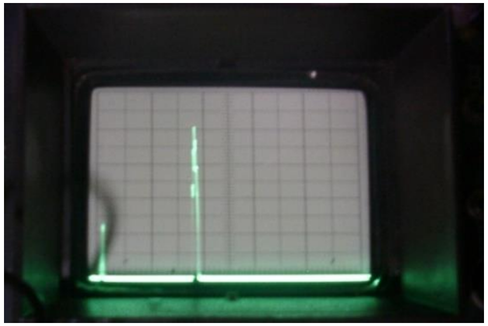
Ultrasonic Testing (UT)



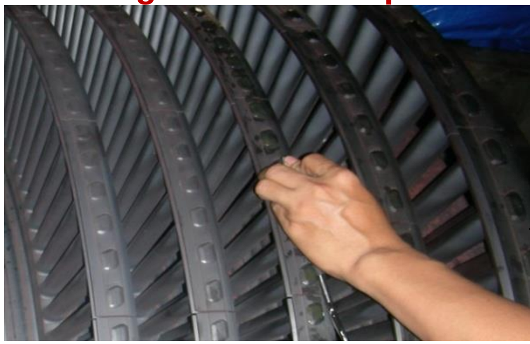
Calibration Technique on Groove Corner, Straddle Lip and Tenon

Scanning on straddle lip of disk



Pulse on straddle lip

Inspection on shaft (HP Rotor)



Inspection on tenon (IP Rotor)

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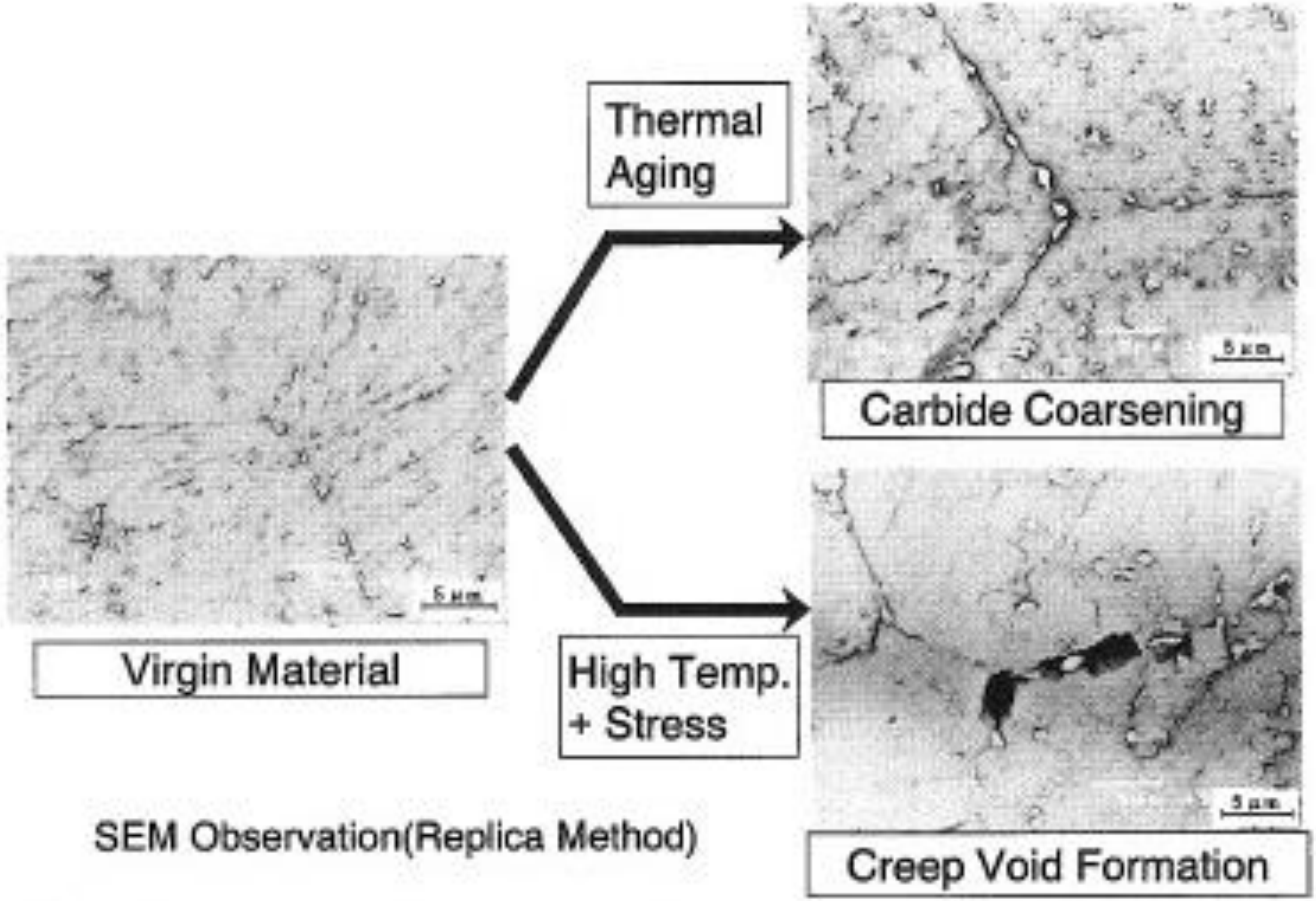
Metallurgical Damage Evaluation

- In-Situ Metallographic Examination by Replication Method
- Field Hardness Testing by Portable Hardness Tester
- Laboratory Material Testing & Evaluation:
  - Hardness Testing
  - Metallographic Examination
  - Fractographic Examination and Analysis by SEM (Scanning Electron Microscopy) equipped with EDS (Energy Dispersive Spectroscopy)
  - Tensile Testing
  - Fatigue Testing
  - Creep Rupture Testing
  - Fracture Toughness Testing
  - Others

Example of microstructure changes caused by aged deterioration on a steam turbine component made of Cr-Mo-V steel.



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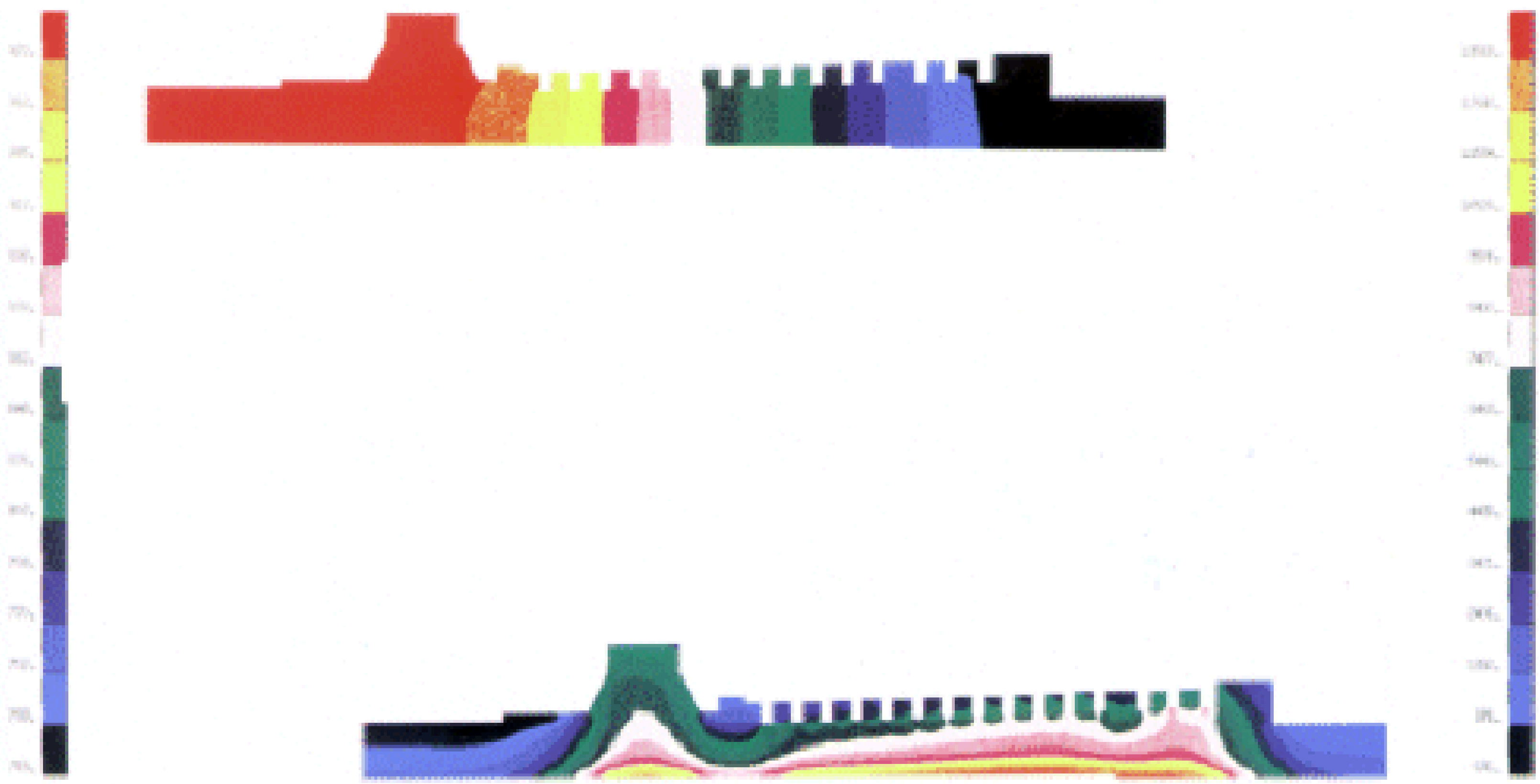
Computational Method using Finite Element Analysis (FEA)

- Calculation of local material temperatures
- Calculation of local stress levels and their direction at critical areas of the components
- Structural integrity and life analysis (Based on fracture mechanics approach)

Some FEA results obtained from HP Rotor (cited from South West Research Institute, San Antonio, Texas)



The SAFER code calculates steady state temperature (°F) contours for a high pressure (HP) rotor (top). Steady state stress contours (psi) for an HP rotor are determined using the SAFER finite element code (bottom).

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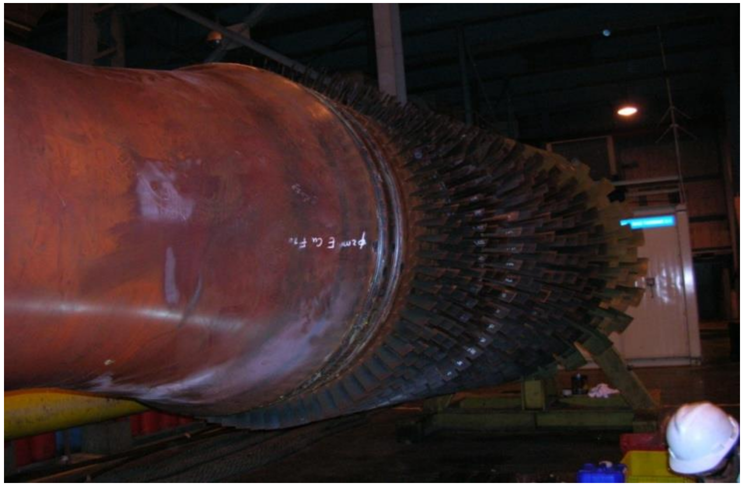
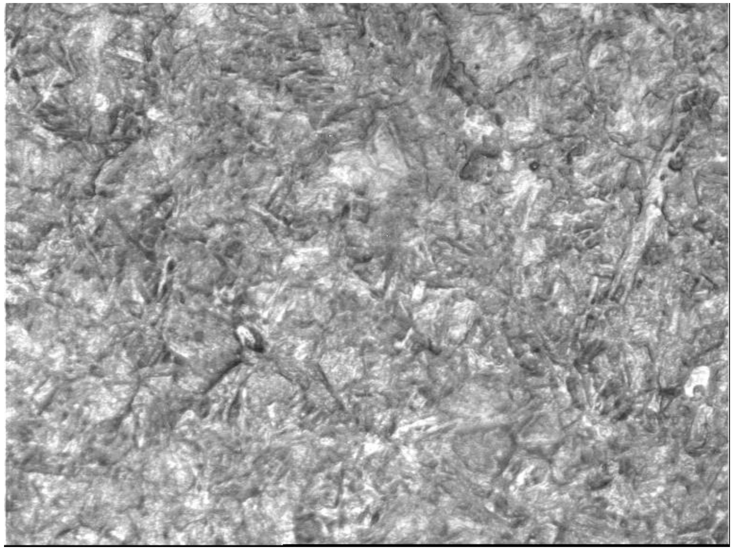
CONDITION AND USEFUL LIFE ASSESSMENT OF GAS TURBINE ROTOR AND HOT GAS PATH COMPONENTS





In-situ metallographic examination on gas turbine rotor

CONDITION ASSESSMENT ON GAS TURBINE INNER AND OUTER SHELL COMBUSTOR

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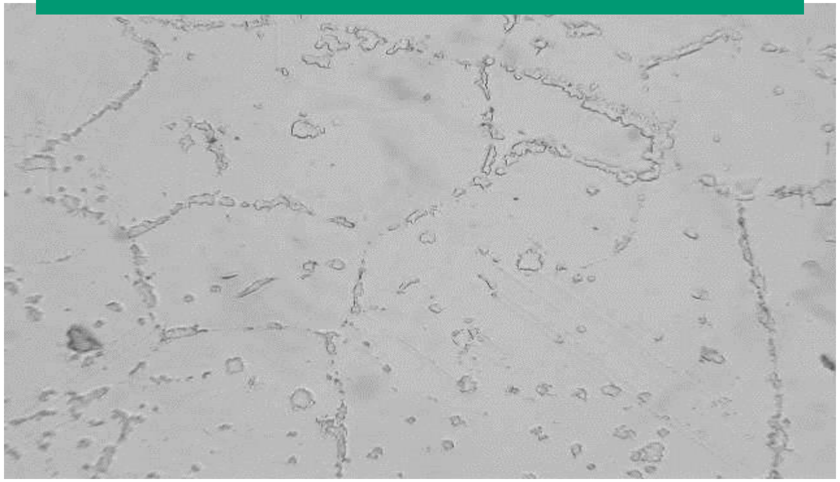
Chemical analysis by a portable Spark Emission Spectrometer

In-situ metallographic examination



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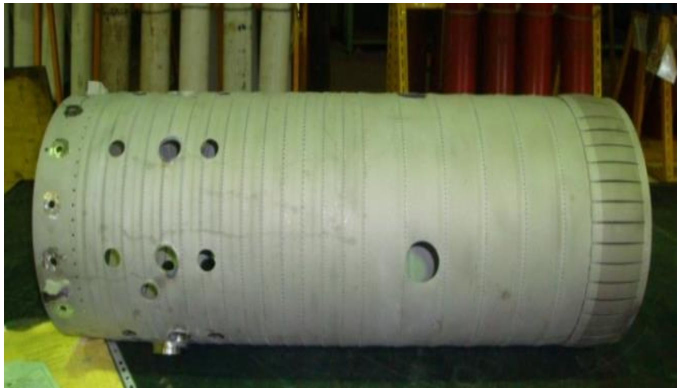
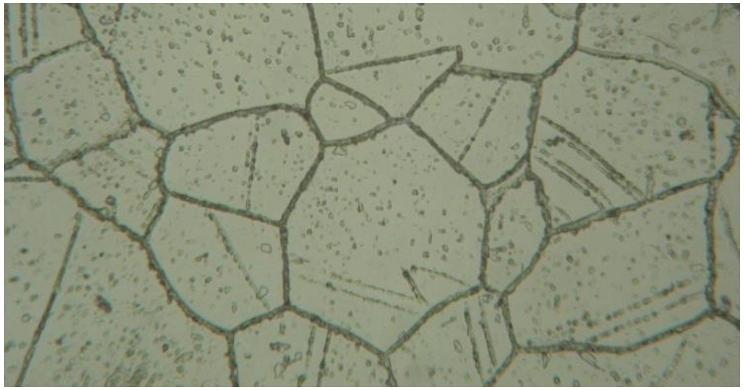
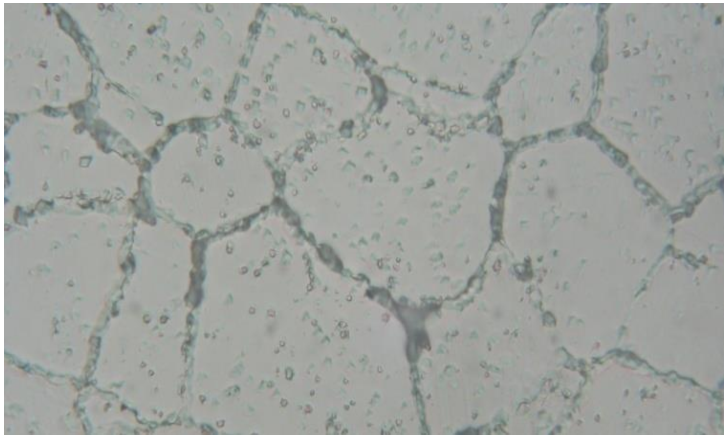


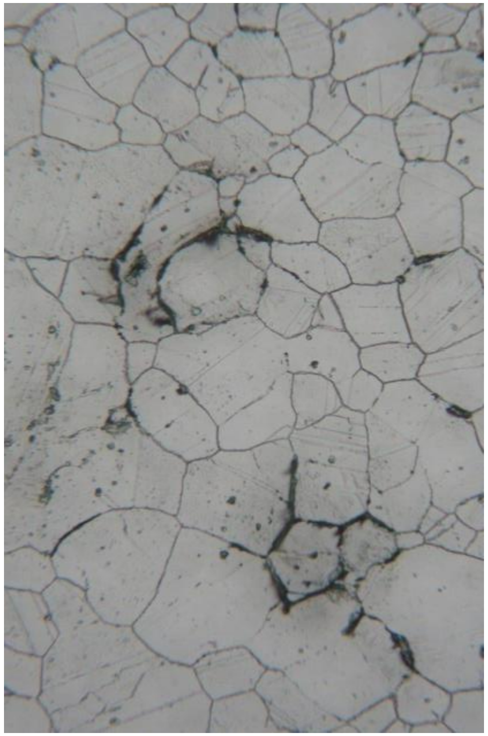
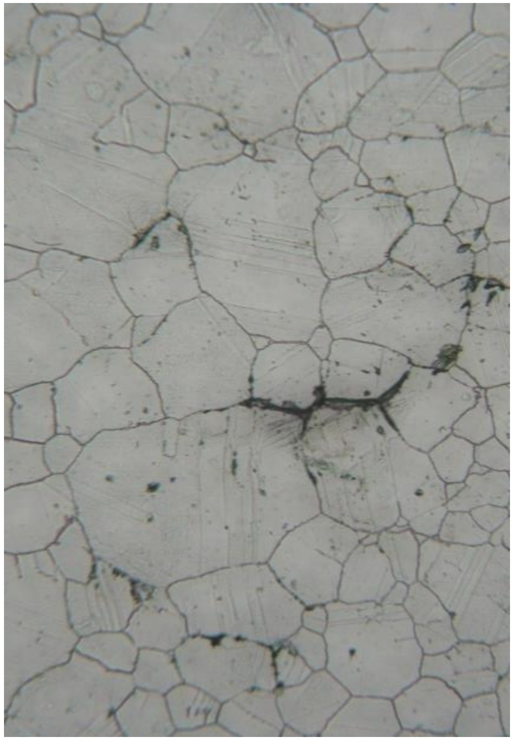




IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE

CONDITION ASSESSMENT OF GAS TURBINE TRANSITION PIECE GE FRAME 9E



IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE ON GAS TURBINE TRANSITION PIECE GE FRAME 9E

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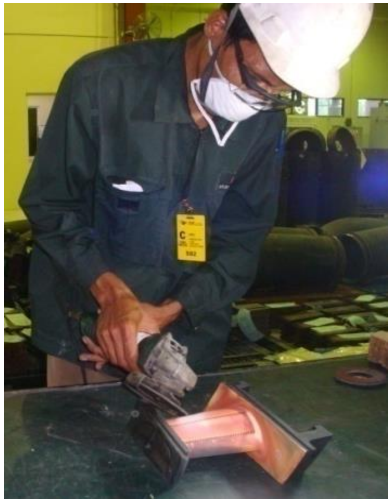
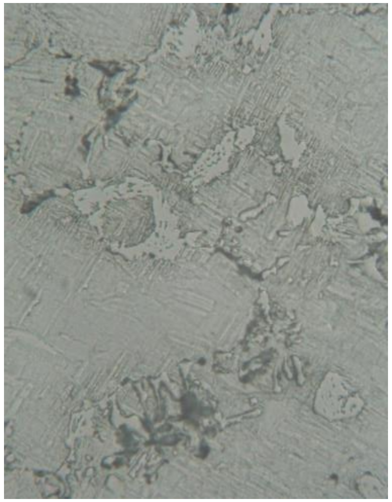
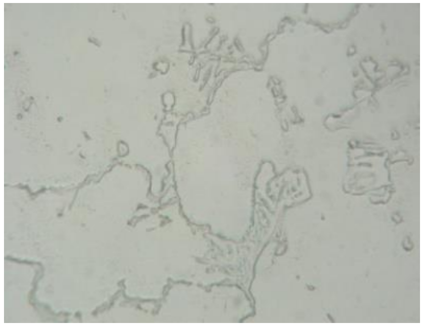
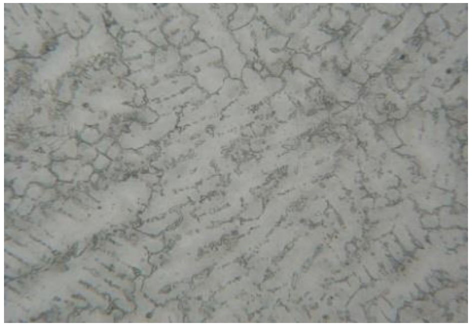
CONDITION ASSESSMENT OF GAS TURBINE VANE ROW # 1 MITSUBISHI MW 701D

IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE ON VANE ROW#1 MITSUBISHI MW 701D

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CONDITION ASSESSMENT OF GAS TURBINE VANE ROW # 2 MITSUBISHI MW 701D

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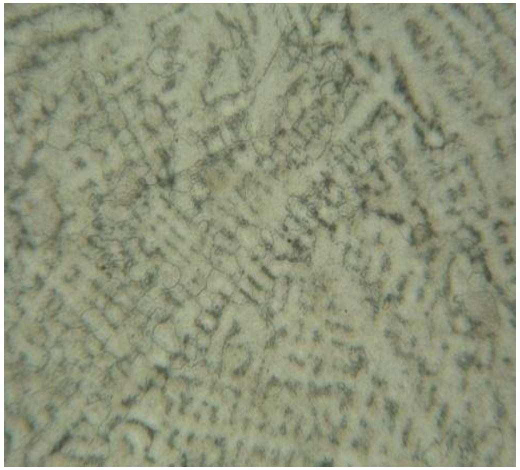
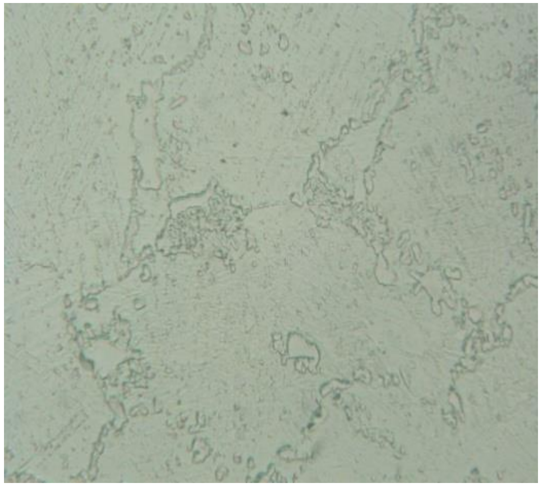
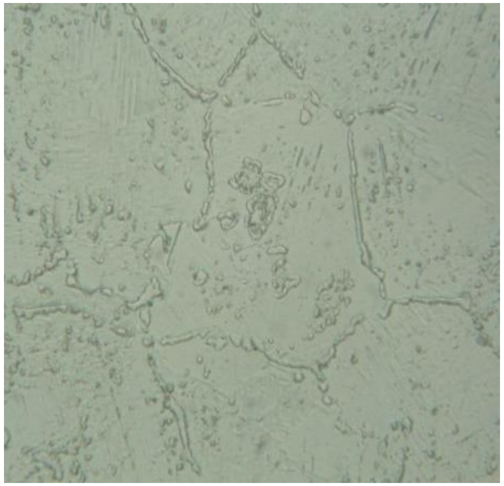
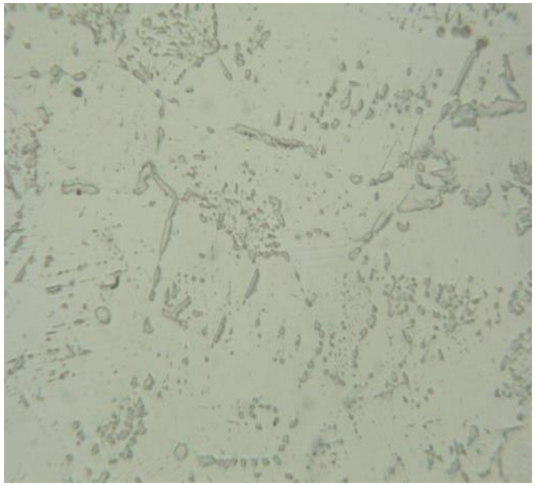

IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE ON VANE ROW#2 MITSUBISHI MW 701D

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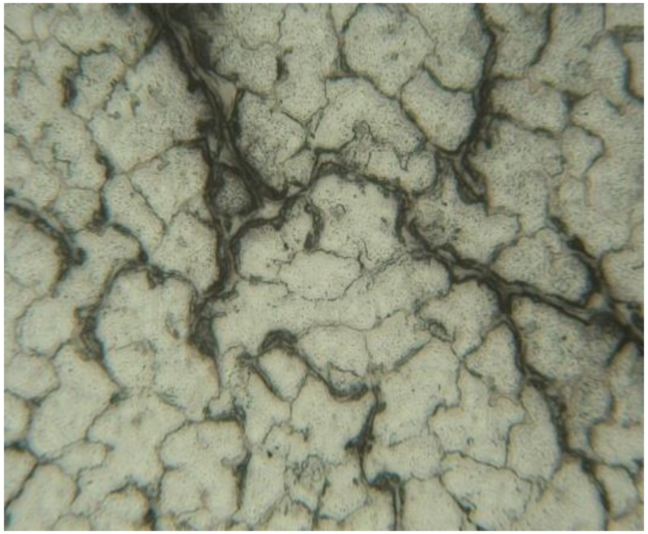
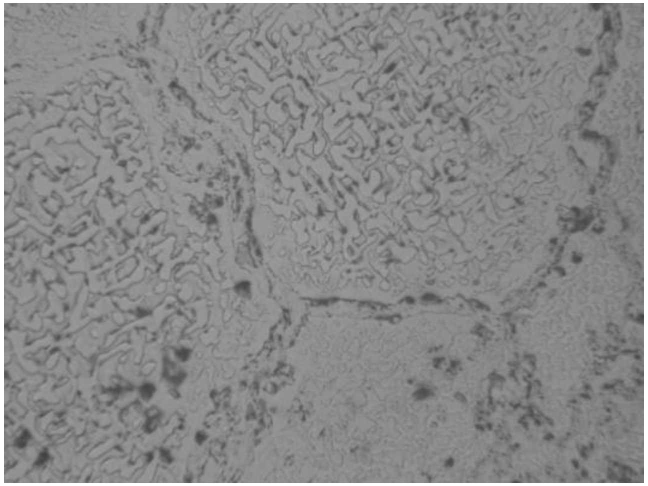
CONDITION ASSESSMENT OF GAS TURBINE FIRST STAGE NOZZLE GE FRAME 9E

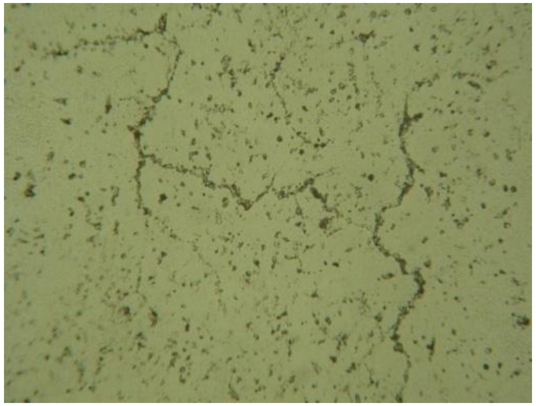
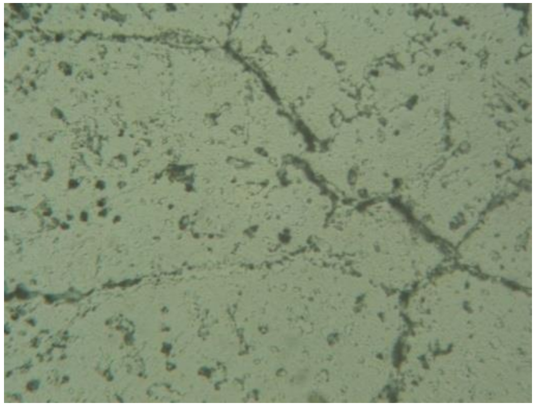
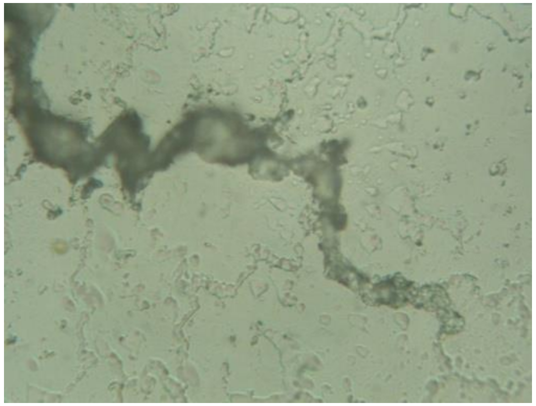




IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE ON FIRST STAGE NOZZLE GE FRAME 9E

CONDITION ASSESSMENT OF GAS TURBINE SECOND STAGE NOZZLE GE FRAME 9E

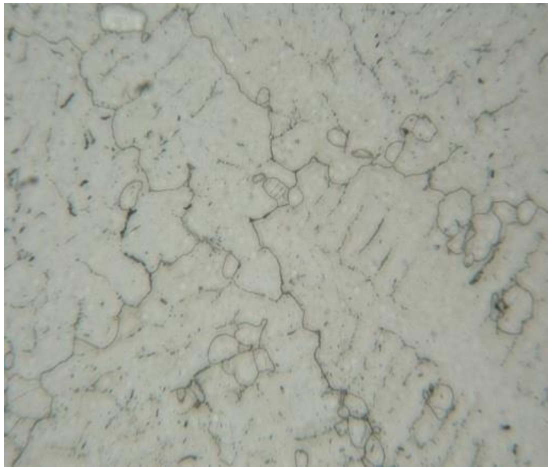
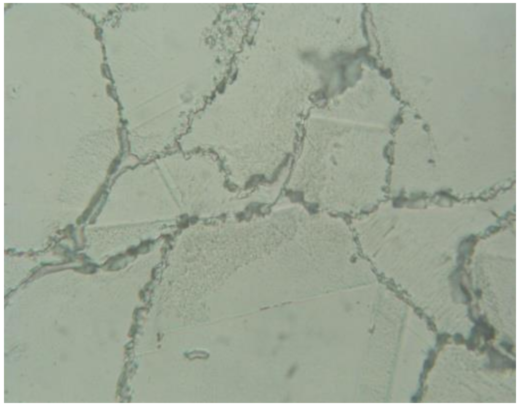
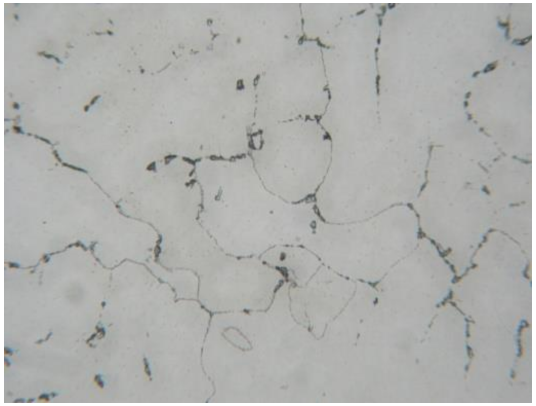
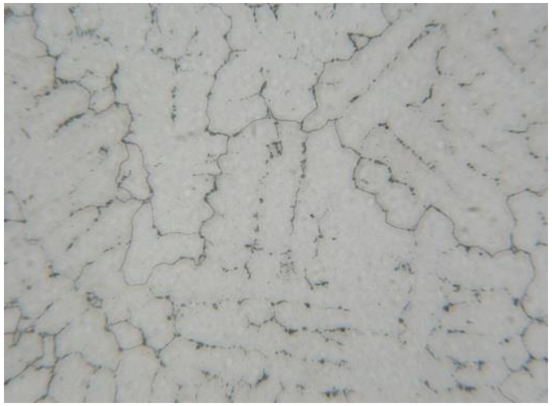


IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE ON SECOND STAGE NOZZLE GE FRAME 9E

CONDITION ASSESSMENT OF GAS TURBINE THIRD STAGE NOZZLE GE FRAME 9E

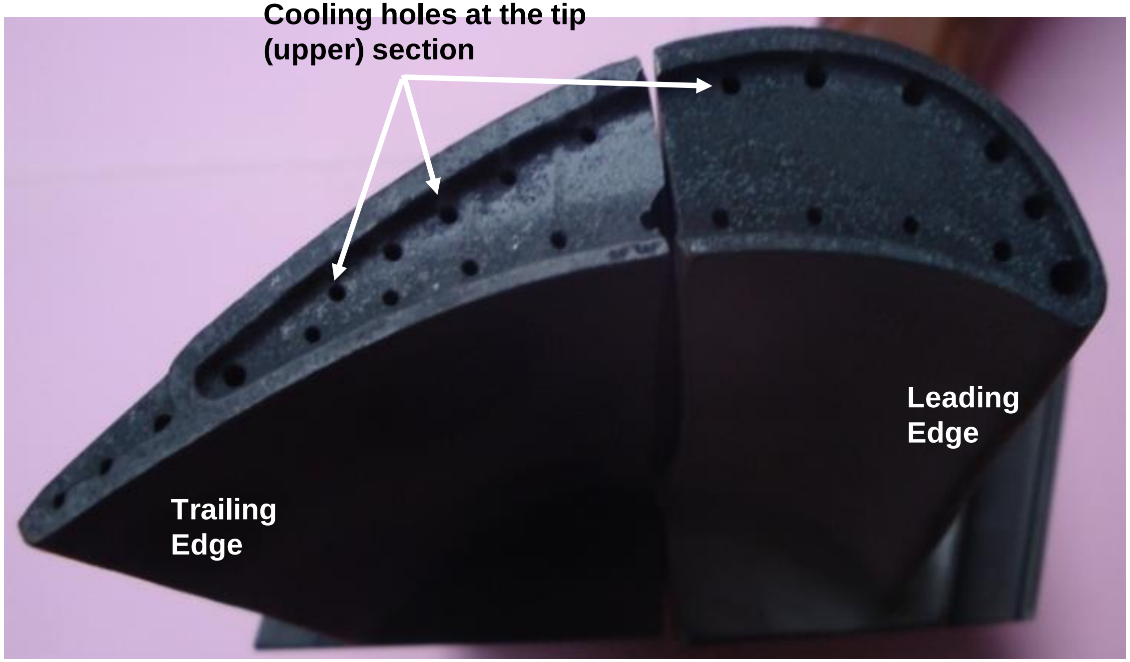


IN-SITU METALLOGRAPHIC EXAMINATION BY REPLICA TECHNIQUE ON THIRD STAGE NOZZLE GE FRAME 9E

CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 1

Cooling holes at the tip (upper) section



Gas Turbine Blade Row # 1

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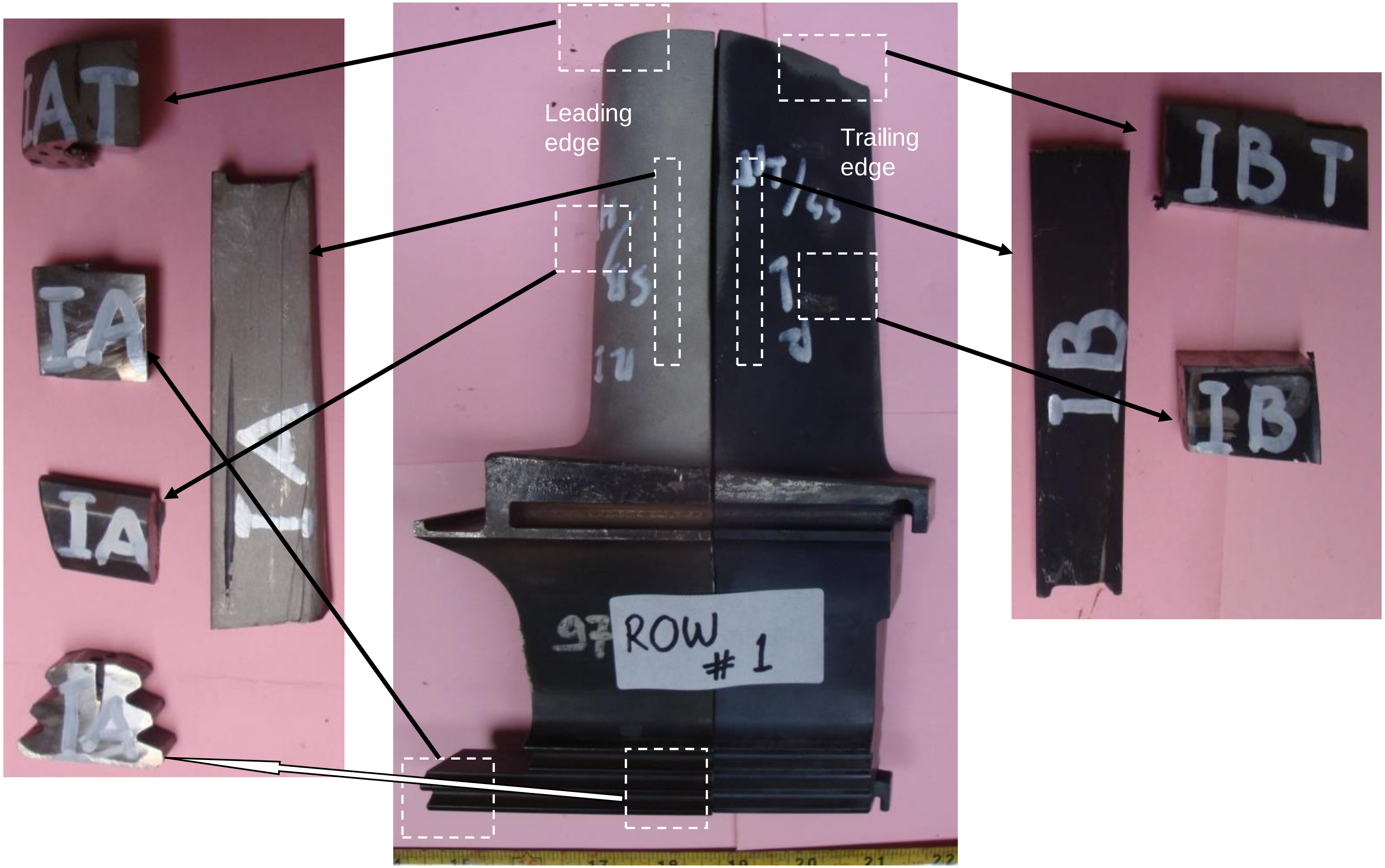
CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 1



Samples preparation obtained from a Ni-base superalloy GT blade row # 1 before and after heat-treatment

CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 1

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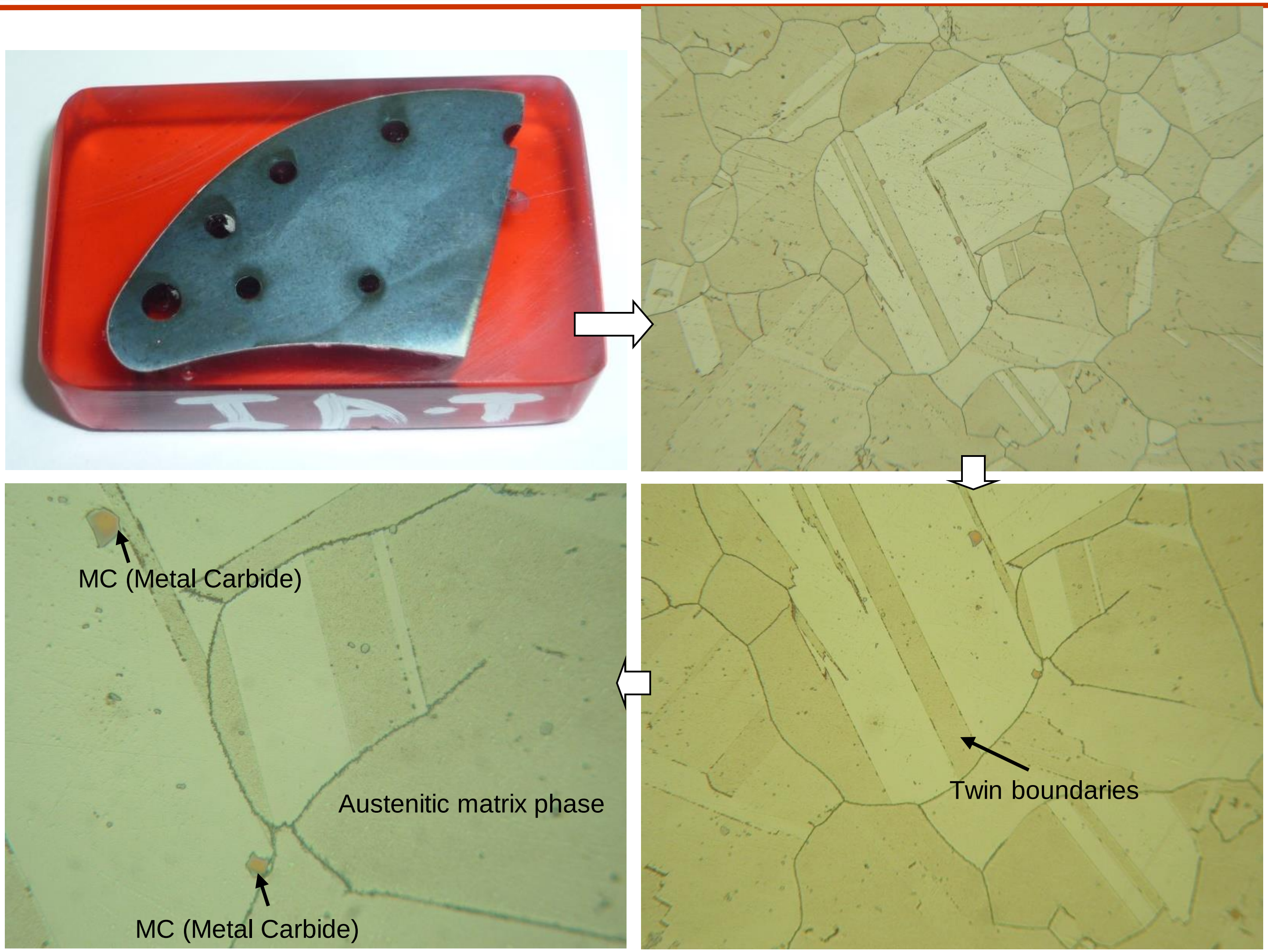
Microstructures obtained from a Ni-base superalloy GT blade row # 1 at its upper section showing no any significant thermal aging due to gamma prime and carbide growth



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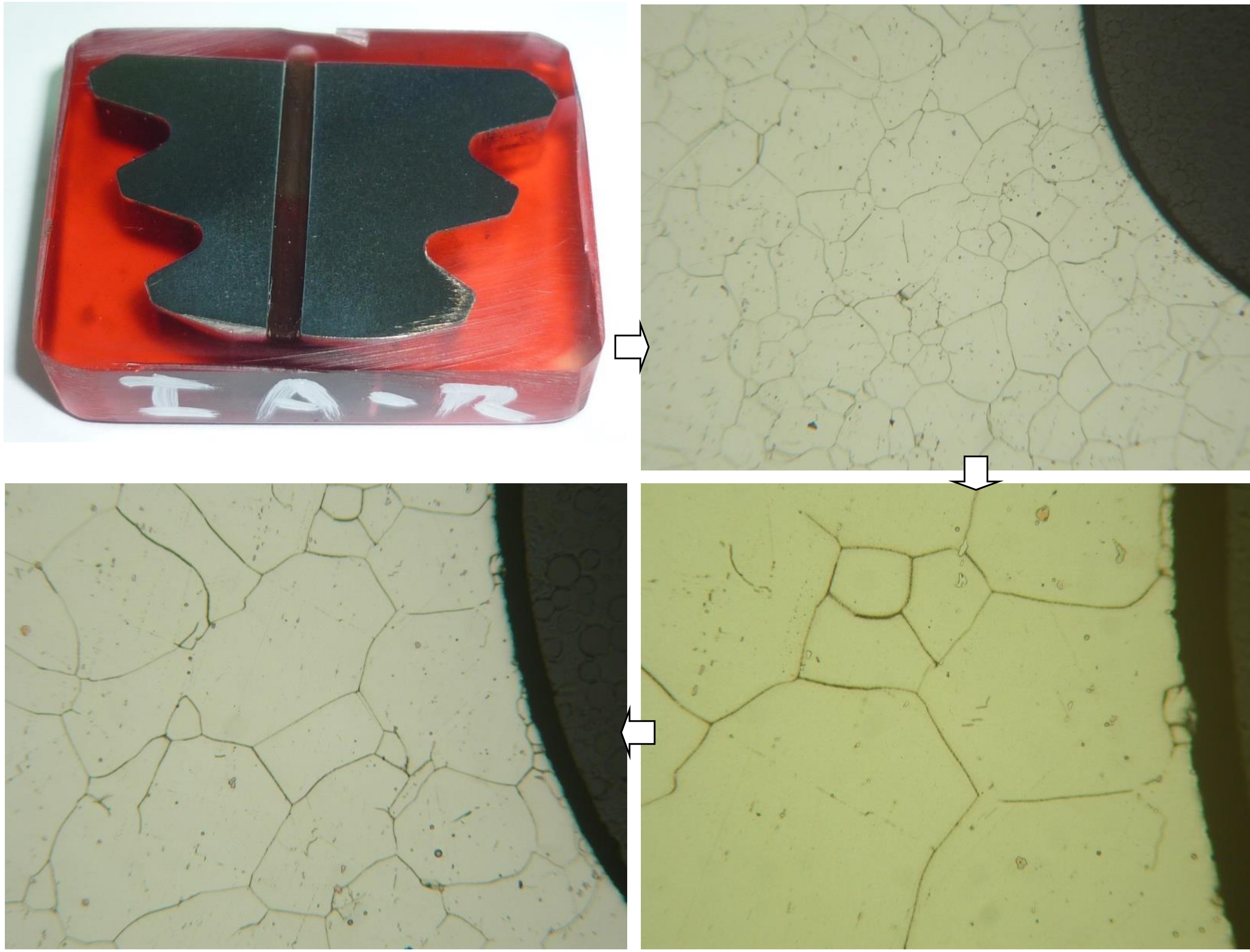
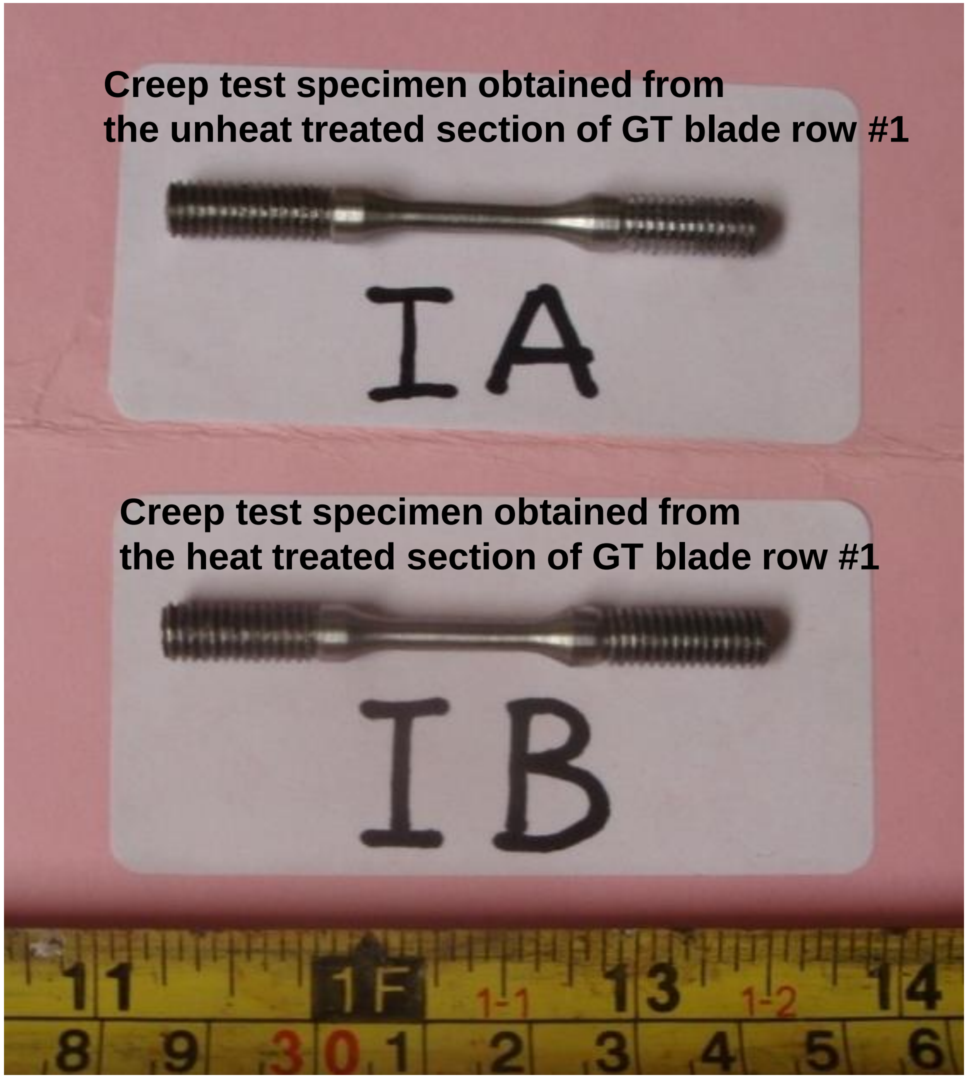
CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 1

Microstructures obtained from a Ni-base superalloy GT blade row # 1 at its root portion around the Christmas tree showing no any significant thermal aging due to gamma prime and carbide growth

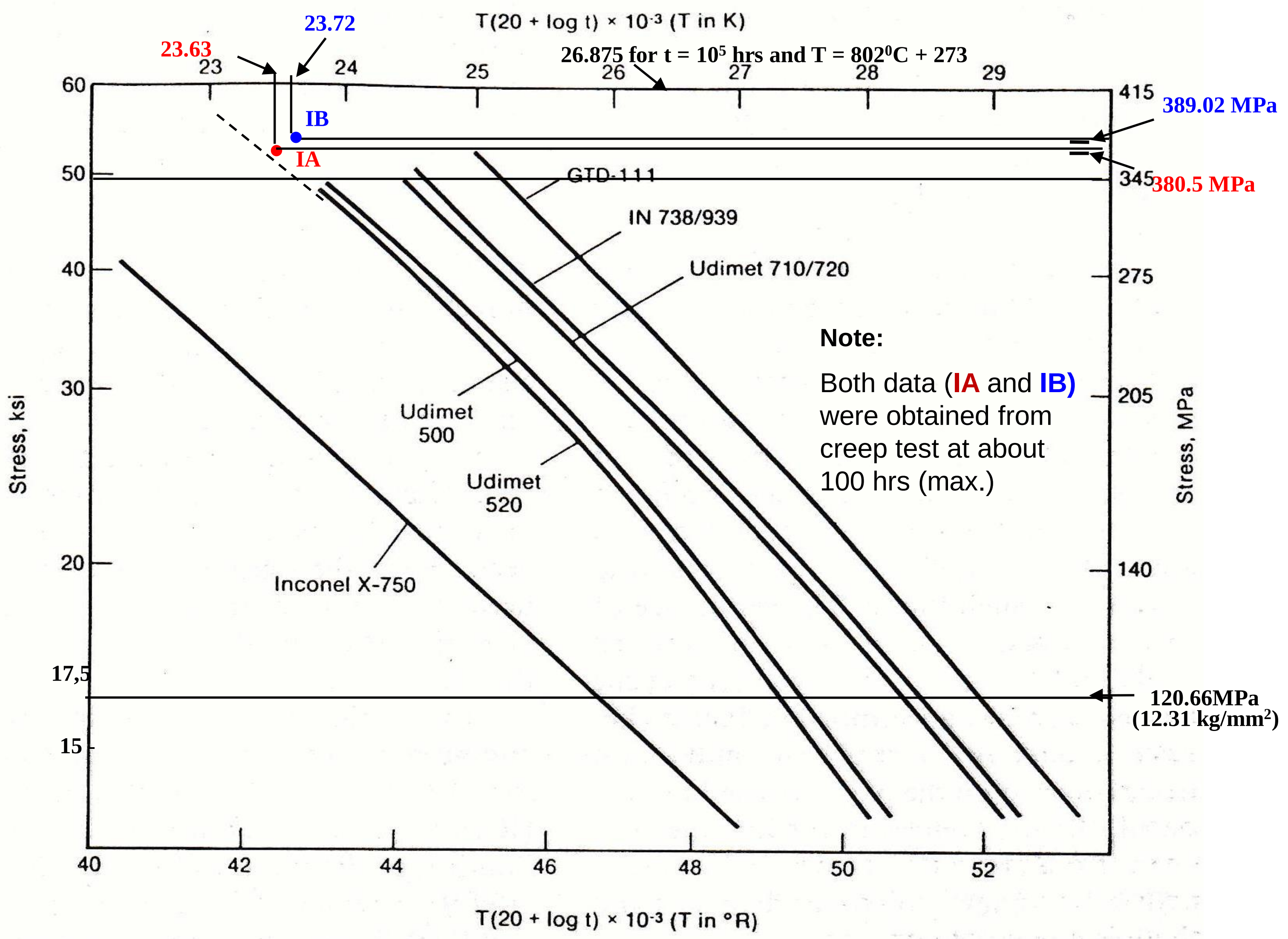


CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 1

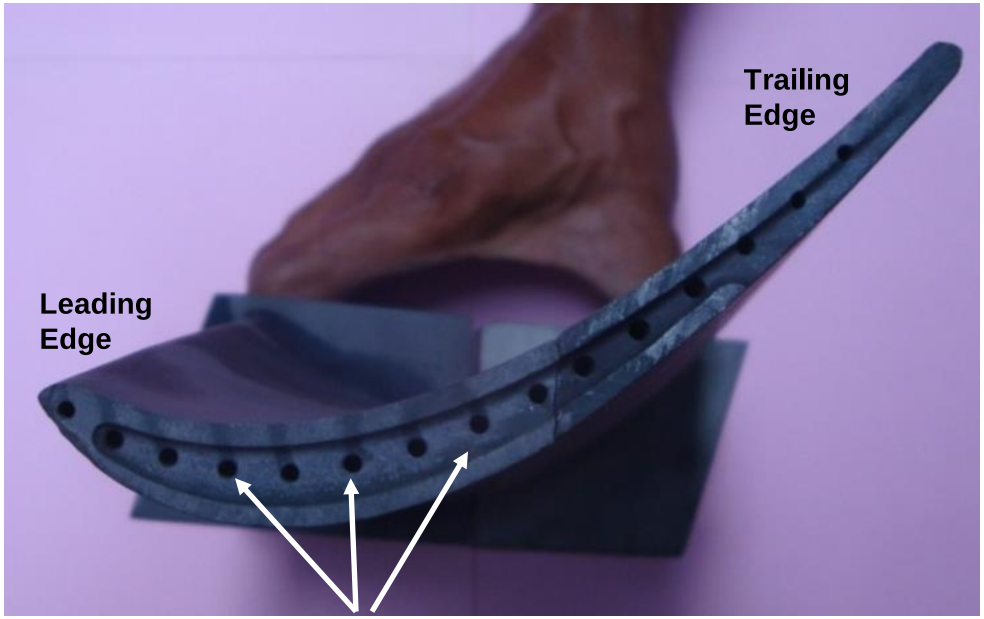


CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 1 (Based on Larson-Miller Curve)

PT. EMPU AGUNG SAKTI



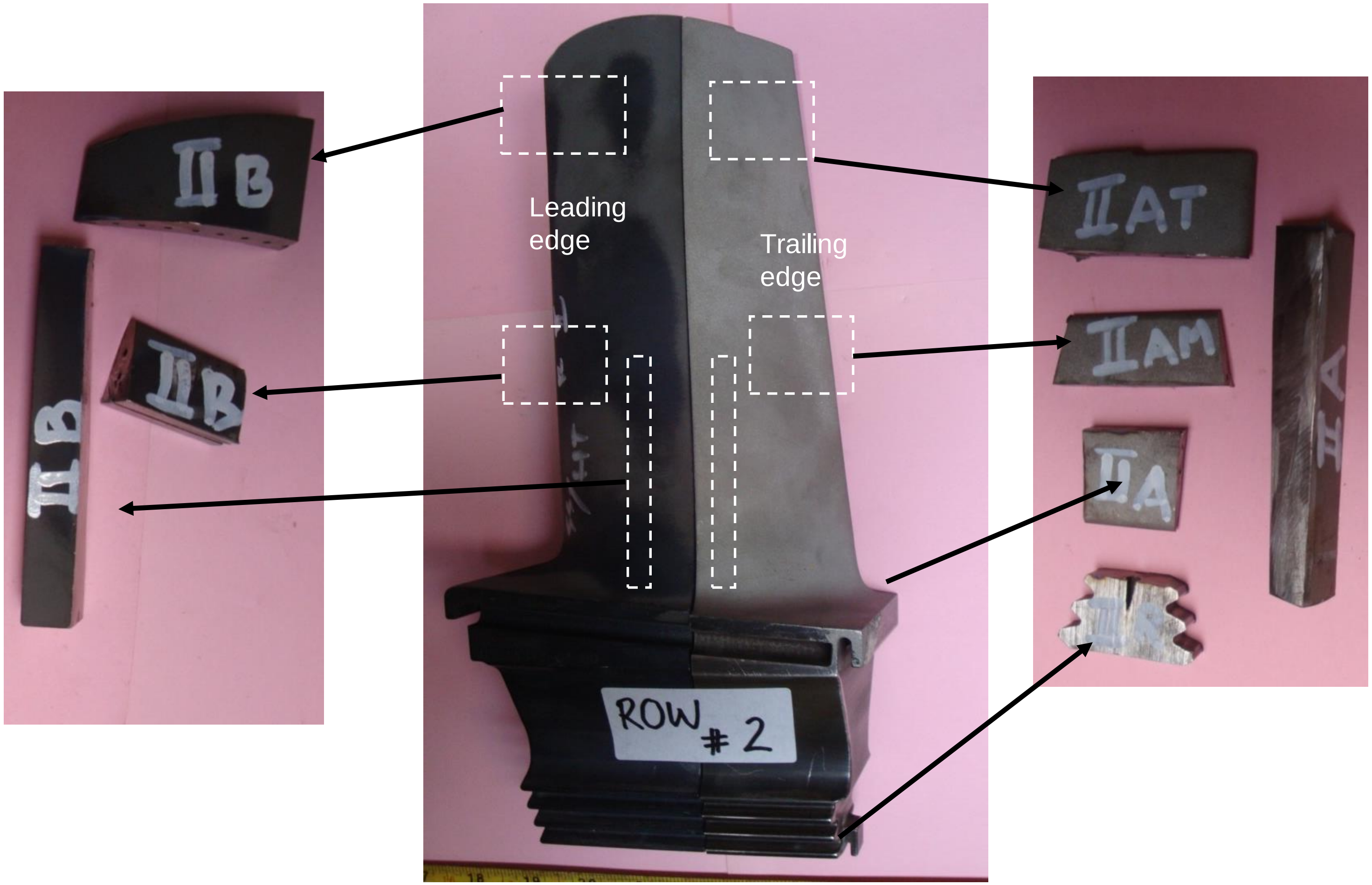
CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 2



Cooling holes at the tip (upper) section

Gas Turbine Blade Row # 2

CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 2



Samples preparation obtained from a Ni-base superalloy GT blade row # 2 before and after heat-treatment

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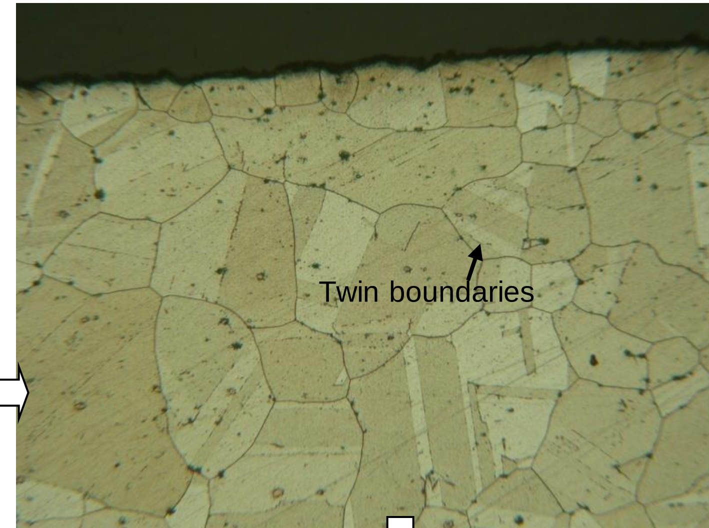
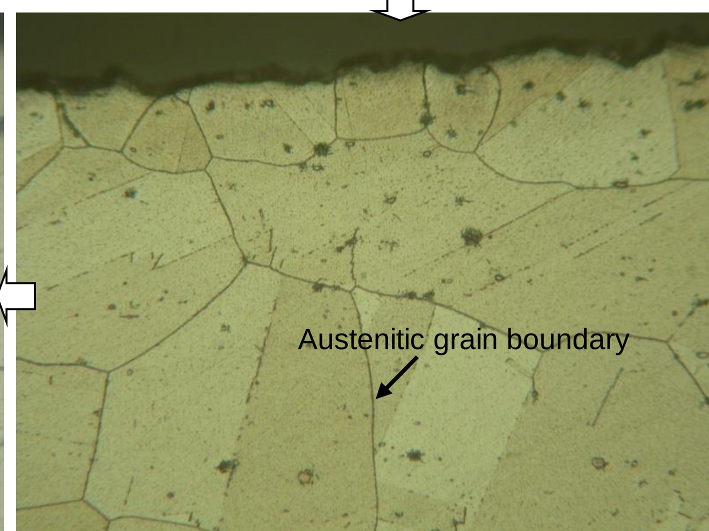
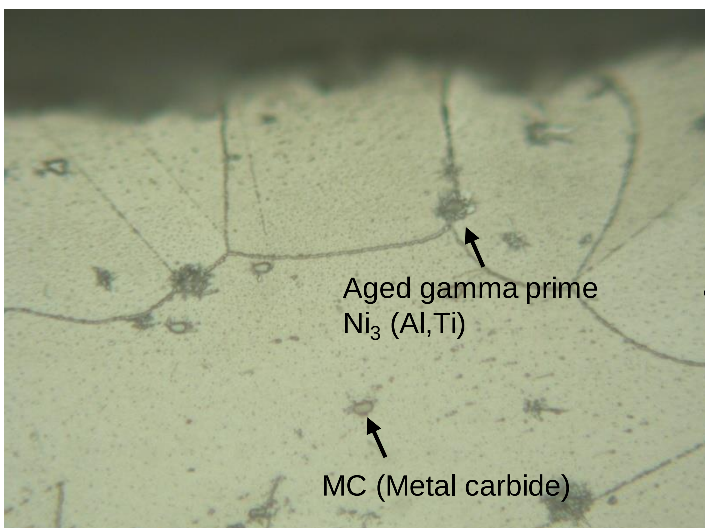
PT. EMPU AGUNG SAKTI

CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 2

Microstructures obtained from a Ni-base superalloy GT blade row # 2 at its upper section showing some mild thermal aging due to gamma prime and carbide growth







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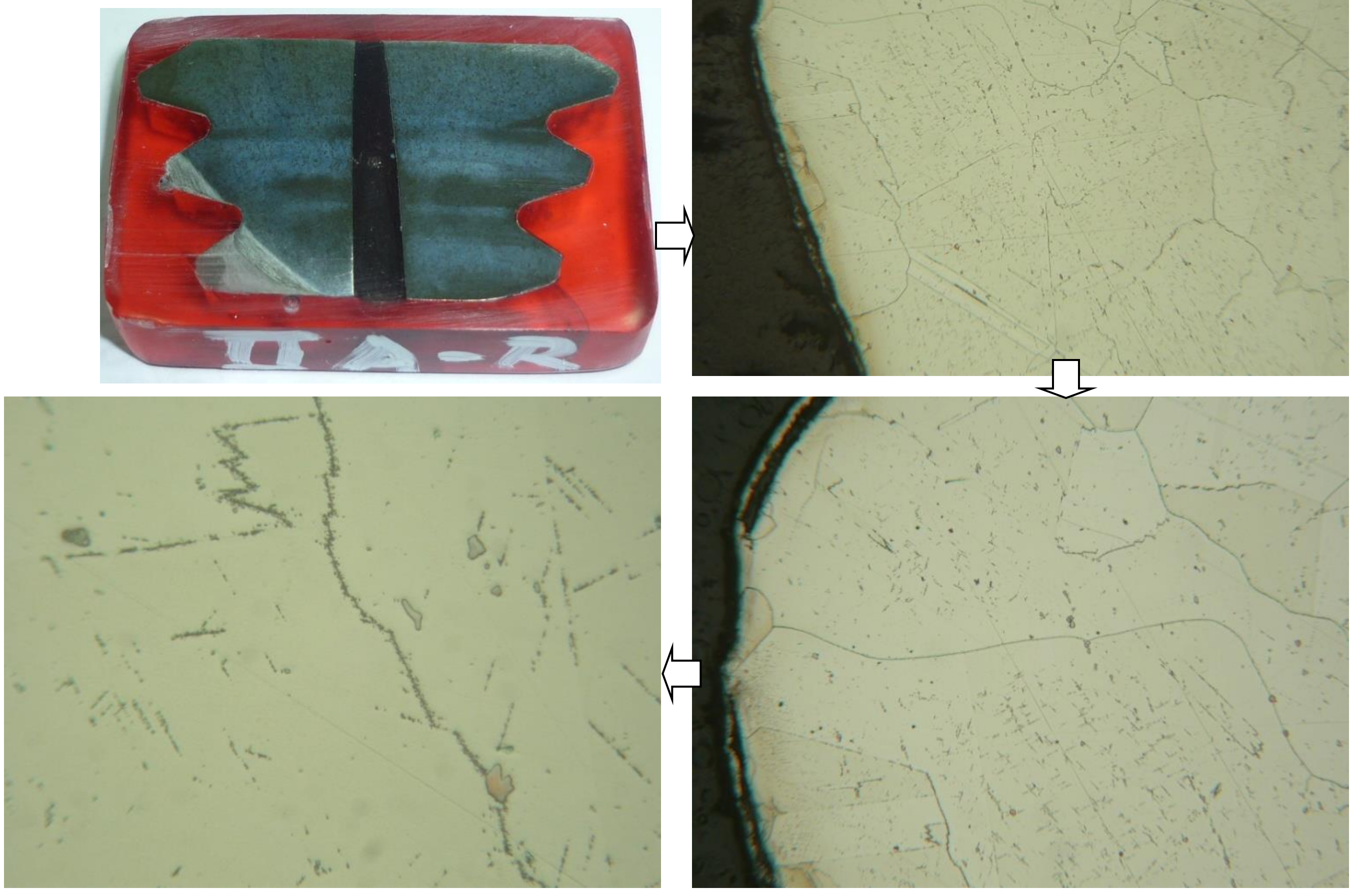
CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 2

Microstructures obtained from a Ni-base superalloy GT blade row # 2 at its root portion around the Christmas tree showing no any significant thermal aging due to gamma prime and carbide growth



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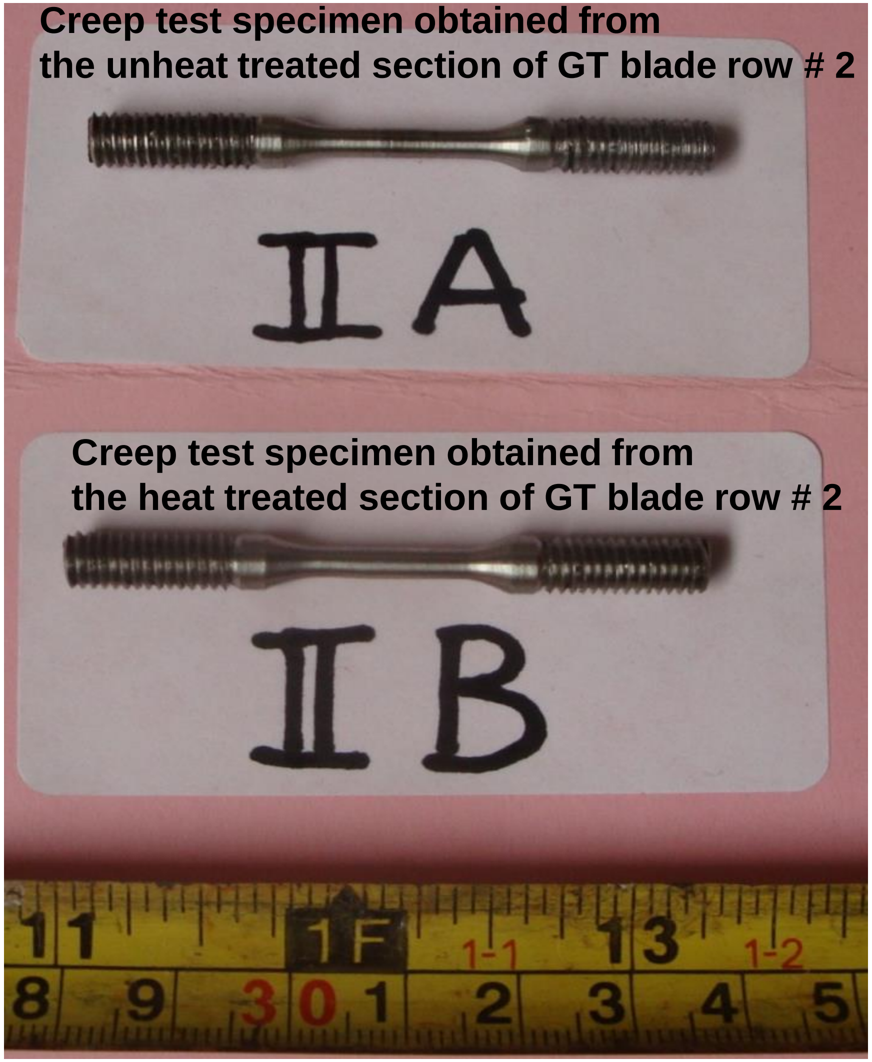
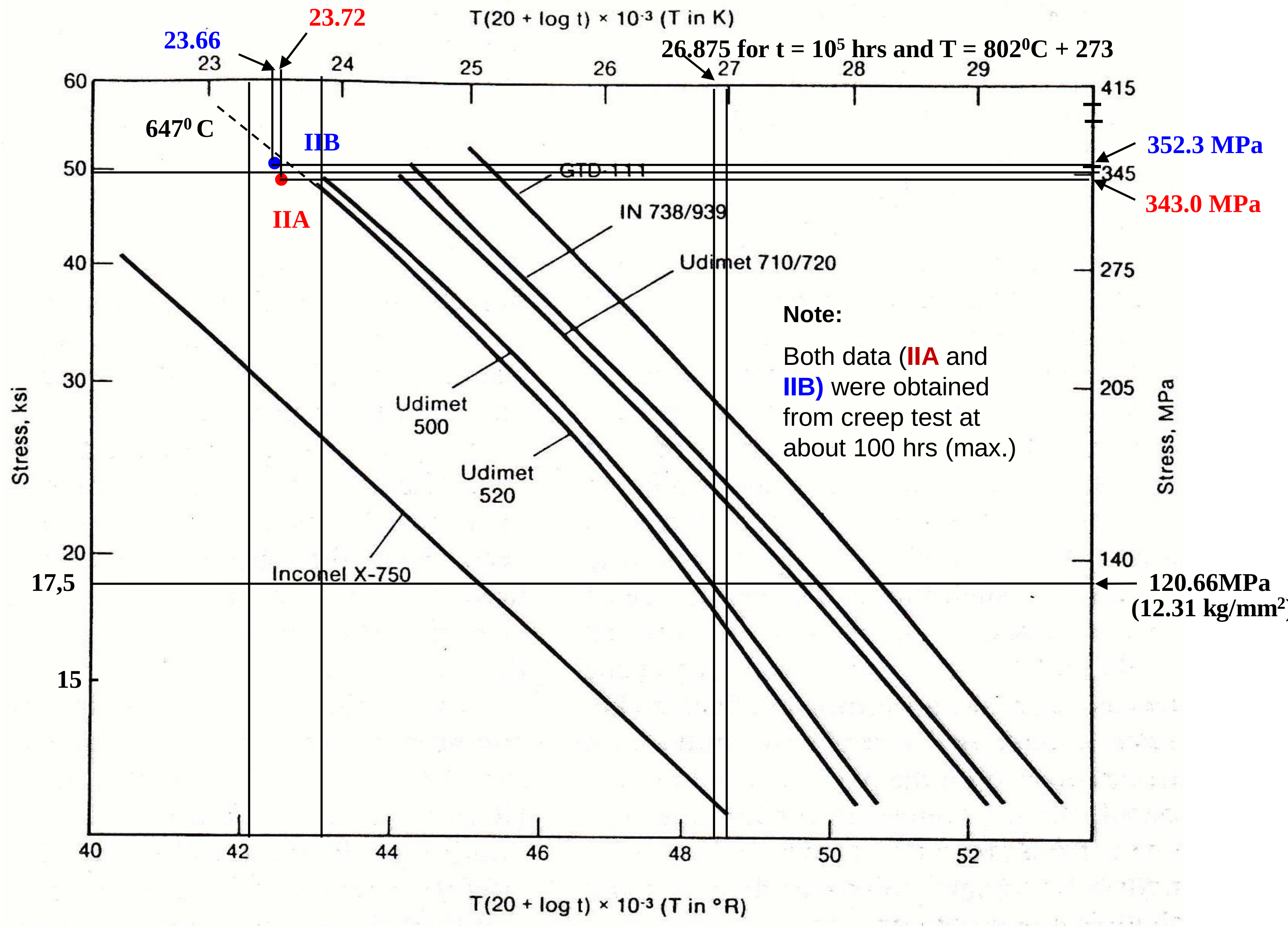
CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 2



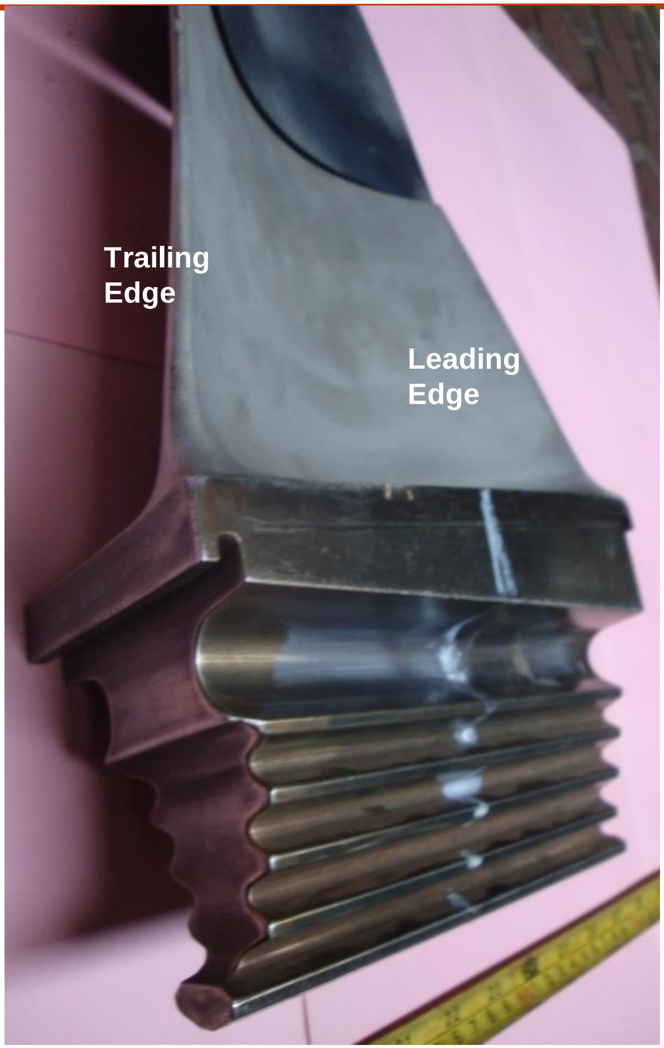
PT. EMPU AGUNG SAKTI

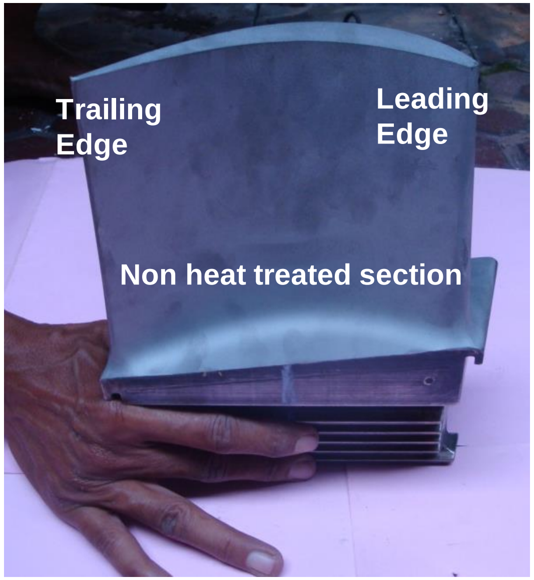
CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 2 (Based on Larson-Miller Curve)



PT. EMPU AGUNG SAKTI

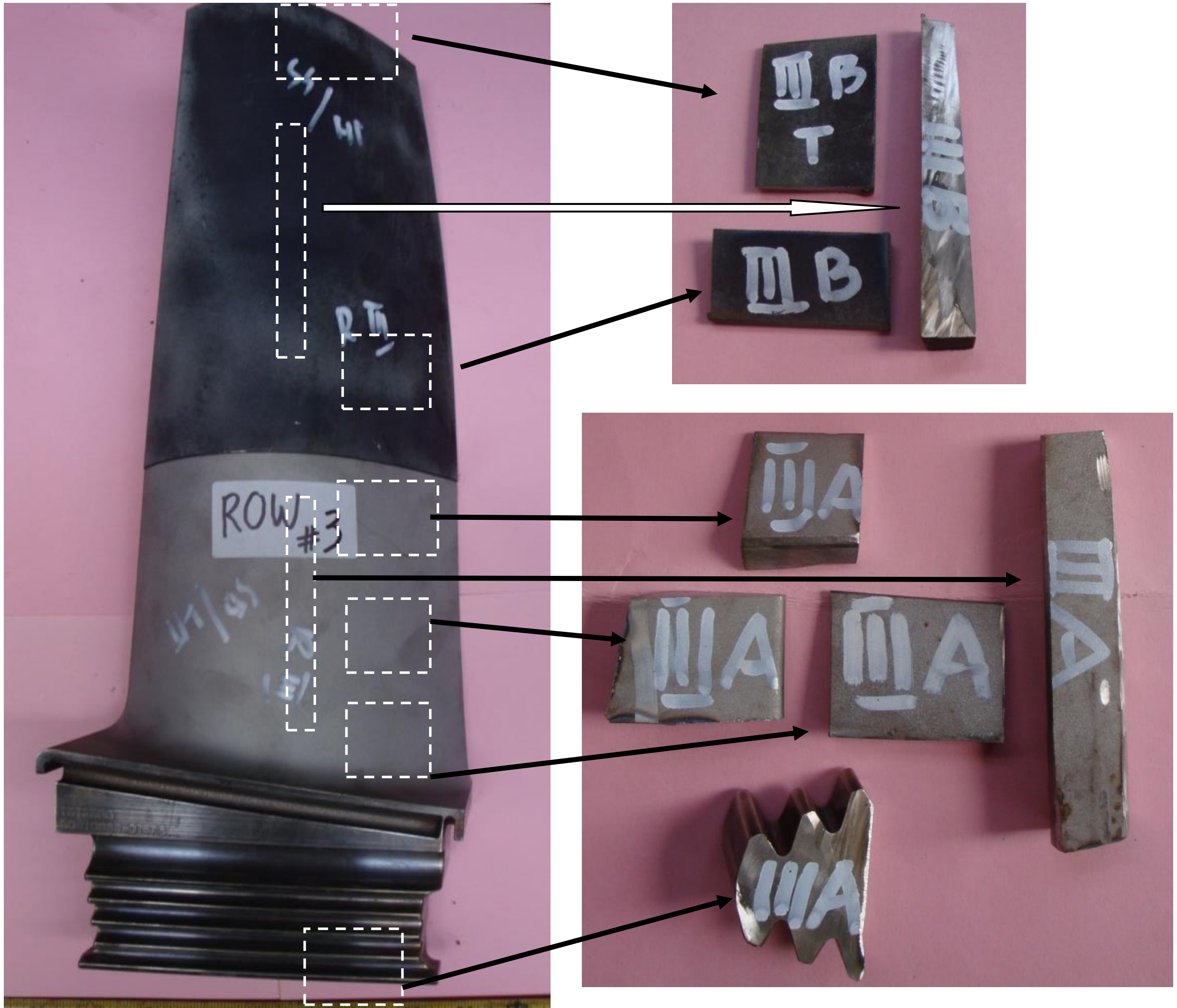
CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 3





Gas Turbine Blade Row # 3

CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 3



Samples preparation obtained from a Ni-base superalloy GT blade row # 3 before and after heat-treatment

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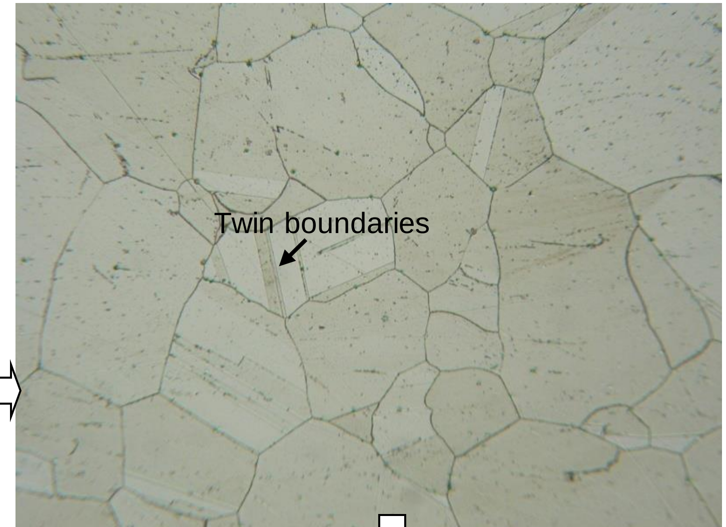
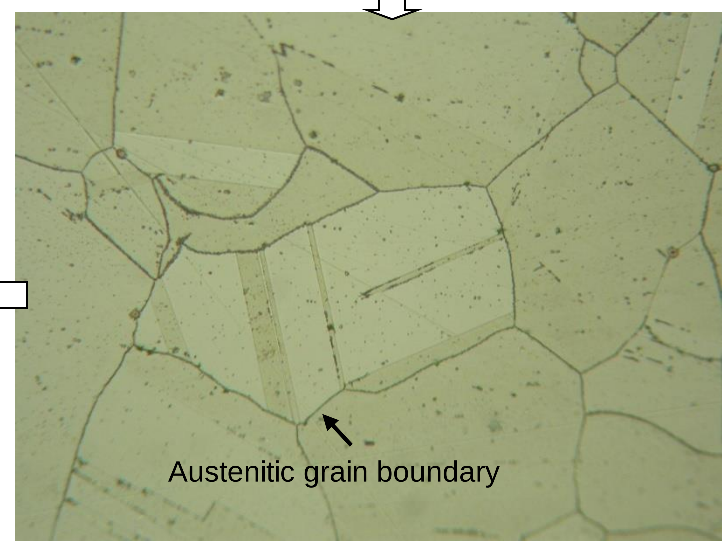
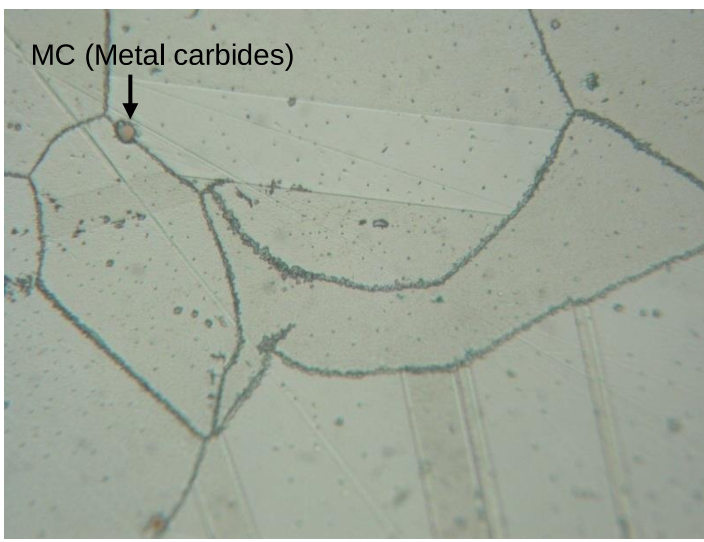
CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 3

Microstructures obtained from a Ni-base superalloy GT blade row # 3 at its upper section showing no any significant thermal aging due to gamma prime and carbide growth







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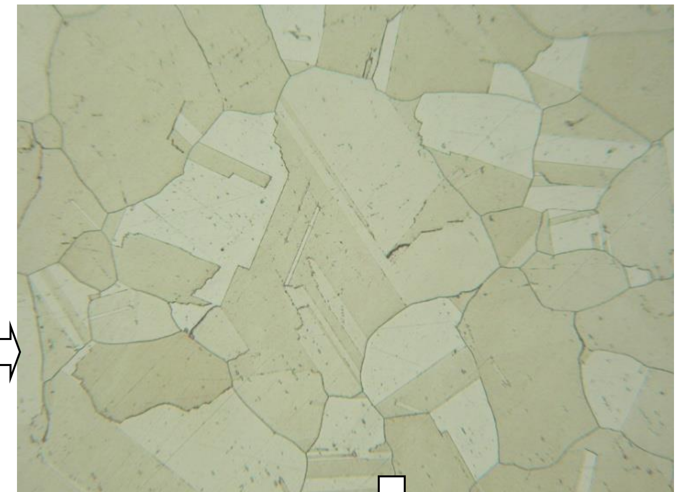
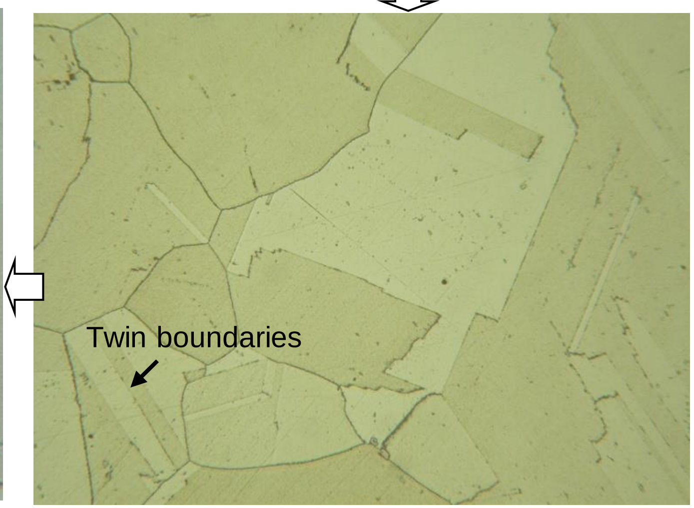
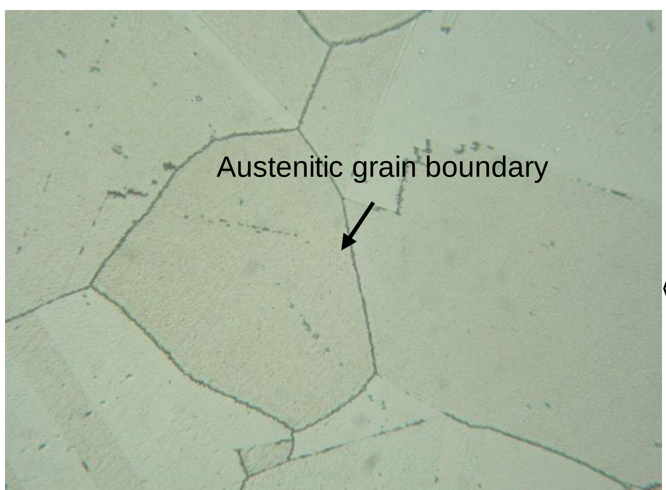
CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 3

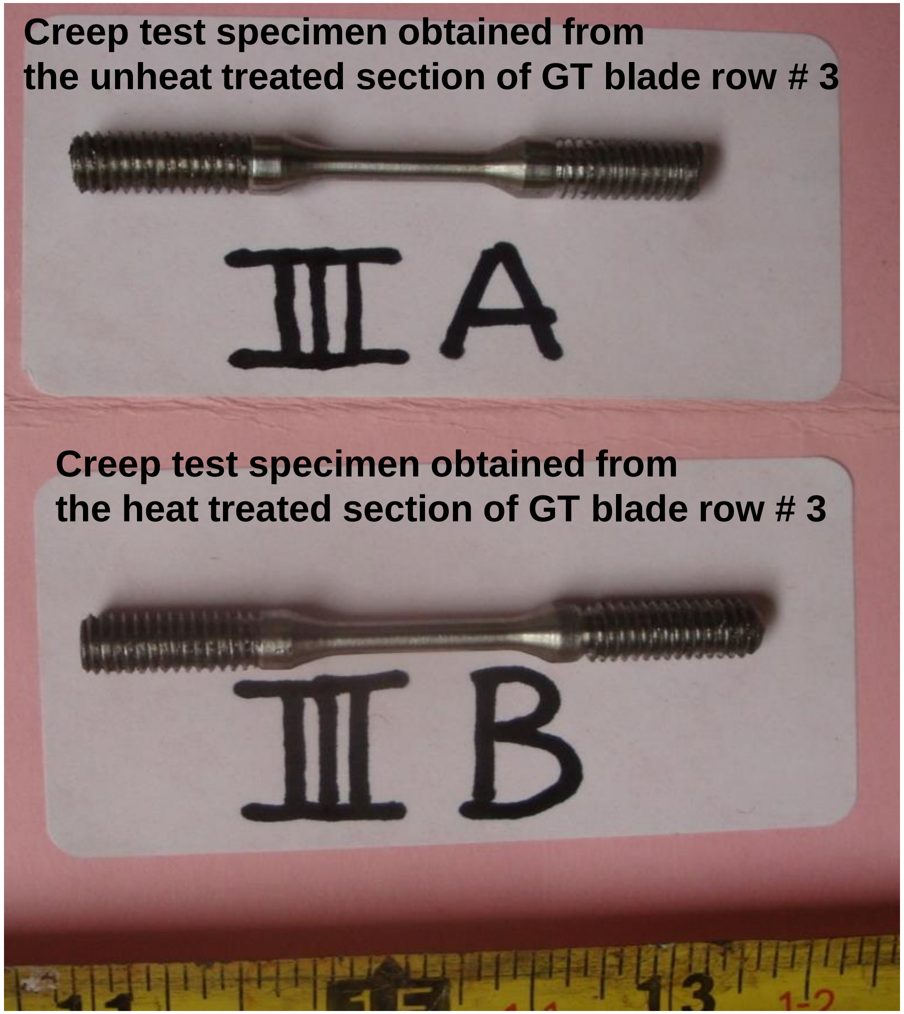
Microstructures obtained from a Ni-base superalloy GT blade row # 3 at its root portion around the Christmas tree showing no any significant thermal aging due to gamma prime and carbide growth







CONDITION ASSESSMENT OF GAS TURBINE BLADES ROW # 3



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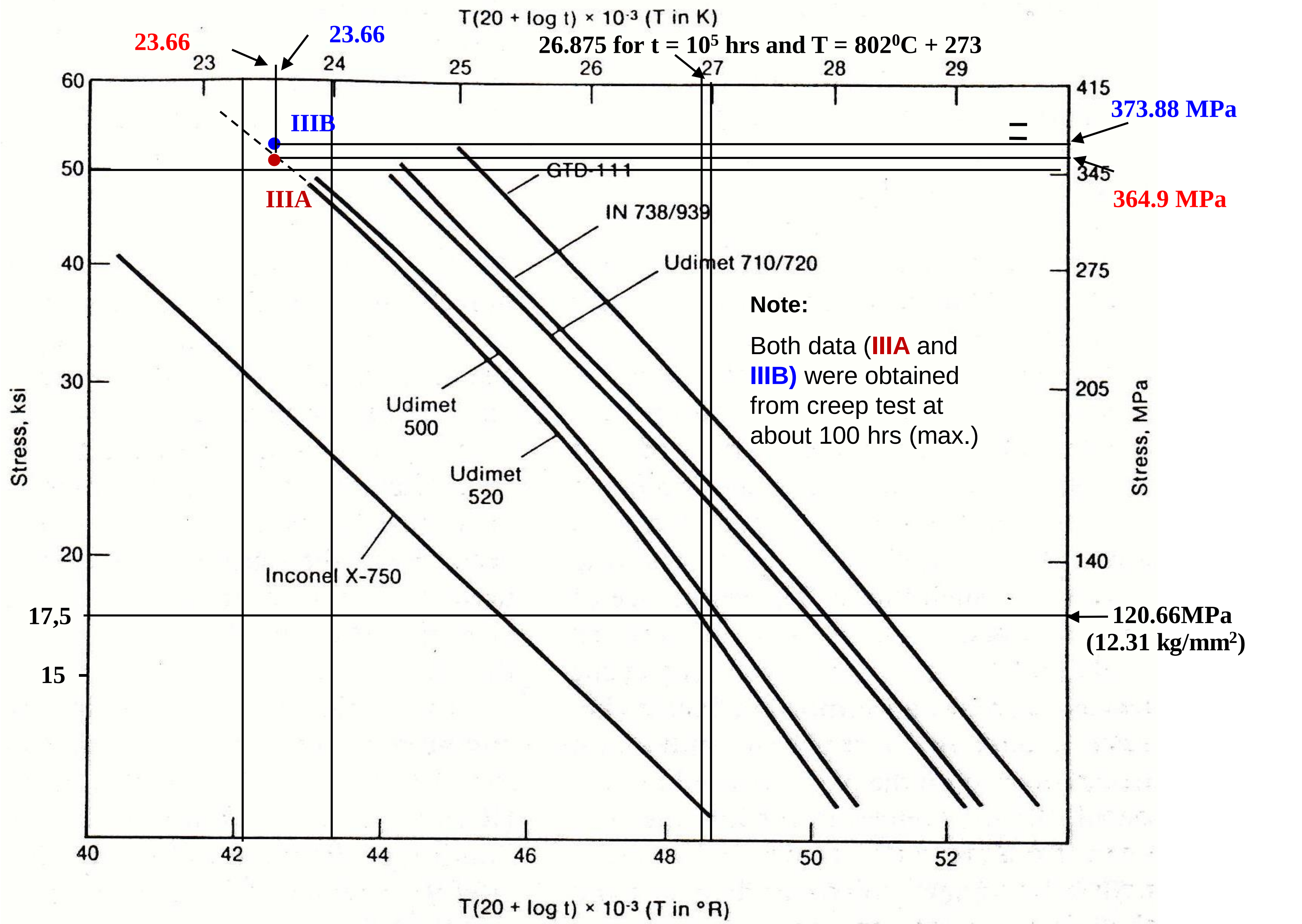
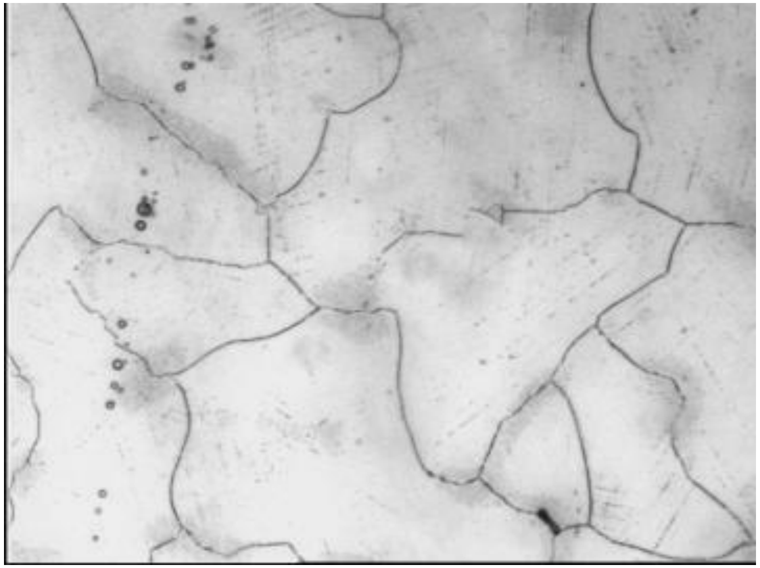
CONDITION ASSESSMENT OF GAS TURBINE BLADE ROW # 3 (Based on Larson-Miller Curve)



CONDITION ASSESSMENT OF GAS TURBINE BLADES 1st AND 2nd STAGES

Second Stage GT Blade



Microstructure obtained from replica test of a Ni-base super alloy GT blade

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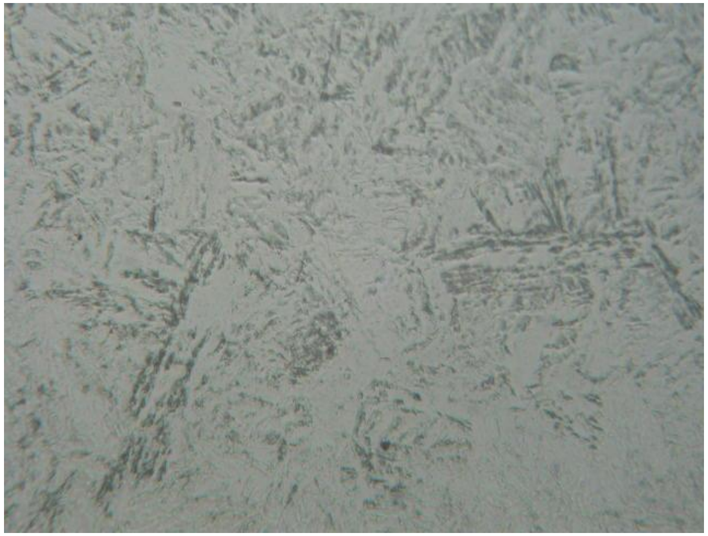
CONDITION AND USEFUL LIFE ASSESSMENT OF GAS TURBINE COMPRESSOR AND TURBINE DISK



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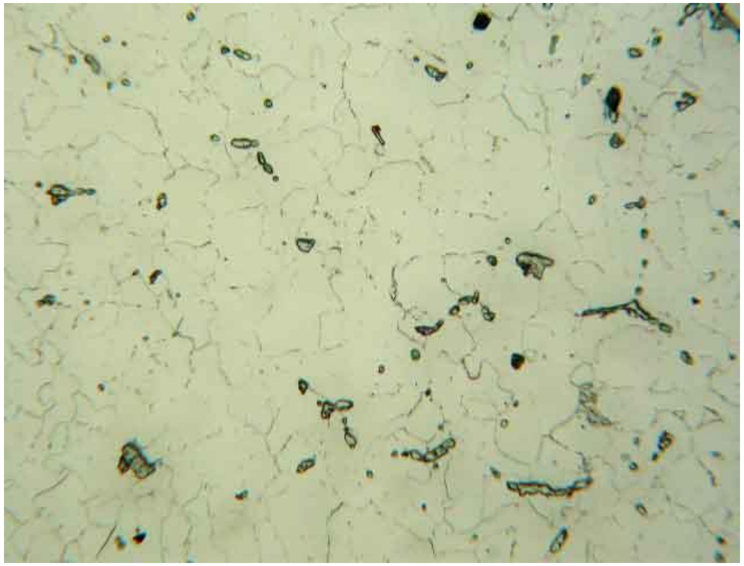
CONDITION LIFE ASSESSMENT OF GAS TURBINE CASING COMBUSTION CHAMBER



Photograph of a gas turbine casing combustion chamber that had experienced some bulging at location near to a burner nozzle.

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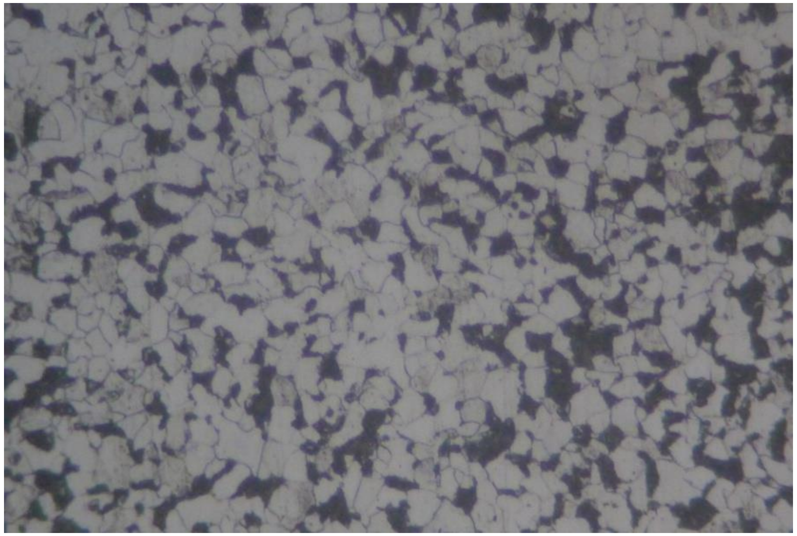
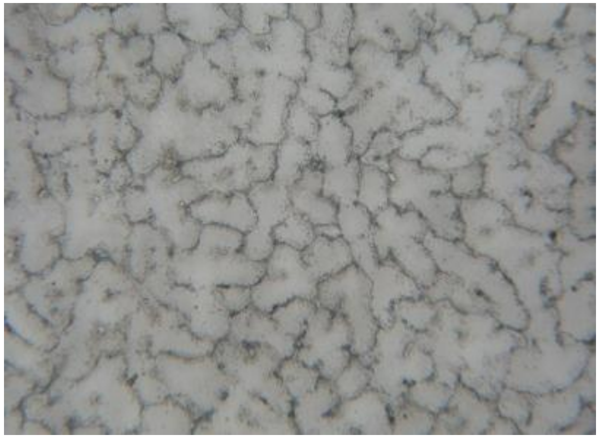
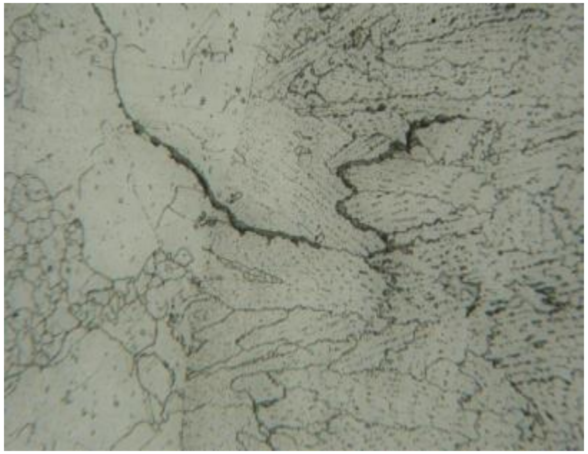
CONDITION LIFE ASSESSMENT OF GAS TURBINE HOUSING CHAMBER

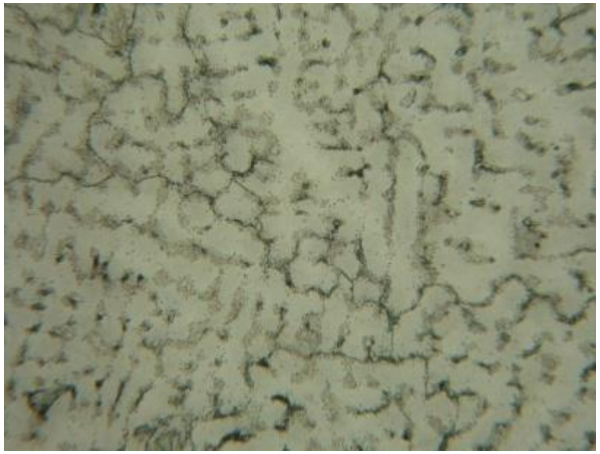


Photograph of two gas turbine housing chambers and the corresponding microstructures obtained from the in-situ metallographic examination .

CONDITION ASSESSMENT OF GAS TURBINE SECOND STAGE NOZZLE







Assessment of Second Stage Nozzle by In-Situ Metallographic Examination

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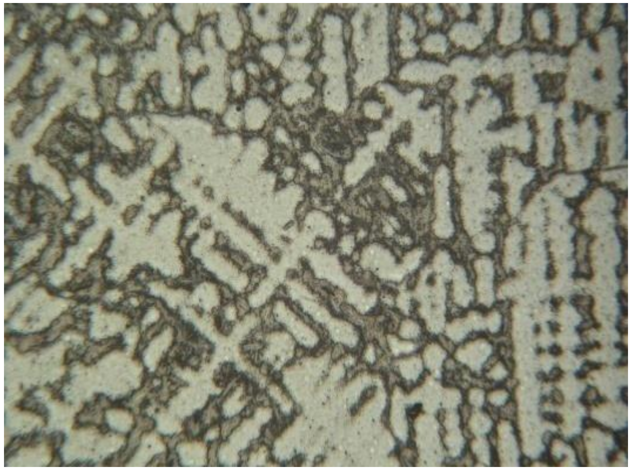
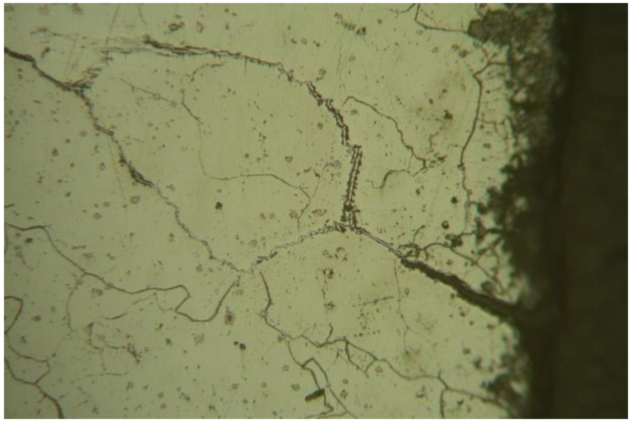
CONDITION ASSESSMENT OF DIESEL ENGINE TURBOCHARGER NOZZLE RING





Assessment of Turbocharger Nozzle Ring by In-Situ Metallographic Examination

LIST OF REFERENCES

1. ASME Boiler & Pressure Vessel Code
2. ASM International Handbook
3. *Boiler Condition Assessment Guideline*, EPRI 4th Ed., Palo Alto, CA, 2006
4. API Standard 530: *Calculation of Heater Tube Thickness in Petroleum Refineries*
5. API RP 571: *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*
6. API RP 572: *Inspection of Pressure Vessels (Towers, Drums, Reactors, Heat Exchangers and Condensers)*
7. API 579-1/ASME FFS-1: *Fitness-for-Service*
8. API RP 580 : *Risk-Based Inspection*

III. QC/QA FOR VENDOR'S PRODUCT FABRICATION / MANUFACTURING SURVEILLANCE

These services include:

- Development of WPS (Welding Procedure Specification)
- Quality Control and Vendor Quality Surveillance
- Assessment of Procedures and Specifications
- Quality Improvement of Product/Component Manufacturing Processes (Reverse Engineering and Re-Engineering)

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EMAS
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WPS-PQR QUALIFICATION


Mobil Cepu Ltd.
TRIPATRA-SAMSUNG CONSORTIUM
PT INWHA INDONESIA

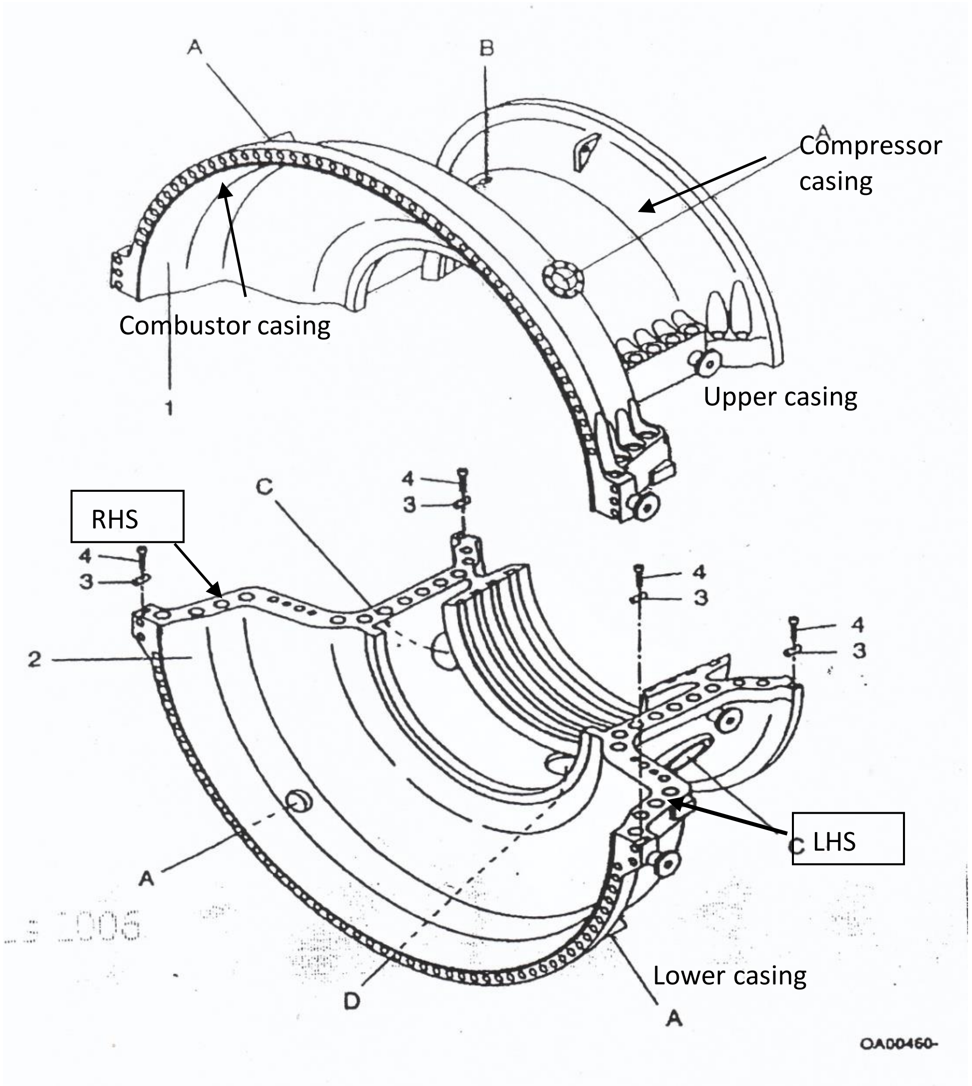
MOBILE CEPU LIMITED - TRIPATRA - SAMSUNG CONSORTIUM
PT. INWHA INDONESIA - PT. BOJONEGORO PUTERA JO

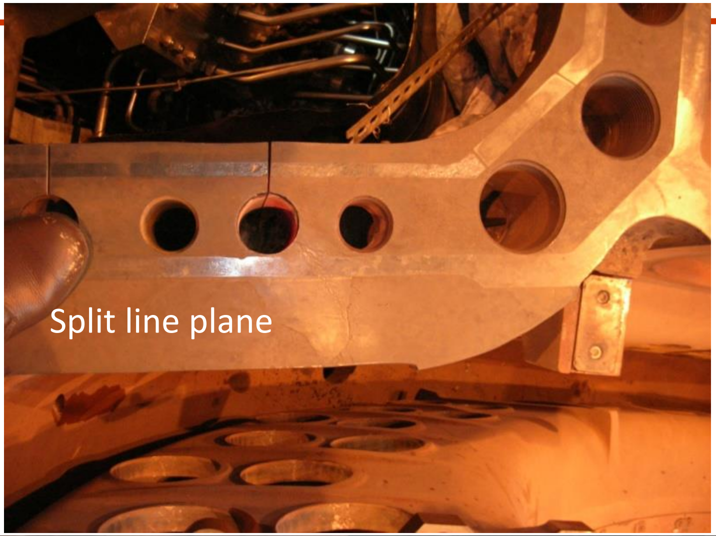
BANYU URIP PROJECT

CENTRAL PROCESSING FACILITY

WELDING PROCEDURE SPECIFICATION
ASME SECTION IX

PRE-REPAIR ASSESSMENT ON CRACKED GAS TURBINE COMBUSTOR CASING





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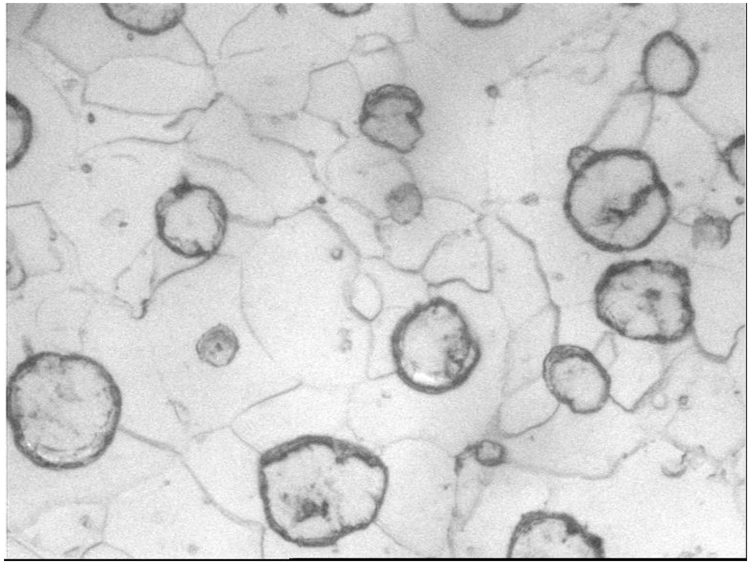
QC ASSESSMENT ON REPAIR WELDED GAS TURBINE COMBUSTOR CASING



In-situ metallographic examination on some repair welded area of a gas turbine combustor casing.
Material casing: Nodular cast iron.
Filler metal:
AWS A5. 15 (E NiFe-Cl)

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EXPERIENCES RECORD

No	Work Assignment and Date	Client
1	**In-Situ Metallography pada GT Hot Path Components (Nozzles, Transition Pieces and Combustion Liners),** Juli 2020	PT. PLN (Persero) PUSHARLIS UP2W III, Bandung
2	**Replica Test on Top Return Bends and LMPH Tubes of Furnace BA-101,** Juni-Juli 2020	PT. Chandra Asri Petrochemical, Tbk
3	**Online Training QA/QC Overhaul Mesin dan Peralatan Mekanik Pembangkit, Batch-2,** Juni 2020	PT. PJB Unit PJB Academy
4	**Online Training QA/QC Overhaul Mesin dan Peralatan Mekanik Pembangkit, Batch-1,** Mei 2020	PT. PJB Unit PJB Academy
5	**In-Situ Metallography dan Hardness Test Pada Saat COC Unit AHU #12 Tahun 2020 di Kilang Pertamina RU VI Balongan,** Maret-Mei 2020	PT. Sucofindo (Persero) Cabang Cirebon/PT. Pertamina RU VI Balongan
6	**In-Situ Metallography dan Hardness Test pada Peralatan di Area CDU & RCC saat Pit Stop Tahun 2020 di Kilang Pertamina RU VI Balongan,** Maret-April 2020	PT. Nusakura Standarindo Cabang Cirebon/PT. Pertamina RU VI Balongan

PT. EMPU AGUNG SAKTI

EXPERIENCES RECORD

No	Work Assignment and Date	Client
7	**Replica Test on LMPH Tubes of Cracking Furnace BA-105,** Maret-April 2020	PT. Chandra Asri Petrochemical, Tbk
8	**Laboratory Examination on Carbon Steel Pipes,** Maret 2020	PT. Paradise Perkasa
9	**Pengujian Laboratorium Scale/Deposit yang berasal dari HPTBV (High Pressure Turbine Bypass Valve) HRSG 2.2 PLTGU Blok-2 ,** Februari 2020	PT. PJB UP Muara Karang
10	**In-Situ Metallography dan Hardness Test pada EV Burner, Front Segment dan Lance,** Januari-Februari 2020	PT. NHTS
11	**In-Situ Metallografi dengan Teknik Replika pada 1st Stage Bucket dan 2nd Stage Bucket**, Januari-Februari 2020	PT. GMF Aeroasia
12	**Jasa RLA HRSG 3.1 Level 3,** November 2019 - Januari 2020	PT. PJB Unit Pembangkitan Gresik

PT. EMPU AGUNG SAKTI

EXPERIENCES RECORD

No	Work Assignment and Date	Client
13	**On-Site Metallurgical Assessment of BFW Convection Section of Furnace BA-105**, September 2019	PT. Chandra Asri Petrochemical, Tbk
14	**Pengujian In-Situ Metallography dengan Teknik Replika pada Boiler 2001B Furnace Front Wall Tube,** September 2019	PT. Chandra Asri Petrochemical, Tbk
15	**On-Site and Laboratory Examinations of Structural Beams,** September 2019	PT. Sari Dumai Sejati, Riau
16	**In-Situ Metallographic Examination and Hardness Test of Various Equipment Packages di PT Chandra Asri Petrochamical,** Agustus-September 2019	PT. Biro Klasifikasi Indonesia, Banten
17	**In-Situ Metallography dengan Teknik Replika pada Vane Segment Row #1 dan Turbine Blade Row #3,** Juli-Agustus 2019	PT. GMF Aeroasia
18	**Laboratory Examination on Pipe Samples,** Juli 2019	PT. Sari Dumai Sejati, Riau

EXPERIENCES RECORD

No	Work Assignment and Date	Client
19	**QC In Fabrication of Intermediate Shaft,** Juni-Juli 2019	PT. Pertamina (Persero) RU V Balikpapan
20	**Destructive Tests of Turbine Blade Row # 1, Row # 2 dan Row # 3,** Juni-Juli 2019	PT. GMF AeroAsia
21	**Jasa Analisa Komposisi Deposit Filter Lube Oil ST 1.4.** April 2019	PT PJB UP Muara Tawar
22	**In-Situ Metallography dengan Teknik Replika pada Vane Segment Row 1 & 2 dan Ring Shroud Segment Row 2,** Maret 2019	PT. GMF AeroAsia
23	**Pengujian Laboratorium Temuan Scale/Deposit Pada Gas Separator dan TCA Strainer PLTGU BLOK 2,** Februari 2019	PT. PJB UP Muara Karang
24	**Jasa Analisa Komposisi Deposit HRSG 5.1 Dan HRSG 1.3**, Januari - Februari 2019	PT. PJB UP Muara Tawar
25	**Pengujian In-situ Metallography Pada Bucket 1st Stage Gas Turbine PLTGU Talang Duku**, Januari-Februari 2019	PT. PLN (Persero) PUSHARLIS UP2WIII Bandung

EXPERIENCES RECORD

No	Work Assignment and Date	Client
26	**Pekerjaan In-situ Metallography Pada Mixer dan Beam Structure Di PT. Hustman Indonesia,** Januari-Februari 2019	PT. Sucofindo (Persero)
27	**Failure Analysis of Feed Preheater Tube BE-504B**, Januari-Februari 2019	PT. BP Petrochemicals Indonesia
28	**Pengujian In-situ Metallography Pada Gas Turbine Hot Parts PLTGU Talang Duku**, Januari 2019	PT. PLN (Persero) PUSHARLIS UP2WIII Bandung
29	**Analisa Sample Serbuk (Scale) yang Terjadi pada H2 Generator PLTGU Blok-2**, Desember 2018	PT. PJB UP Muara Karang
30	**Jasa Destructive Test Tube Heat Recovery Steam Generator (HRSG) Boiler PLTU 1,** Agustus-Oktober 2018	PT. PJB Unit Pembangkitan Gresik
31	**Metallurgical Assessment Hasil Pekerjaan Repair Bucket 1st Stage, Nozzle 1st Stage, Transition Piece, Combustion Liner, dan Shroud 1st Stage yang dilakukan PT.Nuscaco Hasteloy Turbine Services**, November 2018	PT. Nuscaco Hasteloy Turbine Services

PT. EMPU AGUNG SAKTI

EXPERIENCES RECORD

No	Work Assignment and Date	Client
32	**Root Cause Failure Analysis of Water Wall Boiler Tube,** Oktober/November 2018	PT. Ecolab International Indonesia
33	**Pekerjaan Jasa In-situ Metallography Pada Boiler 550-B-MHI dan Boiler Stork di PT. Pertamina RU II – Dumai,** september 2018	PT. Nusakura Standarindo
34	**Root Cause Failure Analysis (RCFA) Tube Heater 87F201, Tube HE 12E1B, Tube HE 14E4C, Tube HE 24E3, Tube HE 24E10, Tube HE 24E18, Tube Boiler 151B501A**, Juli-September 2018	PT. Pertamina (Persero) RU IV Cilacap
35	**Jasa Destructive Test Tube Heat Recovery Steam Generator (HRSG) 1.1; 2.3; 3.2; 3.3 dan Boiler PLTU 2**, Februari – Mei 2018	PT. PJB Unit Pembangkitan Gresik
36	**Pengujian In-Situ Metalografi dengan Teknik Replika pada CT-2 Stator Assy,** January 2018	PT. GMF AeroAsia
37	**Pengujian In-Situ Metalografi dengan Teknik Replika pada Inducer Stator PT-1,** January 2018	PT. GMF AeroAsia

EXPERIENCES RECORD

No	Work Assignment and Date	Client
38	**Remaining Life Assessment (RLA) CFB Boiler PT. Sumber Alam Sekurau,** January 2018	PT. Prima Energi Consult
39	Root Cause Failure Analysis of Leaked Radiant Tube 025 F-101 and Assessment of Leaked Line Pipe Crude LN 11-8C (Area FOC I) Pertamina RU IV, October 2017	PT. Pertamina RU IV, Cilacap
40	Proses Induksi Hardening dan Pengadaan RAW Material Gear Hub pada Pabrikasi Intermediate Shaft KK-3-02B Pertamina RU V, September 2017	PT. Pertamina RU V, Balikpapan
41	Destructive Test of Turbine Blade Row # 1/2/3 and Turbine Vane Row # 1/2, August/September 2017	PT. GMF AeroAsia
42	Uji Metalografi Lapisan Coating Pada Pelat Hastelloy-X dan Pelat SUS-304, August/September 2017	PT. NHTS
43	In-Situ Metallographic Examination of Gas Turbine Rotor and Compressor Shaft of Power Plant, PT. Indonesia Power, Tanjung Priok, July/August 2017	PT. GE Indonesia
44	QC Material and Inspection Pabrikasi Intermediate Shaft KK-3-02A/B/C Pertamina RU V, Balikpapan, Agustus 2017	PT. NHTS

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No	Work Assignment and Date	Client
45	Uji Metalografi dan Hardness Test pada 1st Stage Nozzle GE Frame 5, Juli/Agustus 2017	PT. NHTS
46	QC Round Bar Material Intermediate Shaft Pertamina RU V Balikpapan, July 2017	PT. Pertamina RU V, Balikpapan
47	In-Situ Metallographic Examination of Steam Turbine Rotor and Blades of Coal Fired Power Plant, PT. Indonesia Power, Labuan - Banten, Juni 2017	PT. Sulzer Indonesia
48	Metallurgical Assessment of Leaked Converter, PT. BASF Indonesia, Juni 2017	PT. Bonne Indo Teknik
49	Chemical Composition Analysis Material 2nd Stage Shroud GE Frame 6B and Material 1st & 2nd Stage Shroud GE Frame 5, May 2017	PT. GMF AeroAsia
50	In-Situ Metallographic Examination of Gas Turbine Rotor Components, April 2017	PT. Sulzer Indonesia
51	Failure Analysis of a Cracked Steam Turbine Blade, April 2017	PT. Sulzer Indonesia

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No	Work Assignment and Date	Client
52	Pengujian In-situ Metallography dan Hardness Test Pada Furnace 12-F-101 dan Reactor 12-R-101, April 2017 (PT. Pertamina RU VI Balongan)	PT. Biro Klasifikasi Indonesia, Cabang Cirebon
53	Pengujian In-Situ Metalografi dengan Teknik Replika Pada Combustion Liner GT 1.1 dan GT 1.3, Maret 2017	PT. GMF AeroAsia
54	Pengujian In-Situ Metalografi Dengan Teknik Replika Pada Transition Piece GT 1,1 dan GT 1.3, Maret 2017	PT. GMF AeroAsia
55	Pengujian In-Situ Metallography (Replika) dan Hardness Test pada Heater Coil Tube Furnace 11-F-101, PT. Pertamina RU VI Balongan, February 2017	PT. Regrahta
56	Pengujian Tube Heat Recovery Steam Generator (HRSG) GT 1.3 PT. PJB Unit Pembangkitan Muara Tawar, Januari 2017	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
57	Uji Replika pada Tube Boiler PLTU Unit Sebalang, Lampung, Desember 2016	PT. Gamma Mandiri Teknik
58	Uji Replika Pada Turbine Diaphragm Row#5/ Substitusi, Desember 2016	PT. Nuscaco Hasteloy Turbine Services
59	Examination and Assessment of HP Steam Pipe Material, November 2016	PT. Sari Dumai Sejati

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No	Work Assignment and Date	Client
60	Uji Laboratorium pada Turbine Diaphragm Row #5 yang Keropos, November 2016	PT. Nuscaco Hasteloy Turbine Services
61	Destructive Test Tube HRSG 1.2 PT. PJB UP Gresik, Oktober/November 2016	PT. Pembangkitan Jawa Bali UP Gresik
62	Destructive Test Secondary Superheater Tube Boiler PLTU Unit 4 PT. PJB UP Gresik, Oktober/November 2016	PT. Pembangkitan Jawa Bali UP Gresik
63	Uji Replika Pada Turbine Blade After Heat Treatment, Oktober 2016	PT. Nuscaco Hasteloy Turbine Services
64	Uji Replika Pada Turbine Blade Row#3 dan Row#4 serta Diaphragm Row#3 dan Row#5, Oktober 2016	PT. Nuscaco Hasteloy Turbine Services
65	Uji Creep dan Uji Tarik Material HP SH-1 dan HP Evaporator Tube HRSG GT 1.3 UP Muara Karang, September 2016	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
66	Analisa Lubricating Oil Yang Digunakan Pada Kompresor di PLTGU UP Muara Tawar, September 2016	PT. Pembangkitan Jawa Bali UP Muara Tawar

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No	Work Assignment and Date	Client
67	Destructive Test Hasil Weld Patching Pada Material Stator Blade Stage-1 (Type Siemens V94.2), Agustus 2016	PT. GMF Aeroasia
68	Analisa Deposit Pada HP-LP Drum UP Muara Karang, Agustus 2016	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
69	Analisa Deposit Yang Terbentuk Pada Burner PLTG UP Muara Tawar, Juli 2016	PT. Pembangkitan Jawa Bali UP Muara Tawar
70	Failure Analysis of a Burst Return Bend of a Heat-Exchanger, July 2016	PT. Cabot Indonesia
71	Metallurgical Inspection of Post-Service Heat-Exchanger Tubes and U-Bends, June 2016	PT. Cabot Indonesia
72	Field Testing and Examination of Shell OH Condenser System BE-113 and Laboratory Failure Analysis of Steam Pipe-Elbow BE-113, June 2016	PT. BP Petrochemicals Indonesia
73	Assessment by In-Situ Metallography on Combustion Liner Gas Turbine GE Frame-9, Mei 2016	PT. GMF AeroAsia
74	Assessment by In-Situ Metallography on Transition Piece Gas Turbine GE Frame-9, Mei 2016	PT. GMF AeroAsia
75	Pengujian In-Situ Metalografi dengan Teknik Replika Pada Stator Blade Stage-1, Siemens V94.2, April 2016	PT. GMF AeroAsia

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No	Work Assignment and Date	Client
76	Boiler Assessment PLTU Unit-1 Amurang, Minahasa Selatan, April 2016	PT. Pembangkitan Jawa Bali Services
77	Remaining Life Assessment of HP Superheater Tube of HRSG 1.2 UP Muara Karang by Creep and Tensile Tests, January/February 2016	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wil-Barat
78	Characterization and Analysis of Steam Turbine Deposit of LP Turbine ST 1.4 PLTGU UP Muara Tawar, January 2016	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
79	Assessment by In-Situ Metallography on 1st Stage Nozzle Gas Turbine GE Frame-9, January 2016	PT. GMF AeroAsia
80	Assessment by In-Situ Metallography on Combustion Liner Gas Turbine GE Frame-9, November 2015	PT. GMF AeroAsia
81	Assessment by In-Situ Metallography on Transition Piece Gas Turbine GE Frame-9, December 2015	PT. GMF AeroAsia

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No	Work Assignment and Date	Client
82	Destructive Test of Gas Turbine Blades Row # 1, Row # 2 and Row # 3 Mitsubishi MW701 D, Juli 2015	PT. GMF AeroAsia
83	Jasa Pengujian Tubing HRSG GTG 1.1 UP Muara Karang, Juni 2015	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
84	MPI and Metallurgical Examination of Post-Service Steel Bolts of Storage Tank-201, Juni 2015	PT. Cabot Indonesia
85	Boiler Tube MPI and UT Tests (Non-Destructive Evaluation of CL Boiler Tube Evaporator Bank-2, Mei 2015	PT. Cabot Indonesia
86	Pekerjaan Uji Deposit LP dan HP Drum HRSG Blok-5 PT. PJB UP Muara Tawar, Mei 2015	PT. Pembangkitan Jawa Bali Services
87	Pengujian In-Situ Metallography dengan Teknik Replika pada Combustion Liner, Transition Piece dan Vane Row#1, April 2015	PT. GMF AeroAsia
88	Pengujian In-Situ Metallography dengan Teknik Replika pada First Stage Nozzle, Second Stage Nozzle, Third Stage Nozzle dan Vane Row#2, April 2015	PT. GMF AeroAsia

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No	Work Assignment and Date	Client
89	In-Situ Metallographic Examination by Replica Technique on Combustion Liner GE Frame 9E , March 2015	PT. GMF AeroAsia
90	In-Situ Metallographic Examination by Replica Technique on Transition Piece GE Frame 9E , March 2015	PT. GMF AeroAsia
91	In-Situ Metallographic Examination by Replica Technique on Vane Row#1 Mitsubishi MW 701D , March 2015	PT. GMF AeroAsia
92	Failure Analysis of a Broken Trunnion Shaft of Dryer Cl-2 , March 2015	PT. Cabot Indonesia
93	In-Situ Metallographic Examination by Replica Technique on Vane Row#2 Mitsubishi MW 701D , March 2015	PT. GMF AeroAsia
94	In-Situ Metallographic Examination by Replica Technique on First Stage Nozzle GE Frame 9E , March 2015	PT. GMF AeroAsia
95	In-Situ Metallographic Examination by Replica Technique on Second Stage Nozzle GE Frame 9E , March 2015	PT. GMF AeroAsia
96	In-Situ Metallographic Examination by Replica Technique on Third Stage Nozzle GE Frame 9E , March 2015	PT. GMF AeroAsia
97	In-Situ Metallographic Examination by Replica Technique on Combustion Liner GE Frame 9 , February 2015	PT. GMF AeroAsia

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No	Work Assignment and Date	Client
98	In-Situ Metallographic Examination by Replica Technique on Combustion Liner GE Frame 9 , February 2015	PT. GMF AeroAsia
99	Deposit Analysis Generator OH GT 1.1 UP Muara Karang, January 2015	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
100	Assessment of a Defective Machined Al-Alloy Aileron Block, December 2014	PT. Goodrich Pindad Aeronautical System Indonesia
101	Assessment of Turbocharger Nozzle Rings, December 2014	PT. Nuscaco Hasteloy Turbine Services
102	Assessment of Second Stage Nozzle by In-Situ Metallographic Examination, December 2014	PT. Nuscaco Hasteloy Turbine Services
103	Assessment of Valve Guide, Shroud Ring and Seal Ring of Diesel Engine, December 2014	PT. Nuscaco Hasteloy Turbine Services
104	Metallurgical Assessment of Dryer CL-2 by In-Situ Metallographic Inspection, December 2014	PT. Cabot Indonesia
105	Fabrication of Intermediate Shaft Compressor KK-03-02A, December 2014	PT. Pertamina (Persero) RU V Balikpapan
106	Pekerjaan Uji Deposit LP dan HP Drum HRSG 1.3 UP Muara Tawar, Nopember 2014	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat

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No	Work Assignment and Date	Client
107	Pekerjaan Uji Deposit Oil Cooler, Stator End Winding dan Rotor Retaining Ring Generator STG 1.0 UP Muara Karang, September 2014	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
108	Root Cause Failure Analysis of a Cracked Cage Superheater Tube, August 2014	PT. Sari Dumai Sejati
109	Failure Analysis of PTA Feed Preheater Tubes BE-505A, August 2014	PT. BP Petrochemicals Indonesia
110	Analisa Deposit Peralatan HRSG 1.1 PT. PJB UP Muara Tawar, Juli 2014	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
111	Pekerjaan Uji Deposit PLTU Unit-5 UP Muara Karang, Juni 2014	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
112	Analisa Deposit Peralatan HRSG 1.2 PT. PJB UP Muara Tawar, Juni 2014	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
113	In-Situ Metallographic Inspection of Heat-Exchangers ME-1A and ME-1B, May/June 2014	PT. Cabot Indonesia

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No	Work Assignment and Date	Client
114	In-Situ Metallography dan Hardness Test pada Boiler PLTU Nagan Raya, Aceh, Maret 2014	PT. Prima Energi Consult
115	Metallurgical Assessment on Compressor Disks and Turbine Disks of Gas Turbine GT 2.2 – Belawan, Medan, January 2014	PT. Nusantara Turbin Dan Propulsi (PT. NTP)
116	Metallurgical Assessment on Top Domes and Housing Chambers of Gas Turbine GT 2.2 – Belawan, Medan, December 2013	PT. Nusantara Turbin Dan Propulsi (PT. NTP)
117	In-situ Metallographic Inspection on Dryer CL-2, January 2014	PT. Cabot Indonesia
118	In-situ Metallographic Inspection on Dryer CL-1, December 2013	PT. Cabot Indonesia
119	Failure Analysis on Damage Hot Gas Path Components of PT. AKE Power Plant Unit-1, October 2013	PT. Asta Keramasan Energi
120	Failure Analysis on Damage Hot Gas Path Components of PT. AKE Power Plant Unit-2, September/October 2013	PT. Asta Keramasan Energi
121	Metallurgical Assessment on Shroud Row-1 Ex. GEC, September/October 2013	PT. Asta Keramasan Energi

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No	Work Assignment and Date	Client
122	Root Cause Failure Analysis of Gearbox Quill (Intermediate) Shafts Compressors K-3-02 A/B/C, August 2013	PT.Pertamina (Persero) Refinery Unit V
123	Pekerjaan Assessment RLA HRSG 1.1 PT. PJB Unit Pembangkitan Muara Tawar, September/Oktober 2012	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
124	Jasa Pekerjaan Assessment RLA HRSG 1.2 PT. PJB Unit Pembangkitan Muara Tawar, Nopember 2012	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
125	Jasa Pekerjaan Assessment RLA HRSG 1.3 PT. PJB Unit Pembangkitan Muara Tawar, Februari/Maret 2013	PT. Pembangkitan Jawa Bali, Unit Pelayanan Pemeliharaan Wilayah Barat
126	Failure Analysis of Superheater Steam Boiler Tube, September/Oktober 2012	PT. Multi Nitrotama Kimia (MNK)
127	In-situ Metallographic Examination and Hardness Test on Casing Combustion Chamber, September/October 2012	PT. Nusantara Turbin dan Propulsi (NTP)

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No	Work Assignment and Date	Client
128	Root Cause Failure Analysis of Damaged Wheel Studs and Nuts of Light Vehicles used in Supporting a Coal Mine Operation, (in progress, April/May 2012)	PT. Petrosea, Tbk
129	Root Cause Failure Analysis of Broken Flight Arms of BP-703 PTA Screw Feeder, March/April 2012	PT. Amoco Mitsui PTA Indonesia
130	Failure Analysis on a Ruptured Expansion Bellows of BE-505B PTA Pre-Heater and In-Situ Metallographic Inspection on Channel Covers and Expansion Bellows of Different PTA Pre-Heaters, February/March 2012	PT. Amoco Mitsui PTA Indonesia
131	In-Situ Metallographic Inspection on Dryer Drum ME-2, November 2011	PT. Cabot Indonesia
132	Pengujian In-Situ Metallography dan Kekerasan Pada Pipe/Tube Furnace 14-F-102, November 2011	PT. Pertamina (Persero) RU VI Balongan
133	In-Situ Metallographic Assessment Pada Gas Turbine Blades (Buckets) PLTG PT. Indonesia Power UBP Bali, Oktober/November 2011	PT. Indonesia Power UBP Bali

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No	Work Assignment and Date	Client
134	Failure Analysis on Plate Samples of PD2 Dryer Shell, August/September 2011	Cabot Malaysia Sdn. Bhd.
135	Assessment of PD2 Dryer by In-Situ Metallographic Inspection, June/July 2011	Cabot Malaysia Sdn. Bhd.
136	Failure Analysis on Motor Compressor Bearings of KGM-3 Chiller, June/July 2011	Kelapa Gading Mall, PT. Summarecon Agung, Tbk
137	Jasa Assessment Combustor Casing GT 2.2 UP Muara Tawar, January 2011	PT. Pembangkitan Jawa Bali, UP Muara Tawar
138	Root Cause Failure Analysis of Broken Shaft of SCR 3H Roll Mill Stand, January 2011	PT. Tembaga Mulia Semanan, Tbk
139	Assessment of A Tail Gas Fired Boiler by Wall Thickness Measurement, December 2010/January 2011	PT. Cabot Indonesia
140	Assessment Rotor GT 2.1 UP Muara Tawar Dengan Teknik In-Situ Metallography dan Hardness Test, November 2010	PT. Pembangkitan Jawa Bali, Unit Pembangkitan Muara Tawar
141	In-Situ Metallographic Inspection on Dryer Drum ME-2, August 2010	PT. Cabot Indonesia

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No	Work Assignment and Date	Client
142	Remaining Life Assessment of Furnace Tubes (AB101B and BB-1813), July 2010	PT. Amoco Mitsui PTA Indonesia
143	Metallurgical Assessment of ME-1B Air Preheater Tube Compensators, May/June 2010	PT. Cabot Indonesia
144	Remaining Life Assessment (RLA) HRSG 2.1 PLTGU UP Gresik, Mei 2010	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik
145	Remaining Life Assessment (RLA) HRSG 1.3 PLTGU UP Muara Tawar, April/Mei 2010	PT. Pembangkitan Jawa Bali UP Muara Tawar
146	Failure Investigation and Analysis on Fractured Stud Bolts of A Bypass Ball Valve, March/April 2010	PT. Pertamina Hulu Energi ONWJ Ltd
147	Jasa Replica Test dan Hardness Test untuk HRSG 2.1 PLTGU UP Gresik, Januari 2010	PT. PJB UPHT
148	Jasa Analisa Kerusakan Tube HP Economizer-1 HRSG 3.1 PLTGU UP Gresik, Januari 2010	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik
149	Remaining Life Assessment (RLA) HRSG 1.2 PLTGU UP Muara Tawar, Desember 2009/Januari 2010	PT. Pembangkitan Jawa Bali UP Muara Tawar
150	Analisa Kerusakan Tube HP Economizer-1 HRSG 3.1 PLTGU UP Gresik, Desember 2009	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik

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No	Work Assignment and Date	Client
151	Jasa Remaining Life Assessment Boiler PLTU #1 UP Gresik, Juli/Agustus 2009	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik
152	Jasa Replika Tube Boiler dan Balance Pipe PLTU #3 UP Gresik, Maret/April 2009	PT. PJB UPHAR Wilayah Timur
153	Failure Analysis of Two Damaged Impellers and One Fractured Shaft of a Reactor Feed Pump BG 502 A, January/February 2009	PT. Amoco Mitsui PTA Indonesia
154	Reliability Life Assessment of HP Boiler Tube, October/November 2008	PT. Ecogreen Oleochemicals, Medan
155	Jasa NDT Rotor HP Turbin Unit-4 PLTU UP Muara Karang, Oktober/November 2008	PT. PJB UPHB
156	Jasa Analisa Kerusakan Elbow Tube LP Evaporator HRSG UP Muara Karang, Juni/Juli 2008	PT. Pembangkitan Jawa Bali UP Muara Karang
157	Jasa Remaining Life Assessment (RLA) Boiler PLTU #2 PT. PJB UP Gresik, Mei 2008	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik
158	Jasa Remaining Life Assessment (RLA) HRSG 3.3 PLTGU PT. PJB UP Gresik, Maret 2008	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik

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No	Work Assignment and Date	Client
159	Failure Analysis of Disk Pack Coupling AG-120-B, January 2008	PT. Amoco Mitsui PTA Indonesia
160	Inspeksi Hasil Repair Compressor Casing GT #1 PT. PJB UP Gresik, Desember 2007	PT. Pembangkitan Jawa Bali Unit Pembangkitan Gresik
161	Laboratory Test and Analysis On Corroded Stainless Steel Plate, November 2007	Cabot (Malaysia) Sdn. Bhd.
162	Jasa NDT Rotor Turbin Unit-4 PLTU Muara Karang PT. Pembangkitan Jawa Bali, Oktober 2007	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
163	Instrument Air Compressor After-Cooler/Oil Cooler Failure Analysis, September 2007	ConocoPhillips, Indonesia Inc, Ltd
164	Jasa NDT Rotor Turbin Unit-3 PLTU Muara Karang PT. Pembangkitan Jawa Bali, Agustus 2007	PT. Radiant Utama Interinsco, Tbk
165	Jasa NDT Rotor Turbin Unit-5 PLTU Muara Karang PT. Pembangkitan Jawa Bali, Juni 2007	PT. Pembangkitan Jawa Bali Unit Pelayanan Pemeliharaan Wilayah Barat
166	Instrument Air Compressor After-Cooler Failure Analysis, April 2007	ConocoPhillips, Indonesia Inc, Ltd

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No	Work Assignment and Date	Client
167	Jasa Pemeriksaan Rotating Blade Turbin Unit 1 PLTU Muara Karang, Maret/April 2007	PT. Radiant Utama Interinsco, Tbk
168	Inspeksi/Pemeriksaan Steam Turbine Rotating Blade PLTU #2 PT. PJB UP Muara Karang, September 2006	PT. PJB Uhar Muara Karang
169	Inspeksi/Pemeriksaan Tanki Hidrogen PLTU Muara Karang, September 2006	PT. PJB Uhar Muara Karang
170	Failure Analysis and Prevention of Nozzle Gas Boiler PLTU #2 UP Gresik, Mei/Juni 2006	PT. PJB Uhar Gresik
171	Boiler Assessment PLTU #2 UP Paiton, April – Agustus 2006	PT. Radiant Utama Interinsco, Jakarta
172	Failure Analysis on a Cracked Dryer Drum DD-ME-2, April/May 2006	PT. Cabot Cilegon, Banten
173	Assessment of Dryer Drum DD-ME-1 by In-Situ Metallography, March/April 2006	PT. Cabot Cilegon, Banten
174	Remaining Life Assessment (RLA) HRSG 1.3 UP Gresik, Oktober 2005	PT. PJB Unit Bisnis Pemeliharaan, Gresik
175	Failure Investigation and Analysis of a Boiler Tube, October 2005	PT. Ecogreen Oleochemicals, Medan

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No	Work Assignment and Date	Client
176	In-situ Metallography of Dryer Drum CL-1, August 2005	PT. Cabot Cilegon, Banten
177	Failure Investigation and Analysis of 4 (four) Damaged Metal Parts, August 2005	CABOT (MALAYSIA) Sdn. Bhd.
178	Analisa Kerusakan dan Rekomendasi Remanufaktur Accessory Gears PLTG Frame-5 Unit Pembangkitan Talang Duku, Mei – Juni 2005	PT. PJB Unit Bisnis Pembangkitan Talang Duku
179	Failure Investigation and Analysis of Heat Exchanger Tube Compensators, May – June 2005	CABOT (MALAYSIA) Sdn. Bhd.
180	In-situ Metallography by Replica Technique on a Cracked Dryer Drum, March 2005	PT. CABOT Cilegon, Banten
181	Uji Mikrostruktur Reheater Tube PLTU #1 Unit Pembangkitan Paiton, Februari – Maret 2005	PT. PJB Unit Bisnis Pemelliharaan
182	Analisa dan Supervisi Perbaikan/Repair Forced Draft Fan (FDF) PLTU Unit 3 Muara Karang (28 Januari s/d 2 Februari 2005)	PT. PJB UHAR MUARA KARANG Jakarta Utara
183	Failure Investigation and Analysis of a Transition Ring (November/December 2004)	PT. Cabot Cilegon, Banten

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No	Work Assignment and Date	Client
184	In-Situ Metallographic and Hardness Test of Dryer Drum DD-ME-2 (December 2003)	PT. Cabot Cilegon, Banten
185	Analisa Kerusakan Cylinder Liner Mesin Diesel (November 2003)	PT. Supermal Karawaci Tangerang
186	Analisa Kerusakan Baut Cylinder Head Mesin Diesel PLTD Batakan (September 2003)	PT. PLN (Persero) Jasa Teknik Kelistrikan, Jakarta
187	Analisa Material dengan Scanning Electron Microscope dan EDAX (Energy Dispersive X-ray Analyzer)(Juli 2003)	PT. Theda Persada Nusantara, Jakarta
188	In-Situ Metallographic and Hardness Test of Dryer Drum DD-ME-1 (June-July 2003)	PT. CABOT Cilegon, Banten
189	Failure Investigation and Analysis of a Cast Stainless Steel Pump Impeller (January-February 2003)	PT. Petrokimia Nusantara Interindo, Merak-Banten
190	Hydrotest Leak Investigation on Circumferential Fillet Welds Between Fire Tube and Compensator Inner Sleeve of a Repaired Heat Exchanger (January 2003)	PT. CABOT Cilegon, Banten
191	Failure Investigation and Analysis of a Pelletizer Rotor Shaft (November 2002)	PT. CABOT Cilegon, Banten

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No	Work Assignment and Date	Client
192	In-Situ Metallographic Inspection by Replica Technique and Failure Investigation and Analysis of a SG Steam Superheater (E-0500) (May/June 2002)	PT. Kaltim Pasifik Amoniak Bontang, Kalimantan Timur
193	Failure Investigation and Analysis of a HE Tube Compensator (A Repeat Order), December 2001	PT. CABOT Cilegon, Banten
194	Failure Investigation and Analysis of a HE Tube Compensator (July 2001)	PT. CABOT Cilegon, Banten
195	Analisa Material Heat Seal Gas Turbine (Februari 2001)	PT. Indonesia Power Unit Bisnis Jasa Pemeliharaan, Jakarta
196	Failure Investigation and Analysis of a Ruptured Coil Hanger (December 2000)	PT. CABOT Cilegon, Banten
197	Penelitian dan Pengujian Sample Las Plat Baja untuk Kualifikasi Welding Repair Procedure 2000 Tons VCM Spherical Tank 0-002 (Agustus 2000)	PT. Merka Inspektindo Technical, Jakarta
198	Failure Investigation and Analysis of a Repair Welded Stainless Steel 316 H Dryer Drum (July 2000)	PT. CABOT Cilegon, Banten
199	In-Situ Metallographic Inspection of Two Dyer Drums by Replica Technique (July 2000)	PT. CABOT Cilegon, Banten

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No	Work Assignment and Date	Client
200	Analisa Kerusakan dan Perbandingan Bahan Piston (Second Stage, Compressor 7-C-351), Juli 2000	PT. Petrokimia Nusantara Interindo, Merak-Banten
201	Analisa Serbuk/Serat Pada Piston Compressor (7-C-351) dan Analisa Gumpalan Oli Pada Screw Compressor (8-C-510) (2000)	PT. Petrokimia Nusantara Interindo, Merak-Banten
202	Analisa Kerusakan Diffuser Casing Circulating Water Pump (Juli 2000)	PT. PLN PJB I UP Priok Jakarta Utara
203	Analisa Kerusakan Valve Plates Mesin Compressors No. 7-C-351 (Maret 2000)	PT. Petrokimia Nusantara Interindo, Merak-Banten
204	Failure Analysis and Damage Investigation of Thrust Bearing and Shaft of Centrifugal Compressor (Januari/Februari 2000)	PT. Petrokimia Nusantara Interindo, Merak-Banten
205	Pengujian dan Analisa Kerusakan Poros Mesin Blower (Agustus 1999)	PT. Petrokimia Nusantara Interindo, Merak-Banten
206	Pengujian dan Analisa Bahan Extruder Cutter Blade (Oktober 1998)	PT. Petrokimia Nusantara Interindo, Merak-Banten
207	Analisa Kerusakan Cylinder Liner Mesin Diesel Kapal (Mei 1998)	Pertamina Perkapalan Jakarta Utara

EXPERIENCES RECORD

No	Work Assignment and Date	Client
208	Pengujian dan Analisa Kegagalan Batang Tembaga untuk Bahan Kawat Enamel (1997)	PT. Tembaga Mulia Semanan, Jakarta
209	Analisa Kerusakan Komponen Sepeda Motor (1997)	PT. Astra Honda Motor (d/h PT. Honda Federal), Jakarta
210	Pengujian dan Analisa Tegangan Konstruksi Rig Pertamina Cirebon (1997)	PT. Radinat Utama Jakarta
211	Penelitian Paduan Aluminium Tahan Panas Aplikasi Kabel SUTET (1996-1997)	PT. Supreme Alurodin Jakarta
212	Pengujian dan Analisa Kegagalan Kawat Tembaga untuk Bahan Kabel Listrik dan Kabel Telepon (1996)	PT. SUCACO
213	Analisa Kerusakan Cylinder Liner Mesin Diesel Kapal (Oktober 1996)	PT. Jakarta Lloyd
214	Pengujian dan Analisa Kegagalan Produk Cor Aluminium (1996)	PT. Wijaya Karya – Produk Metal, Jatiwangi, Cirebon
215	Analisa Kerusakan Bantalan Jalan (Journal Bearing) Mesin Diesel Kapal (April 1996)	PT. Jakarta Lloyd
216	Analisa Kawat Las (1996)	PT. Indo Laval, Jakarta Timur
217	Analisa Kerusakan Baut Pengikat Mesin Crane (1996)	Pertamina EP Kantor Pusat Jakarta

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THANK YOU