

The background of the slide is a grayscale photograph of an industrial facility with several tall, vertical distillation columns or towers. A yellow horizontal band is overlaid across the middle of the image, containing the main text.

# REDEFINING ON-TIME QUALITY

Materials Testing Lab, Civil and NDT  
Inspection with NABL, ISO 17025 and BIS  
approval

THE MAGIC



# TCR is serving global industry leaders for close to five decades

**47 Years**

of experience working with Global Leaders across Industries

**500+**

number of TCR Global experts and consultants currently working across 3 continents

**65+**

Corrosion specific NDT cases

**1,00,000+**

Database of Microstructures specialized by Industry vertical-based solution

**6,000+**

Failure analysis cases

**1000+**

Refinery cases

**15+**

Civil and Field Services Prestigious Projects completed

**FOUNDING  
VISION:  
PRINCIPLES OF  
PRECISION,  
TRANSPARENCY  
AND RELIABILITY**

## TCR LEGACY

TCR has a growing global presence and is rooted in behaving ethically in all their interactions-with their employees, partners and their customers.

### Historical Milestones

## TCR Engineering Services was incorporated in 1973

It was the vision of Mr. V. K. Bafna, the founder, a keen metallurgist to provide real, sustainable solutions to companies that would drive progress for them. He infused the principles of precision, transparency and reliability in all actions due to which,

TCR today is a trusted service provider for top-notch companies across the globe and has many 'firsts' to its credit. It has become a thought leader in the industry because of its pioneering work.

**Our journey started as a disruptor for end to end inspection services to a being global leader**

2018

TCR Qatar is established, Civil Lab starts

2010

TCR establishes an alliance - Malaysia

2007

TCR Engineering enters into a JV in Saudi Arabia to establish **TCR Arabia** in Dammam

2006

TCR Engineering opens **TCR Kuwait**, its first international office in Kuwait

1999

TCR Engineering establishes **TCR Advanced** in Vadodara to offer research and consulting solutions for plant management

1980

First to add a chemical analysis spectrometer in India

1975

First to install 100T Tensile Machine in India

1973

TCR Engineering Services Company Founded in Mumbai



**VIRENDRA KUMAR BAFNA**  
Founder & Visionary TCR Engineering Services Pvt. Ltd.

# TCR CREDIBILITY: ACCREDITATION & APPROVALS

TCR is among the few leading & independent laboratories that meet the international standards of quality, accredited by reputed global agencies

## CERTIFICATIONS



## INDUSTRY/UNIVERSITY PARTNERSHIPS



## CORPORATE PARTNERSHIPS



## ASSOCIATIONS



Indian Society for



Non-Destructive Testing



*V.K. Bafna*

**Chairman Emeritus**  
TCR Group of  
Companies



*Rohit Bafna*

**President**  
TCR Global



*Neelam Bafna*

**Managing Director**  
TCR Engineering



*Paresh Haribhakti*

**Global Technical Advisor**  
TCR Engineering



*Viren Khandwala*

**Director, Finance**  
TCR Engineering



**SURESH ACHARYA**  
Country Head



**AVINASH TAMBEWAGH**  
Head, Advanced and Civil



**SRIRAM SHANBHAG**  
Head, Technical Lab



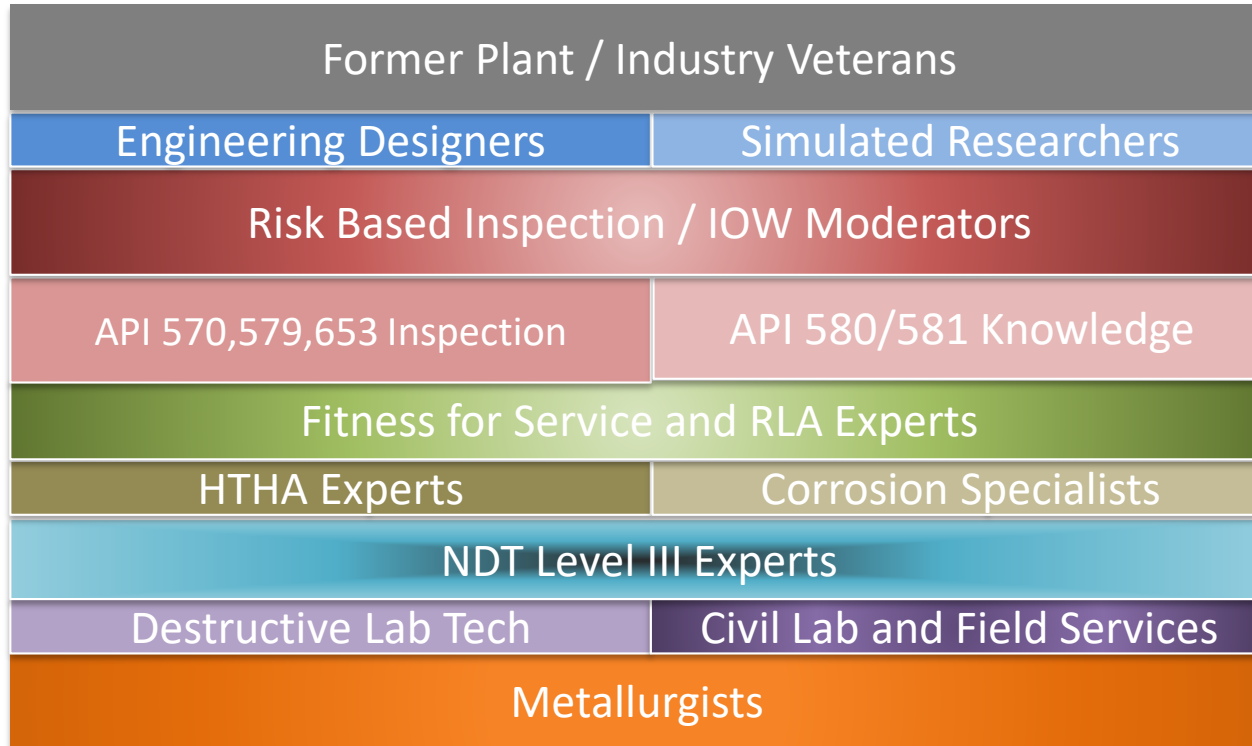
**SHEMI BASKARAN**  
Head, NDT



**GANESH SONAWANE**  
Head, Quality Control



**LALIT SURVE**  
Head, Finance





## KEY INDIA CLIENTS



## KEY GLOBAL CUSTOMERS





Appreciation Award by Vikram Sarabhai Space Center for Contribution in the launch of space shuttle ASLV-D3



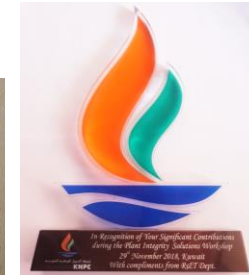
Appreciation from ISNT



Memento from NACE



American Society of Metals (ASM) acknowledged Mr. Paresh Haribhakti at International Conference on 'Material Testing & Characterization'



Recognized by KNPC, Kuwait for contributions to the 'Plant Integrity Solutions Workshop'



KK Award presented to Mr. Paresh Haribhakti, MD, TCR Advanced in the Category of Professional Field for the Year 2015 by Indian Institute of Metals (Baroda)





Mumbai and Chennai (India)



Dubai (UAE)



Dammam, Jubail and Yanbu  
(Saudi Arabia)



Offshore and Sub-Sea



Vadodara (India) and Virtual



Vadodara (India)



Doha



Faheel



Muscat



STRUCTURAL AUDITS, FIELD INSPECTIONS AND COMPLETE CIVIL TESTING LAB TECHNICIANS in association with HPL (A TCR group associate company)

## Material Testing Services

Technical services for testing of materials like soil / Moorum, Coarse and fine aggregates, crusher products, concrete pavement layer, cement, concrete cubes, blocks, cement concrete interlocking blocks, flooring tiles and bricks.

## Cement / Pozzolanic Materials.

Standard consistency, initial & final setting time  
Soundness  
Fineness  
Compressive strength  
Chemical analysis

## Coarse & fine aggregates

Sieve analysis (Gradation)  
Flakiness index, Elongation index  
Stripping value, Impact value, Soundness  
Crushing value, Water absorption  
Specific gravity, Bulk density & voids



## Services include:

- Concrete Tests
- Soil Tests
- Aggregate Tests
- Field test for Soil & Concrete
- Structural assessment of concrete & Concrete delamination Survey



## Fine aggregates, Natural /crusher

Sieve analysis (Gradation), Silt content,  
Moisture content, Specific gravity, Bulk density

## Concrete cubes/blocks/Cement

Compressive strength, RCPT  
Water Permeability

## Flooring Tiles

Flexural strength, Water Absorption  
MOR, Drying shrinkage

## All types Bricks & Blocks

Crushing strength, Water absorption, Effervescence

# SOIL TESTING AS PER IS 2720

- Particle-Size Distribution (Gradation) of Soils
- Modified/Standard Proctor Test
- Particle size distribution (Sieve Analysis)
- Liquid Limit, Plastic Limit & Plasticity Index (Casagrande)
- Specific gravity of soil using Pycnometer
- Max & Min Index Density (Relative Density)
- California Bearing Ratio (CBR)
- Moisture Content of Soil
- In-situ density tests- Sand replacement method for fine and medium grained soils
- In-situ density tests- Sand replacement method for fine, medium & coarse grained soils



## In-Depth Soil Testing and Investigation

- Hydrometer analysis
- Direct shear test
- Unconfined compression test
- Chemical tests
- Dynamic Cone Penetration Test
- Cross hole seismic test
- Seismic Refraction Survey
- Electrical resistivity test (E.R.T.)
- Geological Survey & report preparation

## Concrete Testing as per IS 516:

Design support for Normal concrete, Pump able concrete, High performance concrete, Early de-shuttering, Self-compacting concrete, High Fly ash concrete and Concrete pavement blocks



### Service Includes:

- Compressive Strength of Hydraulic Cement Mortars
- Air Content of Freshly prepared Concrete
- Bleeding test of fresh concrete
- Water absorption for Hardened concrete
- Sampling of Concrete Masonry Units/Hollow
- Determination of Dimensions, Absorption & Compressive Strength Testing of Concrete Masonry Units/Hollow Blocks
- Water absorption and Bulk Specific Gravity of dimension stones (Kerb stones, Concrete flags, Beam, etc.)
- Determination of Flexural strength test of dimension stones
- Determination of Modulus of rupture of dimension stones
- Unconfined compressive strength of intact rock core specimens
- Dimension measurement, Compressive strength and Water absorption of precast Paving Blocks
- Cutting of Concrete Core (Concrete coring on site)
- Curing, Capping, Compressive Strength & Fracture Type Analysis of Concrete Cores in Laboratory
- Compressive strength of dimension stone
- Determination of Water absorption & bulk density of dimension stone



Brick testing



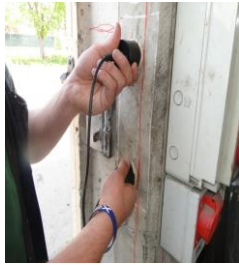
Core Test



Cube Test



## Structural Audit of Buildings, Dams, Bridges, RCC structures and Warehouses



Pulse Velocity Measurement



Concrete cored and sampled specimens



Pachometer test

### Services Includes:

- Visual inspection of concrete structure (Structural assessment)
- Petrographic Examination
- Crack Mapping/Crack measurement
- Cutting of Concrete Core
- Rebound Hammer Test for Hardened Concrete - IS: 13311 (Part 2)
- Ultrasonic pulse velocity - IS:13311 (Part 1)
- Concrete cover to reinforcement (Pachometer test)
- Half-cell potentiometer as per ASTM C876 – 2015
- Carbonization depth test



Column Testing



Rebound Hammer Test



Rebound Hammer Apparatus



UPV Testing



UPV Testing on column



UPV Testing



Reinforcement Testing



Half Cell Potentio Test

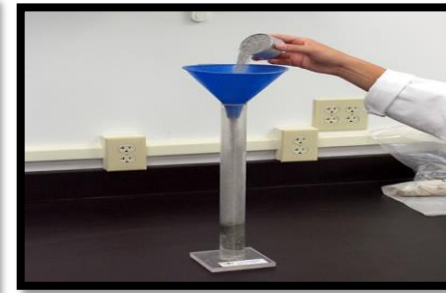
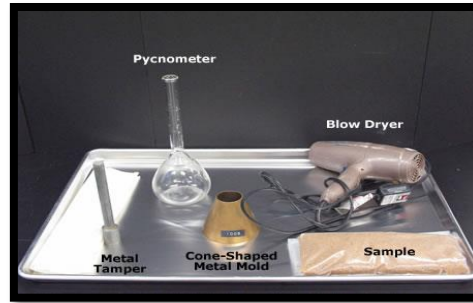


Field Sampling



# AGGREGATE TESTING

- Sampling of Aggregates
- Sieve Analysis of aggregates
- Material Finer than # 200
- Clay Lumps & Friable Particles
- Specific Gravity and Water Absorption (Particle density)
- Sand Equivalent Test
- Moisture content of aggregates (oven dry method)
- Percentage of fractured particles in coarse aggregate
- Soundness of aggregates by sodium sulphate and magnesium sulphate
- Test method for unit weight for aggregates



Hot Air Oven



Curing Tank



ISO 17025 Accredited LAB

# Material Testing Laboratory for Destructive Testing



OFFSHORE ANALYSIS IN INDIA WITH RAPID RESPONSE AND DEDICATED MACHINE SHOP,  
EXPERT METALLURGISTS AND LAB TECHNICIANS



ARL Quantis  
Optical Emissions  
Spectrometer



Inductively Coupled Plasma  
Spectrometer



Atomic Absorption  
Spectrometer



Optical Emission  
Spectrometer



Automatic  
Carbon - Sulphur  
Determination

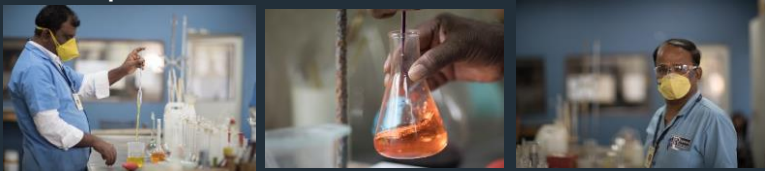


Universal Tensile, Impact and Hardness Machines



GRAVIMETRY/TITRIMETRY  
QUANTITATIVE AND SEMI-  
QUANTITATIVE ANALYSES  
**WET CHEMICAL  
ANALYSIS AND  
SPECTROMETERS**  
PPM / Sub-PPM Detection Level

Identification of chemistry in Ferrous, Non-Ferrous Metals, Ceramics, Glass, Refractory, Minerals and Ferro Alloys in all forms including drillings or turnings, solid samples, and liquids.



Atomic Absorption (AA) Graphite Furnace Spectrometer  
Inductively Coupled Plasma (ICP) Spectrometer  
Optical Emission Spectrometer (OES)  
X-Ray Diffraction Spectrometer (XRD)  
Gas Analysis (Oxygen, Hydrogen, Nitrogen)  
EDAX Analysis  
On-Site Positive Material Identification (Portable XRF and OES)  
pH Value Determination, Acid Insoluble  
Sand Content, Moisture Content, Ash Content  
Sulphates, Chlorides, Silicates, Carbonates, Oxides of Iron  
Calcium, Magnesium, Potassium, Sodium, Iron  
Solder Alloys (Tin/Lead)  
Density of Powdered Metals, Particle Size Analyzer  
Coating Identification, Coating Weights



# WPS-PQR DEVELOPMENT WELD EXPERTS

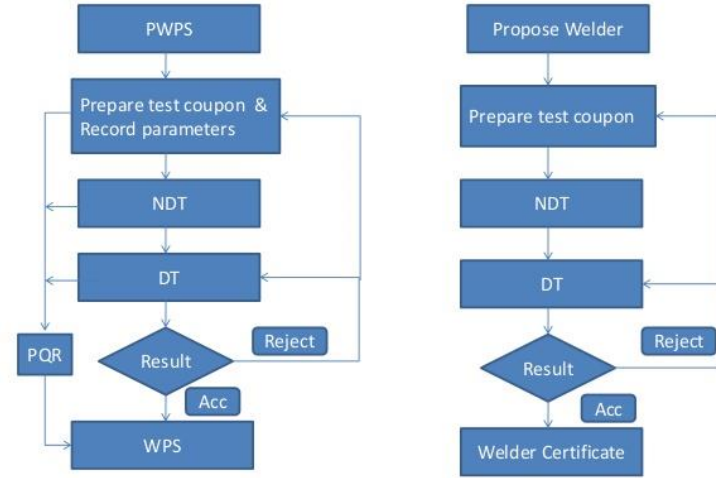
AWS D1.1, ASME IX, API 1104, EN 288

Evaluate the existing welding procedures, Perform welding quality control inspections, Supervise and inspect critical weld procedures in the field.



Complete facilities for testing welding consumable & filler material

## Welding Procedure & welder qualification test



### Department Head - Jaydeep Vora

- 30 years experience. Ex AVP of Godrej.
- Expert in ASME U, U2, U3, S & R stamp qualification.
- Qualified Welding Procedures on Stamicarbon - SAFUREX; Cr-Mo-V Steels; Titanium, Zirconium, Inconel, Monel; DIROS 500
- Successfully welded 2.25Cr-1Mo item weighing 950MT
- Automatic nozzle welding using SAW
- Automatic GMAW for welding Dish ends
- Tandem Submerged Arc Welding (SAW) using up to three wires simultaneously to reduce the cycle time
- Implemented High speed Electro Slag Strip Cladding



## SCIENTIFIC RESEARCH LABORATORY

# SOUR GAS & GENERAL CORROSION TESTING

### Excellent Lab Award by NACE

Equipped with numerous high temperature/high pressure autoclaves, proving rings, salt spray chamber, Corrosion simulation in lab as well as Desktop simulation of corrosion rate with passionate corrosion scientists

Sour Gas (HIC/SSC/SOHIC) – NACE TM0284/TM0177/TM0103  
Chloride Stress - ASTM G 36  
SCC of Aluminum Alloy - ASTM G44/G47  
Pitting/Crevice (Critical Temperature) - ASTM G48  
Potentiostatic / Potentiodynamic Anodic Polarization - ASTM G5  
Chloride Stress - ASTM G 36  
Corrosion of Aluminum NAML - ASTM G67  
Exfoliation of Aluminum - G66/G34  
SCC of Aluminum – ASTM G103  
Intergranular – ASTM A262/ DIN EN ISO 3651  
Immersion Corrosion – ASTM G31  
Ammonia Vapor Test – ASTM B858, Salt Spray – ASTM B117



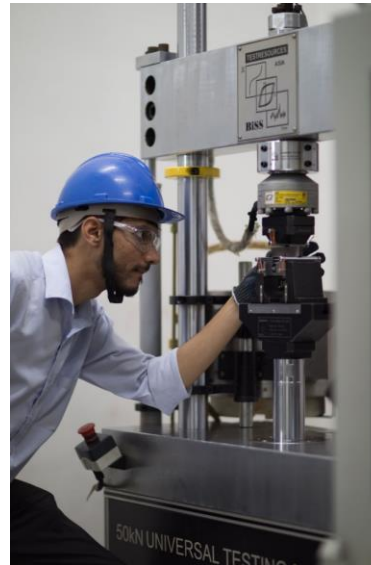


# DURABILITY ANALYSES

# FATIGUE & FRACTURE TOUGHNESS

## CTOD, K1C, J1C, S-N Curve

ASTM E606 (Low-cycle fatigue, strain-controlled Fatigue Testing) and ASTM E466 (Load-controlled Fatigue Testing – High or Low-cycle fatigue testing) widely tested. Fatigue Tests for TMT RE-BAR & COUPLERS as per IS 16172.



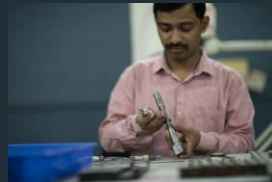
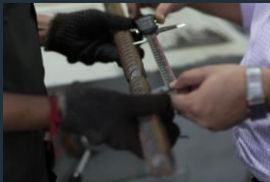
Crack-Tip Opening Displacement (CTOD) - ASTM E1290, BS 7448  
Strain Fracture Toughness (KIC) - ASTM E399  
Fracture Toughness - ASTM E1820  
Fracture Mechanics - K1c, J1c, CTOD  
Force Controlled Constant Amplitude Axial Fatigue - ASTM E466  
Elevated Temperature Tension - ASTM E21  
Strain-Controlled Fatigue Testing - ASTM E606  
Measurement of Fatigue Crack Growth Rates - ASTM E647  
Room Temperature Compression Testing - ASTM E9  
Creep-Fatigue Testing - ASTM E 2714  
Fatigue testing by Axial-strain-controlled method - ISO 12106  
Fatigue testing by Fatigue crack growth method - ISO 12108  
Static Tensile, Cyclic Tensile, Slip Test, High Cycle Fatigue, S-N Curve

# STRESS VERSUS TIME AT ELEVATED TEMP

## CREEP & STRESS RUPTURE

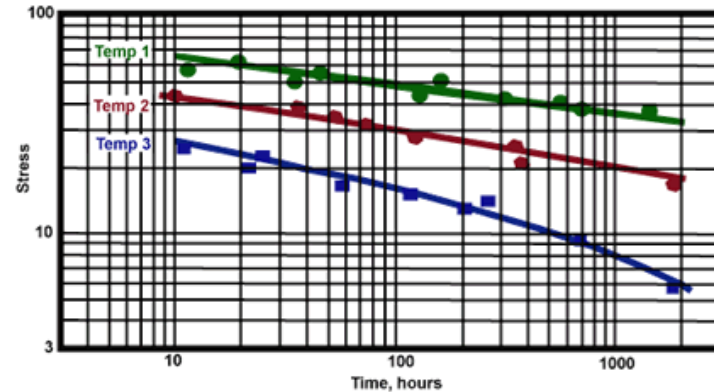
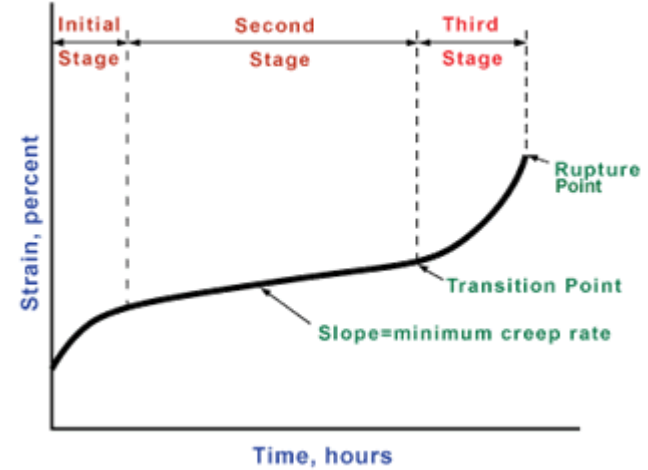
### ASTM E139 and ASTM E292

Reliable temperature control using calibrated thermocouples attached to the test specimens. The load is adjusted automatically at various time intervals for efficiency.



Evaluating materials for boilers, gas turbines, jet engines, ovens or any application that involves high temperatures under load.

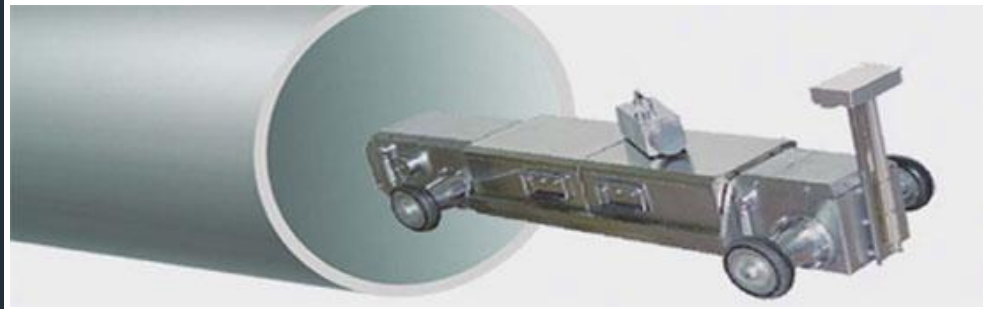
Stress rupture test involves a tensile specimen under a constant load at a constant temperature. Stress rupture tests are employed to find out the time it takes for failure.



# PIPELINE & WELD JOINTS RADIOGRAPHY

## 12 – 24" Dia Pipeline Crawler

Experienced NDT Level III expert along with dedicated team of technicians perform gamma radiography with projectors and crawlers. Computerized Radiography is available.



X-ray pipeline crawlers with high radiographic quality, high imaging sensitivity and low failure rate

Portable frequency-converted and gas-filled  
X-ray NDT equipment



SENTINEL 880 Delta  
Gamma Projector



Glass tube Directional



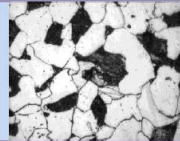
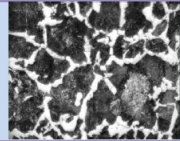
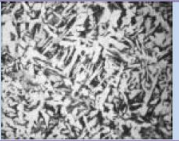
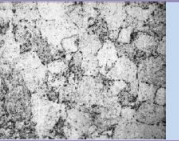
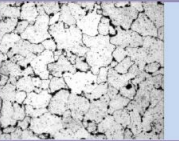
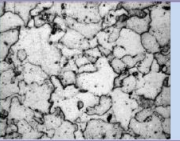
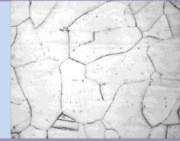
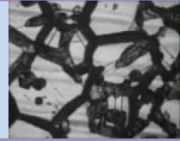
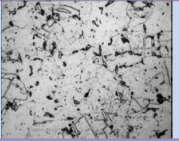
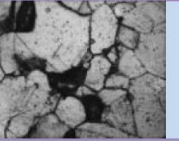

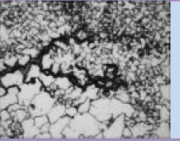
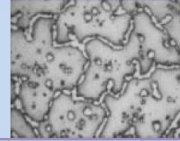
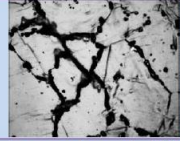
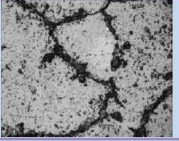
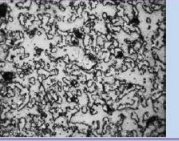
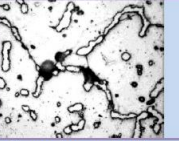
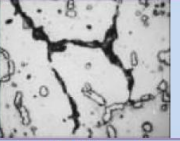
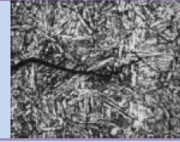
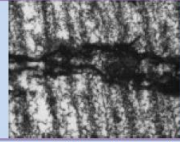
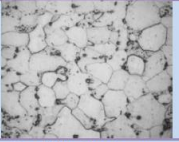
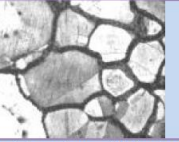
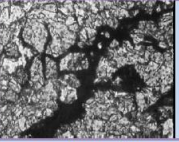
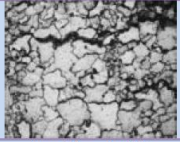
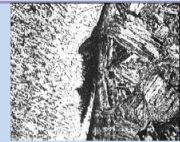

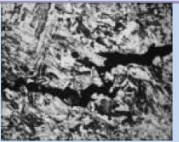
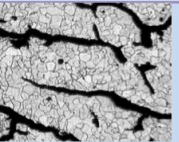
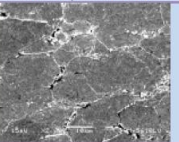
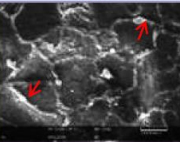


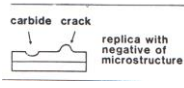
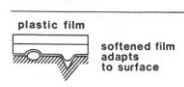
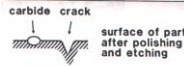
# Metallographic Replica:

In-depth condition/life assessment of process plant components and detection of Graphitization, Degradation Of Pearlite, Creep, Thermal Fatigue, Oxidation, Grain Growth, Hydrogen Attack, Stress Corrosion Cracking, Sigma Phase

## ADVANTAGE

TCR's metallurgists have a database of over 30,000 micro-structure interpretation study of various components and materials.

| Carbon steels                                                                     |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|   |   |   |   |   |   |
| Normalized - 400X                                                                 | As forged or improperly heat treated-400X                                         | Widmanstatten ferrite and pearlite 100X                                            | Spheroidization of pearlite 400X                                                    | Creep voids at the grain boundaries - 400X                                          | Decarburization- 400X                                                               |
| Austenitic stainless steels                                                       |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|  |  |  |  |  |  |
| Solution annealed 400X                                                            | carbide precipitation- 400X                                                       | Sigma Phase 400X                                                                   | IGC 400X                                                                            | TGSCC 100X                                                                          | IGSCC 400X                                                                          |
| Catalytic converters / reformer tubes / hot outlet manifolds                      |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|  |  |  |  |  |  |
| Solution annealed HK40 400X                                                       | Inter-granular crack - HK40 400X                                                  | Oxidation-Incoloy 800HT 400X                                                       | Creep damage In weld HP Mod 400X                                                    | Creep damage in PM 400X                                                             | Interdendritic cracks 400X                                                          |
| Damage mechanisms identified in the microstructure                                |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|  |  |  |  |  |  |
| Quench cracks in alloy steel 400X                                                 | Caustic SCC carbon steel 400X                                                     | Graphitization damage low alloy steel - 400X                                       | Grain boundary oxidation in CS - 100X                                               | Inter-granular crack in rotor low alloy steel 400X                                  | Type IV cracks P22 400X                                                             |
|  |  |  |  |  |  |
| Dissimilar metal weld SS-alloy steel 200X                                         | Thermal fatigue alloy steel 100X                                                  | Corrosion fatigue SS 410 400X                                                      | High temperature hydrogen damage C-1/2Mo. - 100X                                    | Creep Damage in P91/T91 2000X                                                       | High temp. sulphur induced corrosion T11. - 3500X                                   |



Scanning Electron Microscopy



Optical Microscopy



Portable Microscope

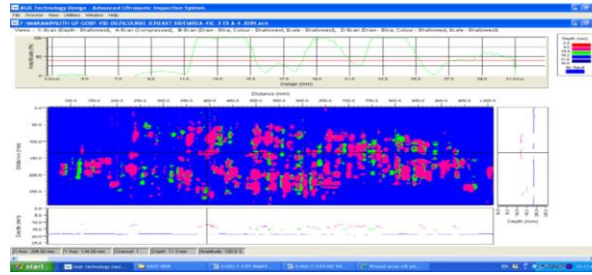


In-situ Metallography by replication method.

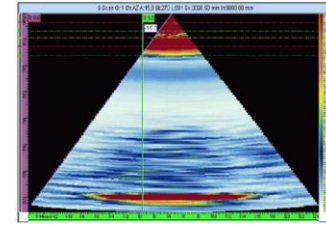
# ON-LINE INSPECTION AND HIGH TEMP NDT

## HTHA AND SWC

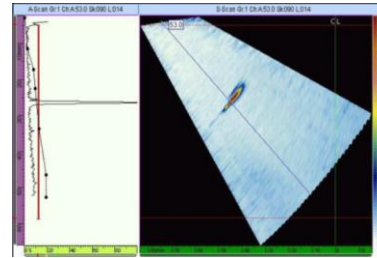
TCR Detects and Monitor's Corrosion Growth Rate/Wall Thinning and In-service defects of Plant piping, Vessels & Tanks operating at elevated temperatures up to 700° F (350° C).



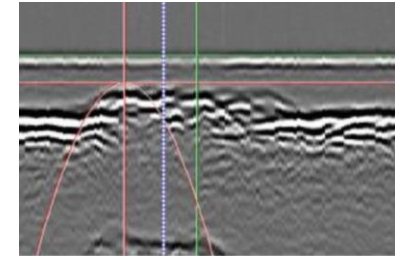
Wall thickness mapping of the area, before making hottaps



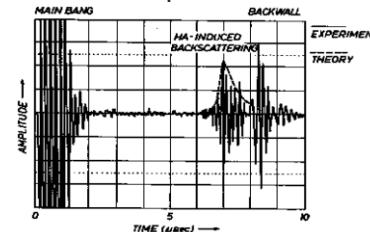
HTHA confirmation using PAUT



Phased Array Inspection of on-line repaired areas



Time of Flight (ToFD) inspection of heavy wall vessels or welds



HTHA using ABUT-L

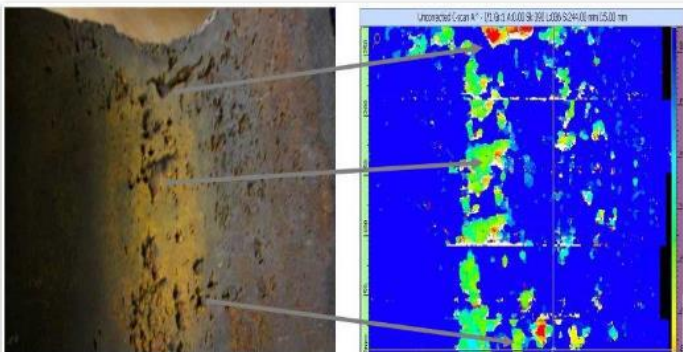


HIC/SWC/Inclusion/Lamination detection

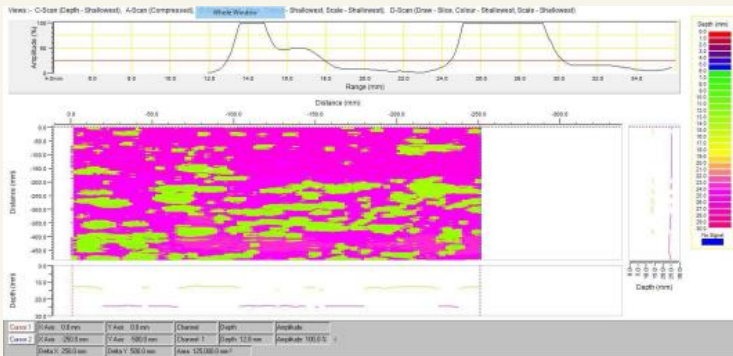


## Step-wise Cracking & HTHA

Sample evidence of corroded areas detected with ultrasonic corrosion mapping



ToFD, AUT P-Scan, PAUT, AUBT-L, AUBT-S

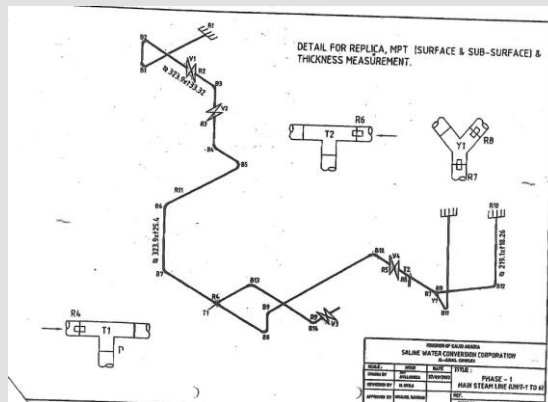


C-Scan showing Step-wise Crack

## Corrosion Thickness Survey

Segregate the given lines as per Corrosion Loops

- Create Isometric drawings for all the loops
- Mark the Thickness Measurement Locations (TML) on loops as well as at Site as per isometric drawing
- Identification of inspection requirement including scaffolding, insulation removal and high temperature measurement
- Review of all thickness reports



TCR will create isometric sketches of all test points surveyed

### Percent of wall loss determination

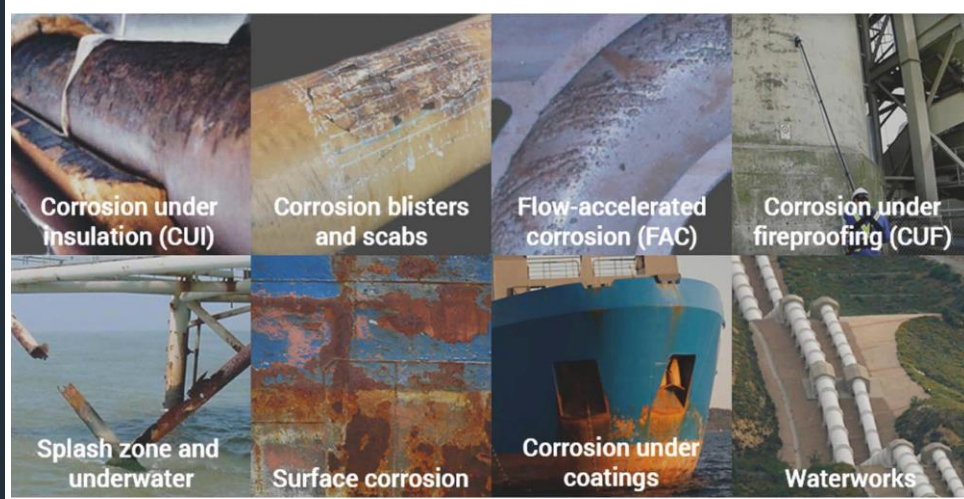
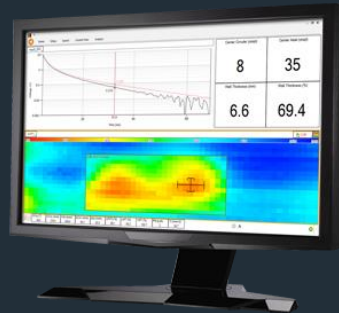
The nominal thickness is the thickness of a fitting or piping that corresponds with A.S.A. Pipe Schedule Manufacturers Chart.

There is a 12.5% mill tolerance (higher or lower) from the chart.

- Any (TML) from 12.5% thru 19% lower is light wall loss.
- Any (TML) from 20% thru 39% lower is moderate wall loss.
- Any thickness readings found to be 40% or greater is severe wall loss and recommended to be replaced and reported

# PULSED EDDY CURRENT CORROSION UNDER INSULATION (CUI)

TCR-U-Sonix's Lyft CUI test equipment can scan through metal thicknesses up to 100 mm (4 in) with insulation as thick as 300 mm (12 in) in stainless steel / aluminum / galvanized steel weather jacket.



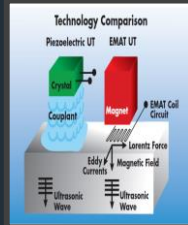
Tank floor probe enables the in-service inspection of storage tank annular rings to slide up to 400 mm (16 in) under tank floor edges, assessing the remaining wall thickness.

Splash zone probe can tackle offshore applications detect damages in metal up to 76 mm (3 in) thick and insulation or marine growth up to 203 mm (8 in) thick.

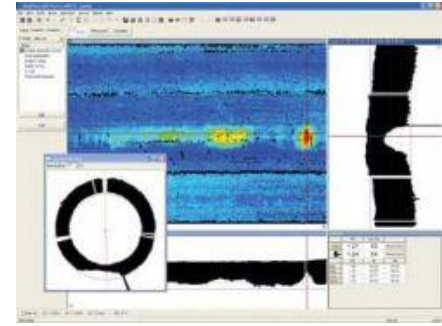
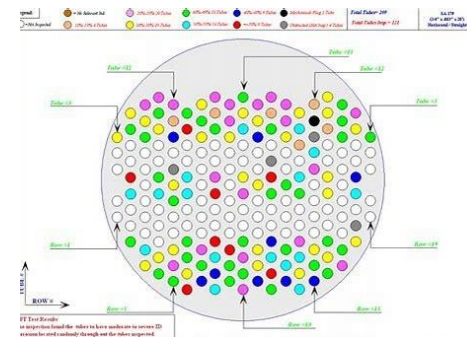
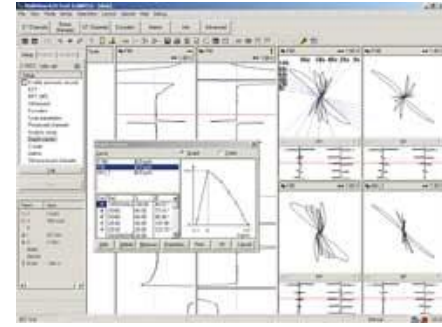
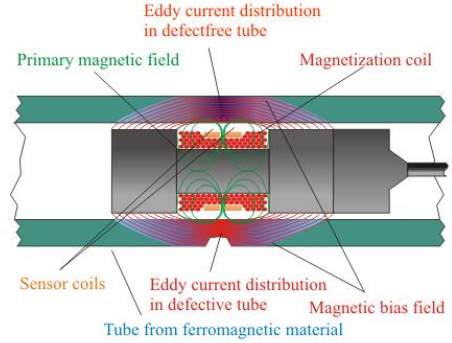
Underwater probes for deeper offshore applications are used on metal as thick as 100 mm (4 in), as well as insulation and marine growth as thick as 300 mm (12 in).

# ECT, RFET, IRIS, MFL, EMAT TUBE INSPECTION

TCR's tube inspection team capable of working multiple shifts in turnaround to detect pitting, corrosion, erosion, cracking, puncture, cracks in tubes of heat exchangers, steam generators, condensers, chillers, air coolers and feedwater heaters.



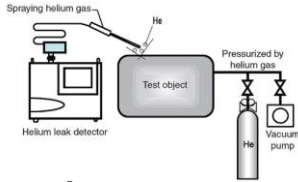
EMAT-Electromagnetic Acoustic Transducer



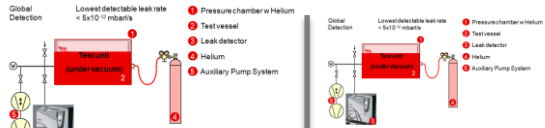


# Key Differentiator

# Beyond Material Composition and Crack Length, TCR provides meaningful insights that drives plant efficiency



## Helium Leak Testing (Pressure Method)



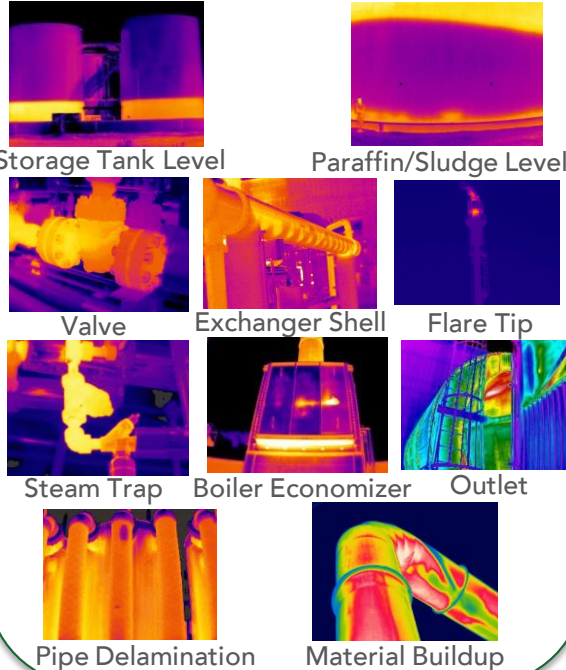
### Global Detect He Outside (Vacuum Method)

### Local Detect He (Vacuum Method)



Locating the smallest leaks in pressure, vacuum, condenser, heat exchanger, steam turbine generator

## Thermography



## Videoscopy



Visual Inspection at unapproachable locations



# TCR INNOVATION AUTOMATED REFORMER TUBE INSPECTION

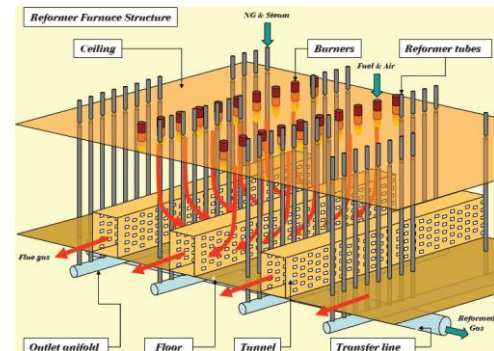
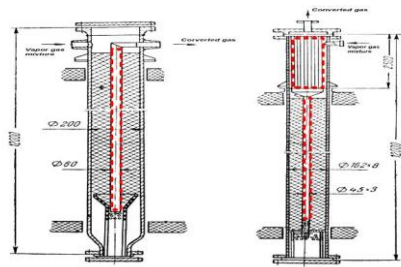
TCR's in-house developed technology solution for Automated ultrasonic scanning on reformer tubes from 105 to 190 mm outer dia.

TCR also undertakes reformer tube condition and integrity assessment & Fitness for Service (FFS) along with unique feature of "when to retire tubes"



Evaluation of damage mechanisms including creep, fissure detection, microstructure degradation, thickness loss and internal carburization

- Inspecting from an external surface without removing the catalyst
- Detection of micro level sub surface and mid-wall creep fissures
- Creep strain and bowing angle estimate at a resolution of 0.1meter
- Eliminate erection of scaffolding



## As stated by NACE

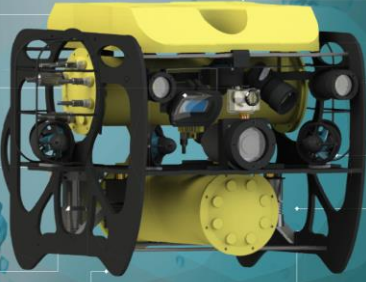
Eddy current examination is not reliable in the detection of early damage (i.e. less than 30% through-wall).

## Ultrasonic Examination

The primary ultrasonic technique utilized for the detection and estimation of creep damage is through transmission ultrasonic attenuation. Recent validations have again found that ultrasonic is more reliable at the detection and quantification of creep damage, particularly in its early stages.<sup>2</sup>

# ROBOTIC & VISUAL INSPECTION

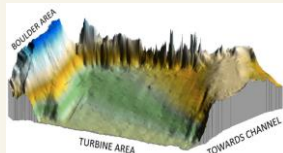
## UNDERWATER



- 200M RATED VEHICLE  
HIGH STRENGTH  
METALLIC ENCLOSURE
- 2X FULL HD CAMERA  
LOW LIGHT VISIBILITY  
20X OPTICAL ZOOM  
DEFOG & IMAGE  
STABILIZATION
- ALTIMETER OPERATING  
FREQUENCY 200KHZ,  
RANGE UP TO 200 M
- SIDE SCAN SONAR  
OPERATING FREQUENCY  
450KHZ, 120 SWATH
- LIGHT WEIGHT FRAME  
RUGGED, MODULAR, EASY  
PAYLOAD ATTACHMENT
- UNDERWATER POSITIONING  
HIGHLY PRECISE  
USBL SYSTEM
- 3X HIGH INTENSITY  
LED LIGHTS2000  
/ 4000 LUMENS EACH
- 8 X POWERFUL BRUSHLESS  
THRUSTERS 5DEGREE  
OF FREEDOM CONTROL
- SPOT CLEANING EQUIPMENT  
MODERATE MARINE GROWTH  
REMOVAL, CAVITATION  
JET CLEANING
- ULTRASONIC INSPECTION  
THICKNESS  
MEASUREMENT GAUGE



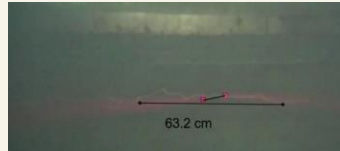
HD live video



SONAR/Bathymetric Surveys



Thickness Measurement



LASER defect quantification



Spot Cleaning of Marine Growth

## UNDERGROUND & ABOVE



Robotic Crawler based pan tilt zoom camera for inspection of pipelines of 20" + diameter upto 200 meter length to ensure the lines are free from defects and foreign particles.

**In-service & Pre-commissioning Inspection : Vessels**  
Client : Reliance & IOCL

**COKE DRUM & Vessels**

Carried out Inspection of Coke Drum, of 37meter height & diameter 8meter. Using Pan Tilt & 18X Optical Zoom camera with self illuminated light.

**In-service Inspection : Desalination Water Storage Tank**  
Client : Reliance

**STORAGE TANK**

Carried out Inspection of Desalination Tank in Reliance as Vacuum was created. During Inspection We found heavy damage like Bending of Supporting Channels And Uniform deformation of Heavy angle in one direction when inspected from Goose neck.

**Pre commissioning Inspection : Turbine Inspection**  
Client : RGPPL

**TURBINE INSPECTION**

Carried out Inspection in Power Industries on various Application on Steam & Gas Turbine, Nozzles, to inspect the condition prior to Commissioning. Using 6mm Articulating

**Pre commissioning Inspection : Fin Fan & Heat Exchanger Tubes**  
Client : Reliance, Essar, IOCL, BPCI & NFC

**FINFAN/HEAT EXCHANGER**

Carried out Inspection of Tube in Heat Exchange, Fin fan Cooler & Condenser up to the length of 30meter both side opening. Using 15meter length, 8mm diameter Articulating Videoprobe

# FORENSIC METALLURGICAL SOLUTIONS ON-CALL **FAILURE INVESTIGATION & RCA**

## Damage Mechanisms

Unravel the mysteries surrounding parts and assembly failures with Fast Turnaround time with in-depth analysis reporting.

Strong Recommendations within each report to avoid future failures.



- Corrosion due to CO<sub>2</sub>, Sour corrosion due to H<sub>2</sub>S
- Corrosion under insulation
- Stress Corrosion Cracking (Cl, NH<sub>3</sub>, caustic, CO/CO<sub>2</sub>, amine, methanol)
- Microbial Induced Corrosion on cold insulation areas
- Bimetallic joint – galvanic corrosion, Crevice corrosion
- Brittle failure due to impacting
- Environmental impurities causing pitting on turbine blades
- Erosion & Erosion Corrosion
- High Temperature Creep
- Fatigue (thermal, mechanical, pressure, vibration)
- Dusting, H<sub>2</sub> damage/cracking

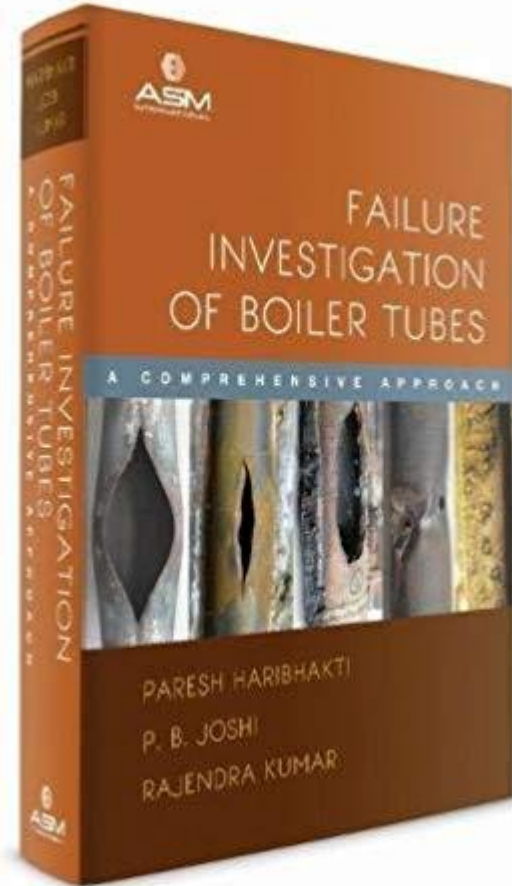




# BOOK ON BOILER TUBE FAILURES INDUSTRY CONTRIBUTION

TCR's Managing Director and Chief Metallurgist Paresh Haribhakti has written an award winning book on Boiler Tube Failures and associated damage mechanisms with detailed case studies

Published by ASM International (USA) and available at various university library and engineering companies as reference study material.





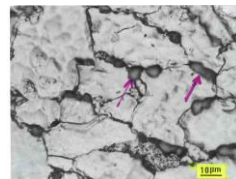
# Remaining Life Assessment of Boiler, Turbine, Heat Exchanger:

Ensuring components are used to the fullest extent for operation beyond desired useful life

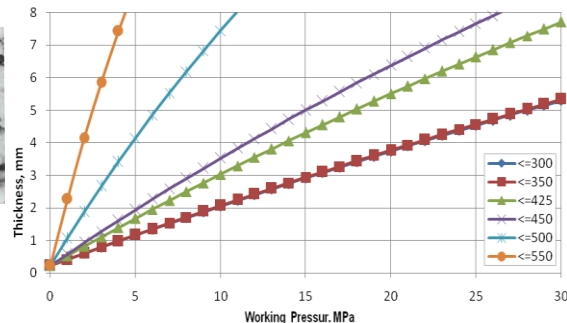
## Metallurgy + Engineering + NDT + Lab Destructive

Replica, EMAT, ACRT, Creep, PAUT, ABUT, RFET, Videoscopy, Oxide Scale, SEM Analysis, Mechanical, Chemical

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



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



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

## Conductive

$$R_{Total} = R_1 + R_2 \quad R_{Total} = \frac{\ln(r3/r2)}{2\pi lk1} + \frac{\ln(r2/r1)}{2\pi lk2}$$

## Temperature

$$\frac{T1 - T3}{R1 - R2} = \frac{T2 - T3}{R2}$$

## Thermal

## Thermal

## Lateral Strain

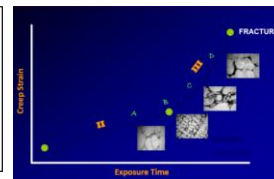
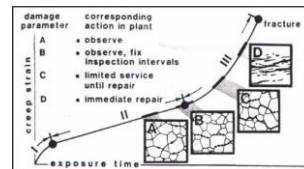
$$\bar{\sigma}_t = E \alpha \Delta t \quad \epsilon_t = \sigma_t / E \quad \epsilon_x = -\nu \epsilon_t$$

## Thermal Axial

$$\sigma_x = E / (1 - \nu^2) * (\epsilon_x + \nu \epsilon_t)$$

## Von Mises Theory

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2)^2 + (\sigma_1)^2 = 2\sigma_y^2$$



## Larson-Miller Parameter

Creep-Stress rupture data plotted as log stress versus combination of log time and rupture

# FITNESS FOR SERVICE AS PER API 579/ASME FFS-1

TCR's in-depth FFS report helps clients take decisions working with plant item in spite of presence a crack, metal loss at localized area, creep damage or mechanical damage like distortion or dents



Brittle Failure / Low Temperature



Decommissioned equipment that may be used in different services



Equipment operating in creep range and cyclic services

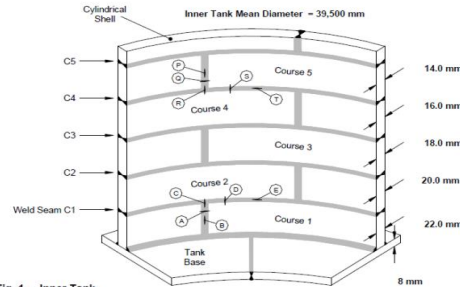


Fig. 1 - Inner Tank

Leak before break assessment of Ammonia Storage Tank



Isomerization reactor certified by TCR with detailed FFS Study post-Fire damage

# Reverse Engineering and Design Consultancy Engineering Design and Analysis Services



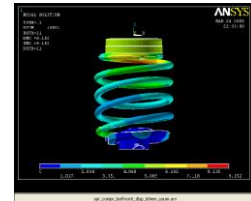
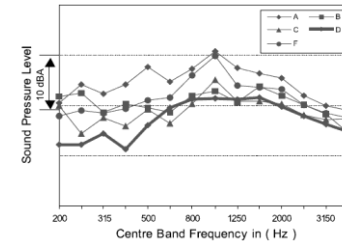
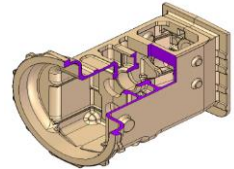
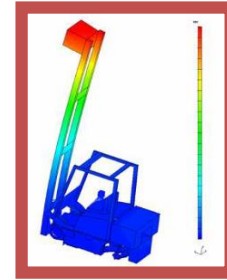
Leading Software - CATIA, Pro/ENGINEER, UniGraphics, I-DEAS, Inventor, SolidWorks, DELCAM, Ansys, CAESAR, HyperMesh, NX Nastran, Moldflow

**Computer Aided Designing (CAD/CAM) for 2D to 3D Conversions, Solid Modeling, Surfacing as well as Legacy Data Conversion**

**Computer Aided Engineering (CAE) including Finite Element Analysis (FEA) using Ansys**

**Structural Analysis including Pipe Support Analysis**

**Noise, Vibration, Harshness (NVH) analysis**



# TCR is leading the new way of Quality Assurance by defining the future

At TCR, we are continuously working towards improving our offerings to provide a better and a more efficient Quality Assurance for your Optimum Plant Health

## Industry-specific Solution

- Plant and industry veterans with understanding of process/operations challenges
- Aware of the business risk versus failure probability
- Keeping abreast on new materials and plant items

## Equipment-specific Solution

- Researching new techniques for inspection
- Constantly buying probes and accessories to ensure no downtime at site
- Train-the-trainer approach to spread knowledge

## Problem-specific Solution

- Corrosion damage evaluation is a specialty
- Metallurgy is the core of all investigation
- Look at a problem through multiple angles



## MAIL US

---

**SALES**

@TCRENG.COM

## CALL US

---

**+91.93233  
97295**

TO GET A QUOTE

## MEET US

---

**TCR ENGINEERING  
SERVICES**

PLOT NO. EL-182, MIDC-  
TTC, ELECTRONIC ZONE,  
BEHIND NELCO, MHAPE,  
NAVI MUMBAI-400 710  
MAHARASHTRA, INDIA

## VISIT US

---

**[www.tcreng.com](http://www.tcreng.com)**



## INDIA



### TCR ENGINEERING SERVICES

EL-182 MIDC-TTC, Electronic Zone,  
Mahape, NAVI MUMBAI-400710  
Tel : +91-22-67380900  
[www.tcreng.com](http://www.tcreng.com)



### TCR ADVANCED ENGINEERING

250-252/9, GIDC Estate, Makarpura,  
Vadodara-390010, Gujarat, India  
Tel: +91-265- 2657233, 2643024  
[www.tcradvanced.com](http://www.tcradvanced.com)



## KSA



### TCR ARABIA COMPANY LIMITED

P.O. Box-2899, Gas Gardens, King  
Abdulaziz Seaport Facility,  
Dammam-32211, KSA  
Tel: +966-3-8475784  
[www.tcr-arabia.com](http://www.tcr-arabia.com)



## UAE

### TCR ENGINEERING CONSULTING

**FZE, PO Box 122453, Dubai, UAE**  
Tel: +971-50-7858901  
[uae@tcreng.com](mailto:uae@tcreng.com)



## QATAR

### TCR QATAR

C/O Biewu International Trading WLL,  
P.O. Box: 24534  
#3, Al Emadi Building, Ras Bu Aboud  
Street, Ummgwallina, Doha, Qatar  
M: +974 55269747  
T: +974 44354768  
E: [Qatar@tcreng.com](mailto:Qatar@tcreng.com)  
[www.tcr-qatar.com](http://www.tcr-qatar.com)



## KUWAIT

### TCR KUWAIT

Fahaheel-64023, Kuwait  
[kuwait@tcreng.com](mailto:kuwait@tcreng.com)  
[www.tcr-kuwait.com](http://www.tcr-kuwait.com)



## MALAYSIA

### TCR MALAYSIA

C/O Approved Group International  
No 6 Jalan DBP 3,  
Dolomite Business Park,  
68100 Batu Caves  
Selangor, Malaysia  
TEL: +603-6188 6311





**TCRENG**

**ENGINEERING**

THANK YOU

For questions, mail us at [sales@tcreng.com](mailto:sales@tcreng.com)