Experts in Metallography and Failure investigation

Advanced Engineering P. Ltd.

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COMPANY PROFILE

// 2018 //

TESTING I NDT I FAILURE INVESTIGATION I RLA
FFS I RBI CONSULTANCY I TRAINING

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1) BRIEF HISTORY OF THE COMPANY

TCR Advanced Engineering Pvt. Ltd. was established in the year 1998, and started working from 14th March 1999 at Vadodara. It is a service partner of TCR Engineering Services Pvt. Ltd. Mumbai, a company established in 1973, an old reputed organization.

TCR Advanced Engineering Pvt. Ltd. has been established to cater to the advanced metallurgical needs of the Industries at Baroda a hub of chemical and petrochemical industries. Company has set-up full-fledged advanced Metallography laboratory facilities at Vadodara, Gujarat. TCR ADVANCED offers specialized services in the field of Metallography, The company provides services such as Failure Investigations, In-situ Metallography for process related equipment in-service degradation, Remaining Life assessment, Fitness for service, Indigenization of the components, Advanced NDT testing, Selection of materials of constructions etc.

TCR Advanced Engineering has a competent team of metallurgical engineers, technicians and other field staff working for catering to the need of Metallography and testing work. Mr. Paresh U. Haribhakti (Managing Director) who is a Metallurgical Engineer and holds Master's degree in 'Materials Technology' heads the company. He is having more than decade experience in the field R & D activities, Failure Investigations, Damage Assessments and RLA studies at India's largest fertilizers and petrochemical complex GSFC Ltd., Vadodara.

TCR Advanced has set up a fully fledged Testing Division to meet the needs for testing such as raw material testing, Material Identification, Welding Qualification, NDT testing, Microstructure examination for evaluation of material processing, chemical properties & physical properties of metallic materials. The testing division of TCR ADVANCED is a NABL accredited Testing Laboratory in the field of Chemical, Mechanical Testing and Non destructive Testing as per international standard ISO/IEC-17025 – 2005.TCR Advanced is the pioneer lab in Gujarat to be accredited for Non destructive testing.

In the year 2012, TCR ADVANCED received recognition as "**Well known Remnant Life Assessment Organization**" and subsequently in year 2013 we received recognition as **"Well known Material Testing Laboratory"**. from Central Boilers Board (CBB), Government of India, Ministry of commerce and industries. With this approval TCR can carry out life assessment jobs and certify the fitness of boiler components and carry out material testing as per Indian Boiler Regulation, 1950.

In the year 2013 the new state-of- the art laboratory building was constructed. The material testing and consultancy facilities of TCR advanced engineering were shifted to this building in July 2013.In the same year TCR became the first lab in Gujarat to have NABL accreditation for Non-destructive testing.

Our Approvals

- Chemical testing, Mechanical testing and Nondestructive testing as per ISO/IEC-17025 by National Accreditation Board for testing and calibration laboratories **(NABL**), New Delhi
- Approved for higher education research work by **M S University**, Vadodara.
- Well known remnant life assessment organization by Central Boiler Board (**CBB**), New Delhi
- Well known Material Testing Laboratory, byCentral Boiler Board (**CBB**), New Delhi
- Approved by third party inspection agencies like NPCIL, IRS, BV, TÜV, LRA,EIL
- Approved lab by Sandvik Asia Ltd, Cameron Manufacturing, ABB, Alstom etc.

2) RANGE OF SERVICES OFFERED BY TCR ADVANCED

TCR ADVANCED's ability to provide value to our metal testing customers is based on organizing multiple talents into a focused set of technological capabilities. TCR ADVANCED provides several testing services, no matter which discipline you choose, one thing is certain, when you send a sample to TCR ADVANCED, you can have confidence in the results, because you are working with a company that has a reputation for being meticulous.

Chemical Analysis
- Lab spectrometer
- Wet analysis
- Portable XRF based spectrometer
- Purity of Metals
- Ash Content
- EDS Analysis for coatings.

Non Destructive Testing
- Ultrasonic Examination
- Dye penetration Test
- Magnetic Particle Inspection
- Thickness measurement
- In-situ Metallography
- Positive Material Identification
- Eddy Current Testing
- Thermography
- Videoscopy
- Reformer Tube Inspection (ARTiS)
- Vacuum Box testing
- Helium Leak testing
- PAUT, TOFD

Specialized Services
- Failure Investigation
- Remaining Life assessment
- Insitu metallography
- Fitness for service
- Third Party Inspection
- Help on indigenization
- Scanning Electron Microscopy
- NDT training
- Metallography training.
- Post Weld Heat Treatment
- Scanning Electron Microscopy(SEM)
- Risk Based Inspection(RBI) services
- High temperature Corrosion

Mechanical Testing
- Tensile Testing
- Bend/ Re-bend Test
- Hardness Testing
- Impact Test
- PQR/WPQ test
- Peel test
- Flaring/ Flattening Test
- Residual Stress Measurement

Metallurgical Testing
- Microstructure Examination
- Macrostructure Examination
- Linear Measurement on weld
- Grain Size measurement
- Inclusion rating
- Jominy End Quench Test
- Case depth Measurement
- Nitriding/ Coating Layer measurement
- Color Metallography
- Sigma Phase measurement
- Retained Austenite
- Micro Hardness

Corrosion Testing
- Corrosion rate as per ASTM A-262
- Pitting and crevice corrosion by ASTM G48
- Intermetallic phases as per ASTM A 923
- Electrochemical testing by Potentiostate
- Salt spray test
- Ammonia stress corrosion
- Immersion testing

Material Testing Services

A. CHEMICAL ANALYSIS

TCR ADVANCED is providing chemical analysis facilities for accurate characterization and identification of metals & alloys. TCR ADVANCED by wet chemical analysis and by Optical emission spectrophotometer using advanced Spectra lab machine SPECTROMAXx is capable of accurately analyzing the Iron base, copper base, nickel base and aluminum base alloys. TCR ADVANCED has more than 35 Certified Reference Materials(CRM) which ensures the highest accuracy in test results.

TCR ADCVANCED is equipped with Portable XRF based spectrometer for Positive Material Identification. This is a NDT technique for analysis of alloy content of the material. It cannot detect the nonmetallic elements. Typical PMI results are accurate to ±10%. This is very useful technique in material sorting, scrap identification etc. TCR Advanced also provides services chemical analysis at site by portable SPECTRO through its service partner company. With this equipment one can analyze all elements including Carbon, Sulfur, Phosphorous, Silicon apart from alloying elements.TCR ADVANCED has added EDS analyzer to the SEM UNIT for identifying the chemical composition of localized area such as plating, coating or localized corrosion defects.

List of chemical Analysis test equipment

NAME OF EQUIPMENT	MAKE	YEAR OF MFG.
Optical Emission Spectrometer	Spectromax X-German	2005
Strohlien's Apparatus for Detecting Carbon and Sulfur	Venus Instruments Mfg. Co.	2001
Kjeldha's Apparatus for N_2 determination	Borosil Glassware with sunbeam heating mantle	2001
Fume Chamber	Fabricated Indigenously	2001
2 KW Furnace with temp. Controller	Fabricated	1998
Hot air oven	Jaymet	2001
Electronics Single Pan Balance (0.0001 gm Accuracy)	Ohaus, US	2001
Full Fledged Lab Glassware for Chemical Analysis	Borosil	-
Electrolytic Apparatus with Platinum electrodes for Cu and Pb determination	Electrodes are made by Hindustan Platinum ltd.	2001
PMI (Portable XRF based spectrometer)	Niton	2013
EDS analyser	Oxford Instruments SMax 20	2012

B. MECHANICAL TESTING

TCR ADVANCED provides a comprehensive range of Mechanical Testing. The Mechanical Testing Facility consists of Universal testing machine, Rockwell hardness tester, Brinell cum Vickers hardness testing machine, Micro Vickers hardness testing machine, Impact testing machine etc. TCR ADVANCED conducts tensile tests for understanding the strength characteristics of a material and provides precise determination of Proof Stress by the attachment of electronic extensometers. The following tests are also carried out: Welder Qualification test, welding Procedure qualification tests, Bend Tests, Compression Tests, Flaring and Flattening Tests on Universal testing machine. The mechanical testing personnel of TCR ADVANCED are well aware of the requirements various national & International codes of testing such as IS, ASTM, DIN, EN, API, ASME, AWS.

Superior technology, responsive versatility, and quality performance ensures reliable and fast turnaround on all test results. Experienced technicians at TCRADVANCED are capable of low stress grinding and machining sub-size specimens to very close tolerances. We have designed several fixtures for tensile testing of end products without machining them to tensile test specimens.

List of Mechanical test equipment

NAME OF INSTRUMENT	MAKE	YEAR OF MFG.
Rockwell hardness tester with standard accessories Measuring Range –HRA, HRB, HRC & superficial hardness testing scales HR15N, HR30N, HR45N, HR15T, HR30T, HR45T	SMS, Ahmedabad	2005
Vickers Cum Brinell Hardness tester with standard accessories Load range Vickers hardness test 5,10,15,20,30,40,50,60,100 and 120 kgf Brinell – 15, 31.25, 62.5, 187.5 kgf	German make, Sold& serviced by Blue-star	-
Vickers Hardness tester with standard accessories Load range Vickers hardness test 5,10,15,20,30,50,100 and 120 kgf	FIE	2010
40 T Computerized Universal testing machine • Electronic Extensometer for 0.2 % Proof stress	FIE Make Model	2015
60 T Computerized Universal testing machine With Electronic extensiometer for 0.2 % Proof stress	FIE Make Model: TUN 600	2013
Vicker's Micro hardness tester Load range: 10, 25, 50, 100, 200, 300, 500, 1000 gms	Wison Wolpert	2002
Vicker's Micro hardness tester Load range : 10,25, 50, 100, 200, 300, 500, 1000 gms	Banbros	2007
Impact testing machine	FIE make	2008
Jominy End Quench Test setup for hardenability of Steels	Developed In house	2008
Lateral Expansion Gauge, Squareness gauge for impact specimen	Anand Testing Machines	2009
3000 Kgf Brinnel hardness tester	FIE	2010
Profile Projector	Metzer, Megavision	2008
Automatic programmable Heat treatment facility with chart recorder	Premier Instruments	2011

C.METALLURGICAL TESTING

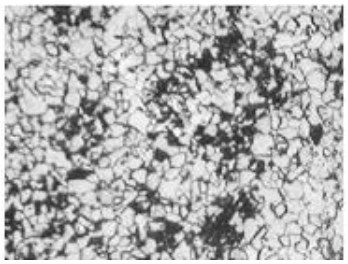
Qualified metallurgists at TCR ADVANCED are experts in Metallographic preparation & examination to evaluate the characteristics of metals. We can assess a material's heat treatment condition, microstructure, and forming process. The team undertakes Macro and Micro examination including Weld Examination, Case Depth and Decarburization Measurement. Micro Hardness Testing and Coating/Plating evaluation is also undertaken. The Metallography laboratory has the state-of-the-art Inverted Metallurgical Microscope Olympus GX51 and three other inverted microscopes attached with CCD camera of capturing metal structures on Image processing workstation for Image Analysis. TCR ADVANCED has developed Microstructure Characterizer (MiC) software that assists metallurgists for analysis of images to determine depth of decarburization, phase/volume percentage, grain size, inclusion rating, particle size, Nodularity, nodule count, porosity and coating thickness, Austenite spacing.

TCR Advanced has taken a lead in certifying Heat Treatment Quality aspect from microstructure point of view. A conventional acceptance criterion for heat treatment is through hardness testing. However, hardness testing alone can be misleading, since certain unwanted phases and its distribution is not reflected in hardness reading. Fine distribution of phases and its monitoring through microstructure is the only answer for the acceptance of heat treatment that promises desired or extended life of component. TCR Advanced has taken this challenge and helped many industries for use of microstructure examination as quality control tool for determining heat treatment.

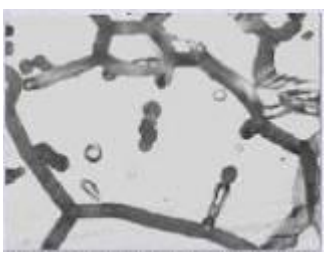
We certify following heat treatments…

Bulk	Surface	Metals / Alloys
Normalising	Nitriding	Steel
Homoginization	Carburizing	Cast Iron
Solution Annealing	Carbonitriding	Super Alloys
Hardening & Tempering	Hard Surfacing	Nickel Alloys
Precipitation Hardening	Induction Hardening	Copper Alloys
		Stainless Steel
		Aluminium Alloys
		Heat Resistant Alloys

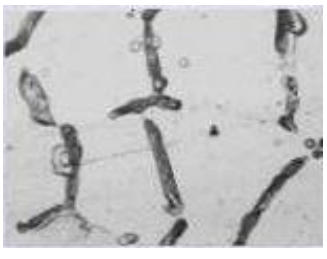
As cast carbon steel



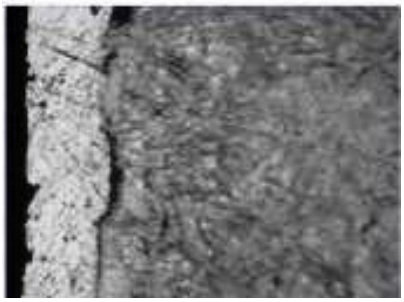
Normalized carbon steel



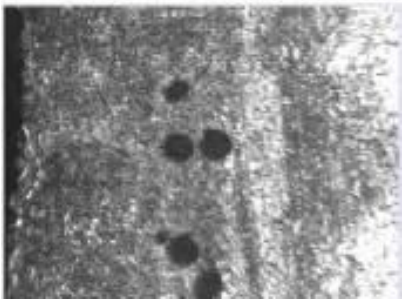
Intergranular carbide precipitation
Solution annealing is not satisfactory



Isolated carbide precipitation
Solution annealing is not satisfactory



White layer developed during gas nitriding process
Undesirable structure



Porosities developed with Sursulf nitriding treatment

TCR Advanced has expertise in metallurgical testing. We undertake intermetallic phase identification, volume fraction of various phases in weld, HAZ, and Cast structures. TCR ADVANCED is the only accredited facility for microscopical measurements such as coating thickness, weld penetration measurements, minimum leak path in tube to tube sheet joints etc.

List of Metallurgical test equipment

NAME OF INSTRUMENT	MAKE	YEAR OF MFG.
Inverted Metallurgical Microscope (Model: GX 51-233D) with digital camera	Olympus Corporation, Japan	2005
Optical microscope with CCD camera attachment model EPY TYP – II	Carl Zeiss, Jena	-
Inverted Metallurgical Microscope (Model: GX 51-233D) with digital camera	Olympus Corporation, Japan	2010
Low Magnification observation station with CCD attachment	Machine Vision, MV5100HU	2010
Metallurgical image processing workstation with Microstructure Characterizer(MiC) Software	Developed Indigenously	-
Metallurgical Microscope (Model: BMI-101 A)	Banbros	2005
Inverted Metallurgical Microscope	Radical	2008
Stereo zoom microscope with standard accessories	Carl Zeiss Jena	-
Portable Etching Cum Polishing machine model – Insipol 2000	Instruments Universal	2001
Metal Polishing with D. C. drive	Naresh Industries	2003
Portable Angle grinders & Polishing equipment model – 875	Chicago Pneumatics	2001

NAME OF INSTRUMENT	MAKE	YEAR OF MFG.
Low speed metallographic Cutting/ Sectioning machine Type Vs- 100	HIFIN	2000
Hot moulding machine Type MHP – 310	HIFIN	1999
Automatic Polishing Machine model MoPao 1000	MoPao	2009
Heat treatment Furnace(up to 1100 C)	Shivang furnaces	2009

D.CORROSION TESTING

TCR ADVANCED undertakes a wide range of corrosion tests per ASTM, DIN, or as per an individual client's requirements. Experienced staff members are available to provide corrosion consulting, advice on corrosion prevention and corrosion control services including materials selection in laboratory or on-site inspection. TCR's staff with specific industry expertise covers a variety of corrosion problems that are encountered in industries such as oil and gas production, oil and gas transmission, energy conversion systems, and nuclear power systems. The objective of the corrosion detection department at TCR is to provide quality service. A wide variety of corrosion related tests are undertaken at TCR ADVANCED to determine susceptibility to intergranular corrosion, pitting corrosion, stress corrosion cracking etc. The range of instruments available to perform these tests is unrivalled in our operating regions. Highly experienced and qualified engineers routinely undertake corrosion studies. We also carry out the testing under witness of 3rd party inspection agencies like LRS, TÜV, DNV, ABS, BV and other inspection agencies.

TCR ADVANCED has added fully automated state of the art Salt spray testing facility in the year 2011.This test is very useful in analyzing the corrosion resistance properties of Plating, Coating, Painted surfaces or the materials that are to be used in corrosive environments.

List of Corrosion test equipment

NAME OF EQUIPMENT	NO OF SETS
Gamry Make Series G750 Potentiostate/ Galvenostate for Electrochemical Analysis and Corrosion studies.	1
Full fledged set up and Erlen Meyer Apparatus for conducting Various IGC tests as per ASTM A – 262	15
Complete set up for conducting various tests as per ASTM A – 923 for pitting corrosion	12
Complete setup for conducting various tests as per ASTM G-48	6
Constant temperature bath range: 5°C to 80° C	1
Constant Temperature bath Range : RT to 100° C	1
Salt Spray Test apparatus	2

E. NON DESTRUCTIVE TESTING (NDT)

At TCR ADVANCED, a team comprising of qualified and expert metallographers and metallurgists to carry out in situ metallography testing (Replica). Also the qualified NDT technicians (ASNT levelI) perform Ultrasonic Flaw detection, Magnetic Particle and Liquid Dye Penetrant testing, Ultrasonic Thickness Gauging survey, hardness testing Storage/Sphere Tank Inspection, Eddy Current testing, Helium Leak detection, Internal Oxide scale thickness measurement for boiler tubes. Field service Metallography and structural inspection are also offered. Our experienced personnel are respected for their integrity and recognized by all the relevant inspection authorities. Our NDT services are routinely performed in the following market sectors: petrochemical, automotive, construction, transport, defense and general engineering.

TCR ADVANCED offers advanced NDT testing facilities such as Eddy Current testing, Internal Oxide scale measurement for Boiler tubes, Helium Leak testing, Thermography, MFL (Magnetic Flux leakage for tank bottom), Hardness testing by UCI (Ultrasonic Contact Impedance) Method using Kraut Kremer Hardness tester.

TCR Advanced is now offering services of new and upcoming heat Exchanger tube inspection techniqueAcoustic Eye™ based on Acoustic Pulse reflectometry principle. This is an ultrafast flaw detection technique with detection time less than 10 seconds per tube. It can detect blockages apart from pitting or punctures- useful for detecting extent of cleaning, to increase efficiency of heat exchanger.

TCR has IRIS DVR 5 Videoscope and an indigenously developed boroscope machine which can be used to carry of visual inspection of closed inaccessible spaces such as tube ID surface, vessels. Our viodeoscope probe can be inserted up to 10 mm dia holes. In the year 2013 TCR Advanced became the first NABL accredited lab in Gujarat for NDT testing.

In the year 2014 TCR added Crack depth Meter, Ferritometer and Surface roughness measurement facilities at lab and site testing

List of NDT testing equipment

NAME OF INSTRUMENT	MAKE	YEAR OF MFG.
Portable Hardness Tester	Time Group Inc.	-
Electro Magnetic Crack Detector (Yoke Type) with A. C. & H. W. D. C. Mode,	Magnaflux	2003
Ultra Violet Black Light with power supply unit	Magnaflux	2003
Magnetic Field Indicator	Magnaflux	2003
Magnetic Field Meter (0-10 G.)	In-electronics	2003
Dry and Fluorescent Magnetic Particle Powder	Magnaflux	2003
Dye Penetration Kit	Magnaflux	-
In-situ Metallography Kit	Developed	2003

NAME OF INSTRUMENT	MAKE	YEAR OF MFG.
	In-house.	
Ultrasonic Flaw Detector (Model: Einstien-II, Da Vinchi) with Reference Blocks (IIW V1, V2 & Step Wedge)	Modsonic	2004
Ultrasonic Thickness Gauge (Model: ETM-2) High temperature probe.	ParikhInd. (EEC)	2006
Coil type MPI Machine (Model D500)	Magnaflux	2008
Internal Oxide thickness Gauge	Olympus/ Panametrix	2010
Portable Hardness tester Hardness tester UCI method (Model MIC 20) with Diamond Inventor	Kraut Kremer	2010
Rebound type hardness tester	MITECH	2009
Acoustic Eye™, Dolphin G3 system	Acoustic Eye™	2011
Eddy current tester	ECT 48 µDock Olympus	2012 2014
Time of Flight Diffraction Technique (TOFD)	Modsonic	2012
Videoscope	ITConcepts IRiS DVR 5	2013
Phased Array Ultrasonic tester (PAUT)	Olympus	2014
Vacuum Box for tank bottom inspection	East west	2013
Crack Depth meter		2014
Ferrite meter	FMP30 Fischer	2013
Surface roughness meter	Time	2014
Durometer		2015
Ultrasonic Flaw Detector (02 nos.)	GE Krautkramer	2016
VIDEOSCOPE – MODEL No. - XLVUDC B8480	GE	2016
Permeability meter (Ferromaster)	Stefan Mayer	2016
Gauss meter	Magnaflux	2017
Coil MPI machine (includes one coil)	K-lectronics/ MT-6000	2017

NAME OF INSTRUMENT	MAKE	YEAR OF MFG.
Digital Gauss meter	East west	2017
Battery operated UV light (Qty-2 Nos)	Arora	2017
Ultrasonic thickness gauge (High Thickness Measurements)	Cygnus/Agency: Eastwest/Model: Cygnus 4+	2017
Ultrasonic thickness gauge	Cygnus/Agency: Eastwest/Model: Cygnus 2+	2017

4) SPECIALIZED ACTIVITIES:

A. FAILURE ANALYSIS AND INVESTIGATION SERVICES

TCR Advanced Engineering Pvt. Ltd. and her associate company TCR Engineering Services have completed more than **2500 failure investigation assignments**, including major projects on manufacturing or metallurgical failure analysis on ASME boiler and pressure vessels, Gas turbine engine components, Oil and gas transmission pipelines, Food processing equipment, Heat exchangers, Medical supplies, Automotive components, Refineries, Petrochemical plants, Offshore structures, Industrial machinery, Weldment and Ships.

Evaluating high temperature and high-pressure failures are Our strong areas of failure investigation. The Failure Analysis Team at TCR Engineering has experience in the materials, failure analysis, metallurgical, welding, quality assurance, and forensic engineering fields and is conducted by engineers holding advanced degrees in metallurgy, and mechanical, civil, chemical, and electrical engineering.

Our investigation team works with clients to plan the failure analysis before conducting the investigation. A large amount of time and effort is spent carefully considering the background of failure and studying the general features before the actual investigation begins.

We have a methodical approach to determine the mode and root cause of a failure. For experts of TCR, Failure analysis or problem solving is more than just brainstorming a solution to an identified problem. Successful analysis is achieved through a structured technique, which uncovers the facts of the incident and adheres to a defined process for every step of the analysis process.

Failure Analysis Objectives

The first step in managing the actual failure analysis effort is to determine what you expect from the final outcome. During TCR's initial meeting with clients we develop a charter that clearly delineates the terminal objective of the analysis. This is further enhanced through the development of critical success factors that outlines whether the terminal objectives have been obtained. At TCR Advanced Engineering, we adopt a disciplined vertical problem solving methodology used to determine levels of root causes of specific failure events. The following process is necessary to implement a successful failure analysis project.

Prioritize - Determine what is most important to work on.
Analyze - Analyze the failure event to determine root causes.
Recommend - Develop recommendations as solutions to the causes discovered.

The TCR ADVANCED Engineering Approach

Our failure analysis team is always headed by a senior metallurgical engineer who has the following characteristics:

- Ability to remain unbiased and reject conventional wisdom.
- Ability to facilitate a group of people toward a common objective.
- Trained in logic tree approaches to failure analysis.
- Affinity for listening and questioning for understanding.
- Patience and perseverance.

Procedure to conduct a Failure Analysis

Cause of failure is determined using state-of-the-art analytical and mechanical procedures and often includes simulated service testing. A combination of analysis and physical testing locates problems and provides recommendations for solutions.

In the course of the various steps listed below preliminary conclusions are often formulated. If the probable fundamental cause of the metallurgical failure becomes evident early in the examination, the rest of the investigation focuses on confirming the probable cause and eliminating other possibilities. The metallurgical failure analyst compiles the results of preliminary conclusions carefully considering all aspects of the failure including visual examination of a fracture surface, the inspection of a single metallographic specimen, and the history of similar failures. The complete evaluation sequence is summarized as under:

- Collection of background data and selection of samples
- Preliminary examination of the failed part
- Complete metallurgical analysis of failed material
- A thorough examination of the failed part including Macroscopic and Microscopic examination and analysis (electron microscopy, if needed)
- If necessary tests may also include Weld Examination, Case Depth, Decarburization Measurement, Coating/Plating Evaluation, Surface Evaluation and/or Grain Size Determination
- Chemical analysis (bulk, local, surface corrosion products, deposits or coating and microprobe analysis)
- Tests to simulate environmental and physical stress that may have played a role in the failure analysis of fracture mechanics.
- Selection and testing of alternative products and/or procedures that will significantly improve performance
- On-site evaluation and consulting services and Formulation of conclusions and writing the report

The Failure Analysis Report

The failure analysis report represents the culmination of the analysis effort and the beginning of failure elimination. The goal of any failure analysis by TCR is targeted towards the elimination of identified causes. The completed failure analysis report includes the following sections:

- Description of the failed component

- Service condition at the time of failure
- Prior service history
- Manufacturing and processing history of component
- Mechanical and metallurgical study of failure
- Metallurgical evaluation of quality
- Event Summary of failure causing mechanism
- Recommendations for prevention of similar failures

The final failure analysis report provides solutions with expected returns on investments but also identifies how the failure occurred in the first place. To accomplish this event summary, a description of the failure mechanism and list of recommendations are included in the report.

The event summary is a brief description of how the failure was first noticed how long it has been going on and the method(s) used to isolate or mitigate the consequences of the failure.

The failure mechanism can be thought of as a summary of the root cause(s) that led to failure occurrence. TCR will chronologically characterize the things that must occur in order for the failure to manifest itself. The report will outline the Mechanical and metallurgical study of failure including the Metallurgical evaluation of quality. The list of recommendations will explain what, when and who (if TCR consultants are on the project) is going to be responsible for implementation, and also include a recommendations for prevention of similar failures.

B. THIRD PARTY INSPECTION AND QUALITY ASSURANCE SERVICES

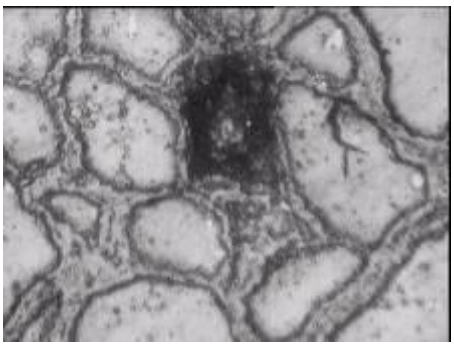
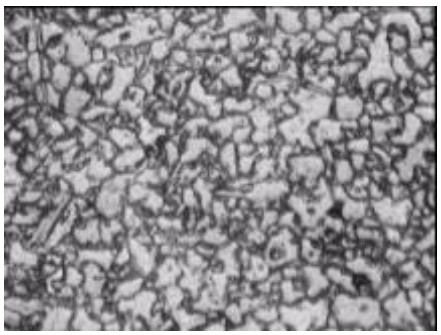
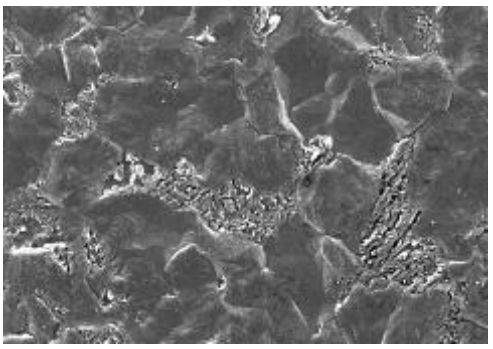
TCR ADVANCED, through its service partner company's offices, provides inspection and quality assurance services to help retailers, trading partners, importers and manufacturers assess product quality and meet the regulatory requirements of their industry vertical. Independent, third-party inspection and quality assurance services results in improved product quality, with a reduction in customer complaints, noncompliance and product recalls. The on-site inspection team covers the all states across India and abroad. The pricing structure for the on-site inspection services is set competitively and is based on man-day charges. Our inspection services include:

C. IN-SITU METALLOGRAPHY

Performed as an NDT service, In-Situ Metallography from TCR determines in-service degradation of critical components of process plants operating under high temperature, high pressure or corrosive atmosphere. TCR's Metallurgists have strong experience in the interpretation of microstructures. More than 10,000 replica microstructure interpretations have been logged and captured to our databases. These databases contain extensive information from various plants that have been captured over the course of us performing this service. The databases also include rare collections of varying microstructure damage levels for various industries such as power, oil and gas, petrochemical, fertilizers, and other process industries. The In-Situ Metallography team is highly skilled in the art of replica preparation. TCR has custom developed special purpose in-situ polishing devices which assist to enable metallographic polishing in difficult locations and allows the field services team to carry out high quality replication even on warm components.

- The In-Situ metallography is performed for following areas:
- To find out in-service degradation of critical components of the process plants operating under high temperature/high pressure/corrosive atmosphere.
- Damage Assessment of fire affected equipment of the plants.

- Microstructure survey for critical components viz., Boilers, Pipelines, Reactors and Vessels for condition monitoring/health assessment.
- To develop a data bank of critical components of equipment of process plant by periodical monitoring for preventive maintenance and planning for inventory control.
- To provide suggestions on their welding used components of process plants.
- To check the quality of the microstructure of component for intended service before put in to use.

Examples of Replicated structures

D. DAMAGE ASSESSMENT / RLA

TCR Advanced undertakes Damage Assessment work for the equipment / components exposed to accidents in the industry. Integrity of Reactor/Pipeline/Heat exchanger etc. can be found out with the help of modern NDT Techniques. If required representative samples are drawn to undertake detailed lab study. The usefulness of equipment is derived based on metallurgical requirements and operational details.

E. TECHNICAL HELP FOR INDIGENIZATION

To unfold the metallurgical status/properties of imported components by destructive/nondestructive studies, to generate baseline standard for indigenization. Technical help is provided to decide manufacture route and guidance is provided to derive quality checks on indigenously developed components.

Details required from client:

1. Working condition of component.
2. Type of loading & stresses.
3. Design and operation condition.
4. Service history of component.
5. Life of an important component.

F. SELECTION OF MATERIALS

Weight loss experiments. Samples of different metals/alloys are exposed under simulated or actual process plant solution in the laboratory with and without stirring. This technique has limited application. Coupon of different metals/alloys is exposed to actual plant environment. A systematic approach is formulated based on requirement of intended services, literate survey, and relevant standards like NACE, ASTM and API. The laboratory study is performed on exposed sample to categorize their performance and suitable MOC is recommended. Electrochemical experiments to find out relative corrosion resistance performed by accelerated testing under laboratory conditions. MOC selection is done with readymade database and experience of others from published literature.

G. QUALITY IMPROVEMENT

TCR Advanced undertakes total quality improvements for stringent requirements against international specifications. Thorough survey is undertaken by auditing existing manufacturing procedure. Stagewise investigations are followed for manufacturing of product including raw material. Effects of processing conditions are derived with respect to different properties of the component. Based on the study recommendations are made for improvements in metallurgical process/raw material. Required optimum quality control checks are suggested to ensure consistency in quality for continuous production. TCR Advanced deputes a team of metallurgical engineers to perform this task. report comprises of fundamentals of metallurgical processing variables on final properties of component is submitted along with recommendations.

H.SOLUTIONS OF CRITICAL WELD PROBLEMS

TCR Advanced Engineering Pvt. Ltd., has vast expertise of solving critical weld repair solution of the aged plant components. Nowadays the material resources are limited and value of new product is increasing day bay day. The repair weld solutions can salvage the critical components of process plant and can made huge saving in terms of production loss. The repair weld technology requires in depth understanding of metallurgical degradations vis-a- vis operating conditions. Clear understanding of physical metallurgy and welding technology. There is a right solution of every problem and the solution can be found out by engineering and technical common sense with strong fundamentals. TCR has been leader in many aspects. The off shoot of knowledge bank at TCR Advanced is the successful stories behind more than 600 failure investigations of the industries. This insight in to the failure mechanisms has strengthen the knowledge of TCR technical team which is directly implemented for repair weld solution. When any plant of critical machinery component is under breakdown the immediate right solution is sought after many times the repair welding are done with little or No understanding about the metallurgical fundamentals which in turn proves to be disastrous and management loses the trust in the technical competency. This philosophy promotes hasty decisions for replacing the components at premium cost. Instead of this a systematic detailed metallurgical investigation would provide the extent and nature of degradation there by utilizing knowledge of metallurgy a proper welding procedure can be devised. TCR ADVANCED has helped the industries by providing the repair solutions on critical pump casing, shaft, nitrided components reformers, and so on.

The engineering consulting team can be approached with detailed history of problem. Our team can reach to your sight within 24 hrs and start generating information and data on the components to be repaired. For successful repair a mock up test is necessary from the same material preferably for the aged material of similar grade. In case it is not available then virgin material of the similar grade is also useful. A mock up test will establish the confidence in welder and welding parameters. After successful welding through NDT testing is recommended to ensure the trouble free welding joint for future service.

I. FERROGRAPHY

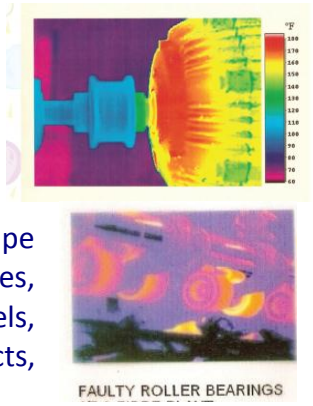
Ferrography or oil analysis is a series of laboratory tests to determine the condition of used Lubricants in equipment /components, over a period. A trend of wear particle distribution and their Concentration typically presents the condition of the Equipment also it provides opportunity for Maintenance programs from breakdown to be proactive.

J. EDDY CURRENT TESTING

The Eddy current test is not a volumetric technique. This is a surface technique and can readily detect very shallow surface defects (fatigue crack, inter-granular stress corrosion cracks etc.), sub surface defects (inclusions, voids etc.) within a depth of say 6 mm. It can also identify pitting, cracking, microbiological induced corrosion damage, support wear, erosion etc. and hence is very widely used as an important tool of in-service inspection of heat exchangers. This Nondestructive testing using a multi frequency Eddy Current system would examine surface and sub-surface areas of materials with suitable electrical conductive and magnetic properties. The instrument used allows Inspection of a large variety of materials and provides documentation of the inspection all in one unit. Our Engineers are well trained in carrying out the test at Site and interpret the results accurately, depicting the actual condition of the tubes based on the test results, particularly very competent in resolving between defects and non-relevant indications. All Eddy current testing jobs were carried out by Level II qualified engineers with a throughput of about 800 tubes per day.

K. THERMOGRAPHY

It is used to find out temperature anomalies present in the equipment during their operation. This is a non-contact method of testing and viewing is remote. Even helicopters can be used for testing large regions. This is a very recent addition of the NDE. Any hot object emits the heat radiation. An Infrared sensor which can pick up such radiation to form the image of the hot body. The hot and cold regions on the surface can be analyzed for the healthy condition of the object. Thermography is useful for applications such as Deposits or blockages in pipe lines carrying hot or cold fluids, Refractory or insulation deterioration in Furnaces, Boilers, heaters, converters etc. Electric sub-stations for control panels, transformers, switch gear etc. for overloading, lose or damaged contacts, Overheated bearings in rotary equipment e.g. Motors, generators, turbines etc.


FAULTY ROLLER BEARINGS

L. ROBOTIC INSPECTION OF TANKS

This technique uses an automatic robotic crawler to enter in to the Tank for collecting data such as thickness, Ultrasonic soundness, visual inspection by video camera while tank is in service. the robotic crawler systematically scans the tank bottom with an array of eight ultrasonic transducers and relays high volume of UT data for analysis. The in tank service follows a digital inspection grid and collects more than 200000 UT scans(based on the average scan pattern in a 100 ft dia. Tank) for computer analysis. The robot pushes sludge aside as it travels, making cleaning and waste disposal unnecessary in many cases. Some of the salient features of this technique eliminates the high cost of taking down your tanks. The testing can be completed as per API 653 inspection in days instead of weeks or months. Reduce environmental and safety risks without opening the tank or due to manned entry.

M. HEAT TREATMENT FACILITY

TCR Advanced offers post weld heat treatment by using electricity as source of heating for stress relieving of weld joints. All TCR's heat treatment services are designed to minimize downtime, improve structural

integrity, and enhance effective plant life. Additionally, depending on the mobility of the required equipment many of our heating processes can be applied on-site or at your facility.

TCR has specialized fully automatic programmable equipment capable of controlling Heating rate, Holding time and cooling rate to carry out a wide range of heat treatment processes like post weld heat treatment of PQR test coupons, and various components. TCR is capable of doing Post weld heat treatment of carbon steel piping welds (pipe-work, headers, flange joints, valves and branches) by means of the electrical resistance method, in the form of ceramic heater pads. The Heat treatment equipment is supplied with chart recorder to record up to 8 thermocouples simultaneously for meeting the critical requirement of heat treatment.

N. ACOUSTIC EYE

Acoustic Eye's breakthrough, non-invasive solution for today's hard-to-inspect tubes up to4" inner diameter enables ultra-fast, accurate inspection of boilers, Fin Fans and other heat exchangers, regardless of tube shape or material. Featuring patented Acoustic Pulse Reflectometer (APR) technology, Dolphin G3™ is an advanced, yet easy-to-use tool that overcomes the limitations of many conventional inspection techniques. With its simple operation, automated analysis and report generation, there is far less dependency on operator expertise. Providing reliable inspection of even the most challenging tube sizes and configurations, Acoustic Eye increases inspection cycle efficiency and operational cost savings.

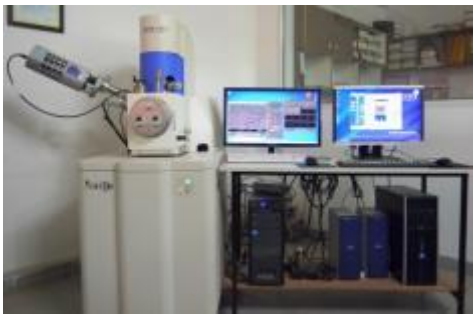
O. SALT SPRAY TEST

Salt spray testing is performed to evaluate the corrosion resistance of painting, coating, surface treatment of metallic components for their usability in the corrosive environment. TCR Advanced has procured a fully automatic salt spray chamber for performing this test as per ASTM B 117 / ISO 9227 specifications it has large chamber size 800 X700X 700 mm for accommodating multiple samples in a single batch. The apparatus is robustly designed to continuously operate for months.

P. SCANNING ELECTRON MICROSCOPE WITH EDS ANALYSER

TCR Advanced has procured state of the art Scanning Electron Microscope (SEM) attached with Energy Dispersive Spectrometer (EDS) system. SEM is a great diagnostic tool for

- Failure investigation
- Fractography
- Quality control
- Morphology and identification of localized defects
- Identifying corrosion products at microscopic levels
- Identifying Surface coating or plating
- Particle size & shape analysis
- Characterizing creep in microstructure
- Identifying submicron features in microstructure
- Identification of Inclusions in metals.

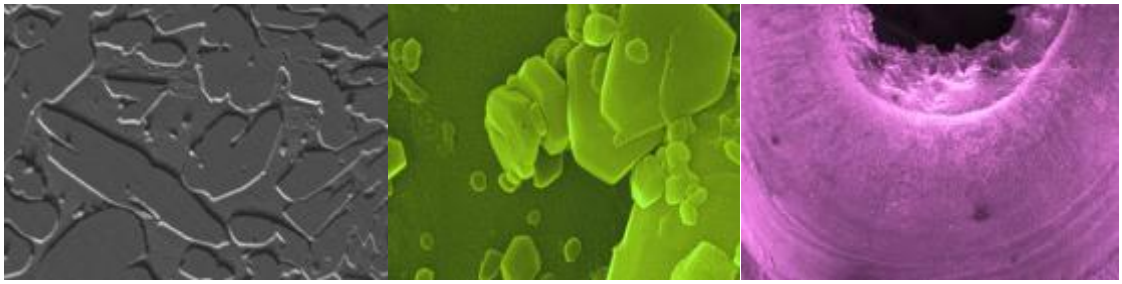


SEMART SS-100 offers simple and very user friendly operating console. It is equipped with turbo molecular pumping system to achieve the high vacuum.

It requires absolutely no start-up time.

The EDS Analyzer X-Max 20 is a versatile X-Ray spectrometer system which does not require Liquid nitrogen for its operation. This greatly reduces the start-up time of EDS analyzer as compared to conventional system.

The large detector area of 20 mm2 gives better count rate at lower accelerating voltages and lower spot sizes resulting in improved accuracy and quantification of elements which is sometimes is a limitation of the conventional EDS detectors with 10 mm2 area.



Q. AUTOMATED REFORMER TUBE INSPECTION SYSTEM (ARTiS)

ARTiS is abbreviated for Automated Reformer Tube Inspection System. TCR ADVANCED has indigenously developed an automated robotic crawler to aid ultrasonic inspection of reformer tubes. It provides tabular and interactive digital output. The 1st point on every tube is referred at bottom of tube climbing up to the 14 meters height and provides tube data at every 0.1 meter distance. The ARTiS can simultaneously collect the tube data such as ultrasonic dB level of attenuation, diameter of tube and bowing angle at every location. An interactive, graphical user interface is part of digital report along with conventional hardcopy print in tabular format.

The major advantages of the ARTiS are as follows.

- The method follows same technique of manual ultrasound coupling and hence it is industry wide proven for the intended inspection.
- A macro level view of overall tubes condition in the reformer is also reported, emphasizing troublesome areas / corner of furnace, if any.
- The outcome of inspection work becomes more systematic and traceable with point wise reading on each tube for ultrasound attenuation and creep strain.
- It avoids the need of scaffolding requirement and saves total tube inspection time and helps achieving reduction in shutdown time of plant.
- Automation deploys limited water source for coupling and nearly eliminates need for overhead water drum arrangement which overcomes additional issues related to drum filling, vacuum water clogging etc.

R.FITNESS FOR SERVICE (FFS)

TCR Advanced provides fitness for service assignments in India and abroad for chemical, Petrochemical, Fertilizer, power plants and their components. TCR's FFS methodology is primarily based on API 579, BS 7910 and correlated with engineering calculations, actual characterization/ flaw / degradation, along with fracture mechanical calculations. It is a practical tool that assists the management to select the alternative action of whether to run, repair or replace the equipment. The heuristic aspect of useful remaining life of the equipment at the time of inspection is also part of FFS study.

ASME, API, BS 5500 & other recognized design codes provide rules for design and fabrication of new items of plant e.g. pressure vessels, piping & storage tanks. These codes do not address the fact that many items deteriorates during operation & that defects due to deterioration or from original fabrication, which are larger than allowed by the "Quality Control levels" found during in-service inspections.

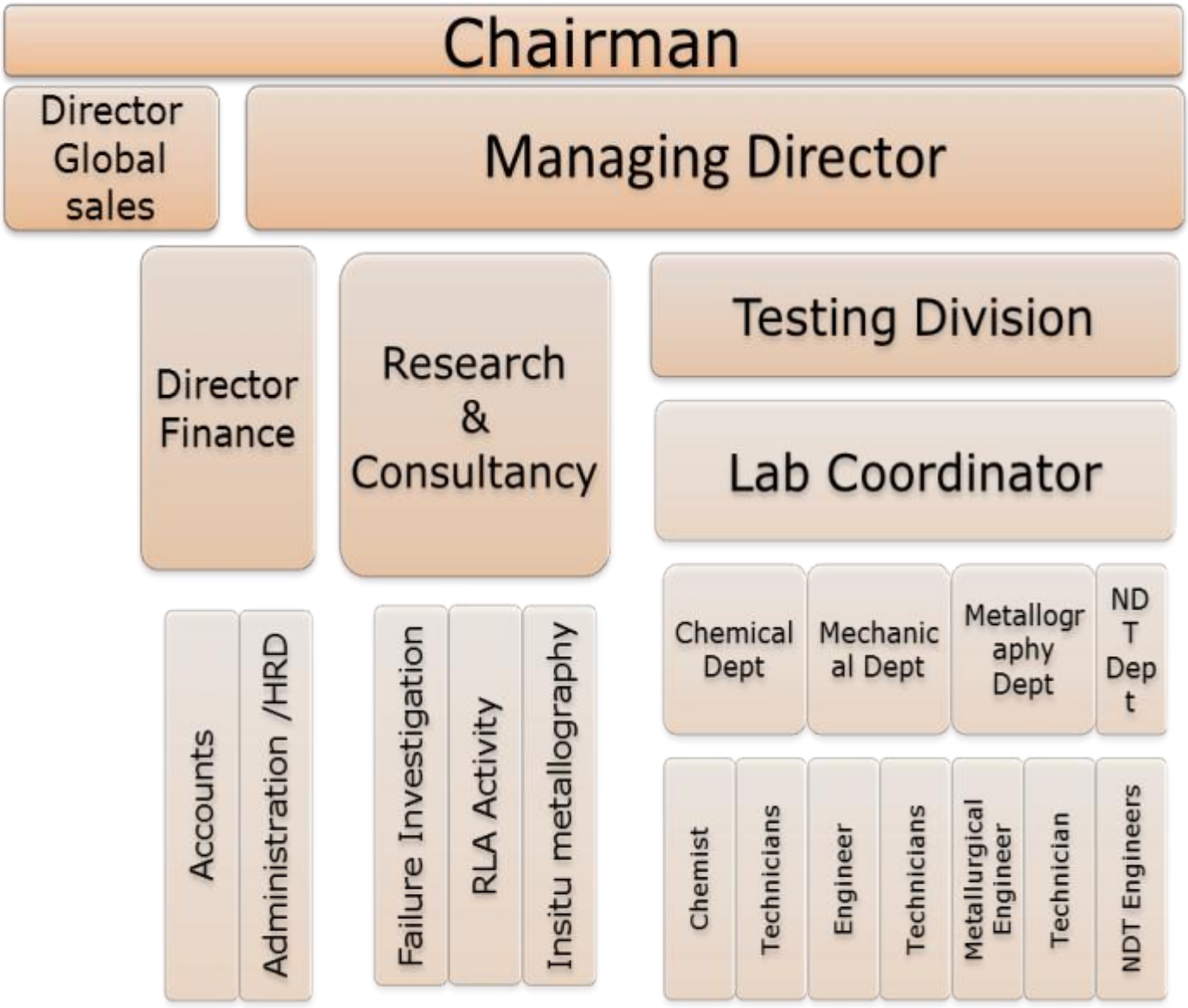
The need for FFS arises when an equipment undergoes some serious operational misshape exposing it to severe conditions than the equipment was originally designed had crossed or flaws such as localized corrosion or cracks are observed or other de-bottlenecking design limiting factors. FFS assessment is a multi-disciplinary approach. The component under screening may contain flaws or other damages, or it might have been subjected to non-anticipated operating conditions.

The purpose of FFS assessment is not simply to continue the component in its service beyond its serviceable life, but to ensure utilization of full potential concerning present damage assessment. The typical outcome of a fitness-for-service approach provides a "go/no-go" decision. This provides a rational makeshift arrangement to continue the production. Additionally, the fitness for service assessment of components can help setting up proper inspection schedules, modified maintenance procedures and more of online monitoring systems.

S. VIDEOSCOPY/ BOROSCOPY

TCR Advanced Engineering provides videoscopy/ Boroscopic inspection services. We have a state of the art Iris 5 DVR videoscope which has total probe length of 7.5 mts and 8 mm probe dia, which is suitable for carrying videoscopy in a component with opening as small as 10 mm. The IRIS DVR is equipped with 4 way articulation to give 360 degree field view. It has a high resolution CCD camera for HD Video recording and interchangeable objective lenses for changing the degree of viewing and field of view. The videoscope is useful in many fields such as Aerospace, Wind Turbines, Gas turbines, Oil and Gas Industries, Chemical Industries, Power generation plants, quality control and internal weld inspection.

5) OUR MANAGEMENT



6) BRIEF BIO-DATA OF COMPANY DIRECTORS& KEY PERSONNELS

Late Shri Virendra Bafna, *Founder*

Late Shri. V.K. Bafna was founder of TCR Engineering Services, Mumbai. He was visionary with sound material sciences experience, strong business acumen and relentless sincerity, TCR ADVANCED matured under his able guidance. With clear sense of purpose and urgency, Through hard work, dedication, integrity and love for his field, Mr. Bafna gained 35 years of practical experience in the areas of corrosion detection, chemical analysis, mechanical testing, failure analysis and materials characterization. He had introduced innovative methods for Corrosion Studies, Non Destructive Testing and was a pioneer in showcasing the advantages of XRF-based positive material identification to the industry.

Mr. Bafna, was a gold medalist from the University of Indore and had two masters degrees to his credit. He has done Master of Engineering from the University of Toronto, Canada and Master of Industrial Management from the Clarkson College of Technology, Potsdam, New York. Mr.V.K. Bafna was member of various professional organizations such as American Society for Testing and Materials, Institute of Standard Engineers, ASM International, NACE, Non Destructive Testing Society of India, and Indian Institute of Metals. He was an ex-committee member of ASM India chapter. Mr. Bafna's vast expertise in the field of laboratory testing has brought numerous laurels to TCR notable amongst them is an award of appreciation from the Indian Space Research Organization (ISRO) for the company's contribution to the Project ASLV. TCR group companies progressed and grew under his able guidance.

Mr. Paresh U. Haribhakti, *Managing Director*

Mr. Haribhakti is a B.E. (Metallurgy), M.E. (Materials Technology) From M.S. University, Baroda. He has done basic research in study of hydrogen embrittlement of steels and stainless steels. He has worked as trouble shooting metallurgist for India's largest fertilizers and petrochemicals complex, GSFC Ltd., Vadodara for nearly 10 years. His area of specialty is microstructure degradation of components exposed to high temperature and pressure. He has hands on experience of more than 500 failure investigation cases of Power Plants, Fertilizers, Chemicals and Petrochemicals Industries. He has provided services of failure investigation and In-situ metallography to major industries in the country and abroad.

Mr. Haribhakti had won first prize for metallography contest held at IISC-Banglore - 1998 under NMD celebration by Indian Institute of Metals (IIM). There are several technical presentations and lectures delivered at National and International seminars to his credit. He is a member of most of the professional bodies in the field of metallurgy.

He has solved materials engineering problems and performed failure analysis on components from petrochemical plants, oil and gas transmission pipelines, offshore structures, ships, pharmaceutical plants, food processing equipment, gas turbine engine components, and weldment.

Mr. Haribhakti investigates the available physical evidence, and performs the necessary tests to develop the most probable accident scenario. He simplifies complex engineering theory into easy to understand and useable concepts. He uses simple analogies, every day examples, and laymen terms to explain data and findings so that clients, corporate executives, government officials, or attorneys may easily understand engineering concepts.

Mr. Rohit Bafna, *Director Global Sales*

Mr.Rohit is currently Director Global Sales based in TCR World in Washington, USA. Under his leadership the US office has grown from its incubation stage to one which is now profitable. Prestigious clients that have trusted TCR to carry out material testing and quality assurance services secured by Mr.Rohit include

Caterpillar, Aventech, Elliot Company, Komline - Sanderson, Constar, Xalloy, Sys-Concept and the US Army. Mr. Bafna has the cost and technical responsibility for execution of specific contract(s), including devising the planning, directing, and coordinating of project activities to ensure that project objectives are accomplished within the prescribed time and funding parameters. Where subcontracts are required, Mr. Bafna manages the development of specifications, statements of work, evaluation criteria, and requests for proposal. Mr. Bafna works with the material testing laboratory and engineering consulting divisions to analyze proposals with respect to cost/risk/quality, lead source selections and negotiation teams, and monitors subcontract costs, schedules, and technical performance. Mr. Bafna has over 8 years of Sales and Marketing experience in the Material Testing and Quality Assurance business. Mr.Rohit has undergone extensive training on Ultrasonic Testing using Time of Flight Diffraction (TOFD) at Olympus in Quebec, Canada.

Mr. Gopul Patel, *General Manager*

Mr. Gopul Patel is a post graduate from Sardar Patel University. He has an extensive knowledge of Vacuum Technology and has worked as scientific officer at Department of science and technology sponsored research centre. He has hands on experience of operation and calibration of various sophisticated analytical instruments such as Transmission Electron Microscope, Scanning Electron Microscope with EDS, X-Ray Diffraction, ICP OES, spectrometers, Thermal Analyzers such as DSC, TGA. He has experience of various advanced methods of material characterization and has worked extensively in the field of microscopy.
He has been trained for operation of Electron microscope at PHILLIPS, The Netherlands and Pemtron, Korea. In fact he has handled India's First Environmental Scanning Electron Microscope with EDAX analyzer for more than five years. He has been handling the scanning electron microscopy analysis work He is qualified as NDT level II in M.T., P.T., U.T. and E.T.
He is responsible for the establishing & implementing management system at TCR Advanced and its functionality. He is actively involved in establishing new testing facilities at lab as well as on site. He has played an instrumental role in establishing custom designed web based sample management system for handling sample flow in the laboratory.

Mr. Ketan Upadhyay, *General Manager – Reliability Engineering*

Mr. Ketan Upadhyaya is a B.E. (Metallurgy) from M.S. University of Vadodara and has experience of 23 years in the field of NDE, Acoustic emission techniques, Vibration measurement and signature analysis, Failure Investigations, microstructure interpretation, Scanning electron microscopy and digital imaging system.He has worked as a metallurgist at India's largest fertilizers and petrochemicals complex, GSFC Ltd., His Job profile includes fabrication inspection, providing welding procedures for maintenance and relevant heat treatments, troubleshooting against organic and inorganic corrosion and microbial induced corrosion. He is a qualified level II for Acoustic Emission testing (IISC Bangalore), Vibration Analyst VT-II (Entec IRD) and Ultrasonic Flaw Detection (EEC Mumbai) techniques. He is actively involved in Plant reliability Engineering and risk based inspection projects for different components such as heater piping, reactors and static equipment of petrochemical and refinery industries. He is well familiar with API/ASME/ASTM/JIS codes and ASM literature. His association with TCR Advanced Engineering strengthens the Remaining Life Assessment, Failure Investigations and Advanced Non Destructive Examination projects. He has played an instrumental role in developing an automated reformer tube inspection system(ARTiS) at TCR ADVANCED.

Mr. Kamlesh Rana, *Technical Manager*

Mr. Rana is a having vast experience of fabrication and forging fields. He holds Diploma in Mechanical engineering and has worked extensively in pipe manufacturing and forging industries. He has more than

20 years of experience. He has headed quality and assurance department of various forge shops. He is qualified internal auditor for ISO 9001 and has handled API audits. Mr. Rana is in-charge of chemical and mechanical testing at TCR.

7) BRIEF BIO-DATA OF COMPANY'S ADVISORY PANNEL-EXPERTS

Dr. Rajendra Kumar ,*Advisor*

Dr. Rajendra Kumar is a world renowned metallurgist of our country. He is a doctorate from world famous University of Shefild, UK. Dr. Rajendra Kumar was the Director of National Metallurgical Laboratory, Jamshedpur and a former Director of Regional Research Laboratory, Bhopal. Dr. Rajendra Kumar has more than 150 publications in national and international journals of repute. He has been a committee member of IBR for failure investigation. He has written three books on metallurgy.He is the recipient of Metallurgist of the year Award for the year 1966.

Dr. P. B. Joshi, *Advisor*

Dr. P B Joshi was a professor in Department of Metallurgical and Materials Engineering, Faculty of Technology and Engineering, Maharaja Sayajirao University, Vadodara. He is a Ph. D. in Material Engineering. Dr Joshi is having more than 25 years of teaching experience in the field of metallurgy. He has more than 50 research publications in International journals & National journals, and authored a book titled "Materials for Electrical and Electronic Contacts".

Dr. K. Baba Pai, *Advisor*

Dr. Baba Pai was the former Head of the department of Metallurgical & Materials Engineering Faculty of Technology & Engineering, M.S. University. He is Ph D from IIT Mumbai. He is having more than 29 years of experience in Educational field. He began his career as lecturer in 1989 and became professor in the Metallurgical and Materials Engineering department. Under his able guidance more than 4 Students were awarded PhD. He has more than 90 national and international publications in reputed journals. Dr. Pai is actively involved in providing Testing and industrial consultancy assignments for many industries of Gujarat.

Mr. Jagdish Baad, *Consultant*

Mr. Jagdish Baad is Bachelor of Technology in Metallurgical Engineering with First Class honors from IIT, Mumbai .He has working experience of 25 years in forge shop, steel, cast iron, S.G. Iron and Non-ferrous foundries. He has worked reached to Sr. Management position starting from the Engineer level. He has handled Turnkey projects related to Foundry Mechanization, Quality Assurance and Product management of critical castings for turbine, material handling and wear resistance applications. Some of them are first of its kind. For last 12 yearhe has been running an independent consultancy, related to TQM-Product Management of Castings & Forgings and metallurgical related turnkey projects. Mr. Baad is well versed in kaizen, Edward Debono /Osborn techniques in creativity management. Energy audits related to metallurgical processes. He is Life member of various institutions such as Institute of Indian Foundrymen , Indian Institute of Metals ,Indian Society of Non-destructive Testing, Indian Institute of Welding Metallography Society of India, Alumni Association of IIT Mumbai.

Mr. Prakash Bhrambhatt, *Consultant*

Mr. Prakash Brahmbhatt is Ex – GM inspection dept. of M/s RIL Erstwhile IPCL. His area of responsibilities during his association with RIL includes inspection & maintenance from health assessment &

reliability/integrity angle for LDPE, PPCP, PBR-I, PBR-II, PP-IV, LAB, EG plants. Since last 32 years he is working in the field of fabrication, maintenance welding, inspection, testing, up keeping, metallurgy/material science, corrosion, health assessment, reliability & integrity monitoring of piping &static equipment in the petrochemical process plants. Familiar with all different type API/ASME/ASTM/ASM etc. codes & standards in respect of inspection ,NDT, welding & material of construction used in such plants in above areas/fields. He was appointed as an faculty on inspection &testing, metallurgy, welding in process plants in training center of IPCL/RIL-VMD. He was also a competent person for pressure vessel testing for GFA compliance.

Dr. Mukesh Pandya, *Consultant*

Dr. Mukesh Pandya is Ex-DGM (Research)from Gujarat State fertilizer Company (GSFC) Limited, India's premier fertilizer company. He has a PhD in corrosion from Gujarat University. He has more than 25 years of experience in corrosion evaluation, materials selection, failure investigation and online corrosion monitoring in chemical, petrochemical and fertilizer industries. He possesses in-depth knowledge on various forms of corrosion. His is having vast experience in conducting laboratory and field experiments on corrosion measurements as per national and international standards. He has been a member of National Association of Corrosion Engineers (NACE) USA, for 8 years. He has provided consultancy services to many industries in India and also successfully carried out international collaborative projects with M/s Avesta, Sweden, M/s Krupp VDM Germany and M/s Cormon UK.

Mr. Hemant Pradhan, *Consultant*

Mr. Hemant Pradhan is a Mechanical Engineer with over 34 years of experience in design, detail engineering services, projects, inspection, mechanical construction, procurement, estimation etc. for fertilizer and petrochemical plants and projects.

His major experience field of expertise has been design, detailed engineering, trouble shooting of fertilizer plants like ammonia, urea, DAP, ASP, AS, phosphoric acid, sulphuric acid etc.; petrochemical plants like Caprolactam, Melamine, Nylon-6, and utility/co-generation/ boiler, water treatment plants. He is also involved in engineering jobs for installing new projects, de-bottlenecking, capacity augmentation, plant modifications, addition of new sections; trouble shooting; estimation; procurement; inspection; expediting for more than 30 years.

He has participated in design conferences at international and national level with process licensors/ detail engineering firms like M/s Enco, Switzerland; M/s INCRO SA, Spain; Tunisian Joint Venture, Tunisia; M/s Schmidt & Clemens, Germany M/s Davy Powergas, M/s Uhde, M/s Linde, at India.

He has vast experience in executing trouble shooting jobs in major plant equipment like Primary Reformer , Air Pre-heaters, Waste Heat Boilers, Various Heat Exchangers, Isothermal Shift Reactor, Urea Reactor, High Pressure Decomposer, high pressure plunger pumps & their discharge piping, Contact Furnace, Decomposer, Sulphur combustion furnace boiler, etc.

Mr. Pradhan has headed various departments like Inspection, Mechanical Construction, Workshop and Phosphoric Acid and Fiber Unit plants. He also has experience in dealing with statutory authorities and third party inspection agencies.

Mr. Awdhesh Kumar Singh, *President – Power Plant & Turbine*

Mr. Awadhesh Kumar Singh, born in 1951 is a power sector professional having more than 42 years of professional experience. He holds Bachelor's Degrees in Science & Engineering and Master's Degree in

Technology from Indian Institute of Technology, Delhi. He started his professional career in the year 1975 in Steam Turbine Engineering Department of BHEL, Hardwar. Shri AK Singh received his initial training in the area of design of steam turbine blades at Muelheim Works of M/s Kraft Werk Union in West Germany and subsequently in mid 1990s worked on a R&D project on "Design of Advanced Low Pressure Steam Turbine Blading" with M/s Siemens in Germany. During his tenure of 22 years with M/s BHEL, he developed many Steam Turbine Flow-Path Designs which have been implemented in many 210 & 250 MW rating machines installed across the country. These machines are more efficient and are having better Heat Rate which had been validated to the satisfaction of respective customers. In 1996, Shri AK Singh joined the Power Generation Segment of M/s Asea Brown Boveri Ltd. at Vadodara in Senior Management Cadre. He received training at the Mannheim Works of M/s ABB in Germany. Shri Singh worked with ABB Power Generation, Vadodara as the Head of Engineering group for large utility steam turbines. He was a member of the Power Segment Technology Team of ABB India. Shri AK Singh represented ABB India as Engineering Manager on global committees formed for developing technical solutions in the area of Retrofit and R&M. He was Manager of Turbine Spare Parts Centre of ABB India. As a strategic Supply Management Initiative, he led a Cross-functional Commodity Team and established the manufacture of Industrial turbine blades at Baroda. From 2000 to 2002, Mr. AK Singh worked as a Professor of Mechanical Engineering with Sardar Patel University and Gujarat University. From 2002 to 2009, Mr. AK Singh worked with Electrical Research & Development Association (ERDA), Vadodara where he rose to become its CEO & Director. During his tenure as Director, ERDA established itself as the premier testing, calibration and research organization of the country. International Business Excellence Award was conferred on Mr. AK Singh by the International Study Circle, New Delhi for the stupendous growth of ERDA. From April, 2011 to October, 2015, Prof. AK Singh worked as a Senior Faculty with Power Training Institute of M/s L&T Power at the L&T Knowledge City, Vadodara. He provides technology training on Steam Turbines and dwells on the comparative features of steam turbines offered by the OEMs across the globe. From December, 2015 to February, 2017, Shri AK Singh was associated with M/s L&T-Sargent & Lundy Limited, Vadodara as Principal Consultant for providing consultancy in the domain of Residual Life Assessment, Renovation & Modernization, Condition and Asset Management of Thermal Power Plants. Mr. Awadhesh Kumar Singh is presently associated with M/s TCR Advanced Engineering Pvt. Ltd., Vadodara.

Mr. MY Joshi, *Advisor– Reliability*

Mr. MY Joshi is a metallurgist & having over 40 years of experience in the field of plant condition monitoring. He headed the inspection department of GNFC, Bharuch that involved trouble shooting of metallurgy and health monitoring of the plant components. His area of expertise involve repair welding of aged plant components, remaining life assessment and life extension of aged plant components. Innovative approach of Mr. Joshi has helped operating plants to ensure minimum downtime under the emergency situations. He is pioneer to adopt fitness for service concept for GNFC. He has extensive expertise in handling corrosion and metallurgical problems for acid handling plants to high temperature application like ammonia plants. He has worked on carbon steel to exotic materials like nickel base super alloys and solved more than 1000 plant problems such as failure investigation, innovative repair solutions and indigenization of engineering components. The leadership quality of Mr. Joshi & his ability for team building, abetted him to handle inspection and quality control departments during his tenure.

8) LIST OF IMPORTANT EMPLOYEES WITH THEIR QUALIFICATIONS

SR. NO.	NAME OF EMPLOYEE	DESIGNATION	QUALIFICATION
1.	Mr. Gopul Patel	General Manager	M. Sc. (Electronics)
2.	Mr. Ketan Upadhyay	General Manager – Reliability Engineering	B. E. (Metallurgy)
3.	Mr. Kamlesh Rana	Technical Manager	Diploma (Mechanical)
4.	Mr. Vishal Soni	Incharge Chem. testing	B. Sc.
5.	Mr. Ankur Haribhakti	Incharge Mech. testing.	B. E.(Mechanical)
6.	Mr. Sohel Vaidya	Business Development Manager	M. Sc.(Applied Physics)
7.	Mr. Dharmendra Joshi	Lab Coordinator	Diploma (Mechanical)
8.	Mr. Nikhil Sabahya	Metallurgy Engineer RLA	M. E. (Metallurgy)
9.	Mr. Krunal Todkar	Incharge metallography testing	B. E. (Metallurgy)
10.	Mr. Sandeep Singh	Lab Manager & NDT Level III	B.E., ASNT Level III (MT, PT, UT,RT, ET)
11.	Mrs. Pooja Mehta	Lab Manager, Failure investigation	B. E. (Metallurgy)
12.	Ms. Rutvi Patwardhan	Metallurgical Engineer	B. E. (Metallurgy)
13.	Mr. Darpan H. Parikh	Accountant	B. Com.
14.	Mrs. Meghna Chaudhary	HR Officer	M. HRM.
15.	Mr. Nachiket Sadhu	NDT Engineer	B. E. (Metallurgy)
16.	Mr. Rakesh Gandhi	Metallographer	I.T.I.
17.	Mr. Jaimin Pandya	Customer Support	B. Com.
18.	Mr. Gaurang Gore	Site technician	H.S.C.

9)OUR MAJOR CUSTOMERS

TCR ADVANCED believes in establishing long-term, strategic relationships with our customers as opposed to short-term, opportunity-based engagements. TCR ADVANCED greatly values the relationships that it has established with over 300+ customers and are delighted to provide technical services & Solutions.

10) MAJOR PROJECTS HANDLED

A. INLAND ASSIGNMENTS

Metallurgical Damage assessment- Provided consultancy Asia's largest grass root refinery, RIL Jamnagar, India for damage assessment work during fire incident in VGO-HT2 Plant.

TCR Advanced was engaged to assess the metallurgical integrity of different components and equipment including pipe lines, flanges, Heat Exchangers, Reactors etc to judge the extent of damage by microstructure examination at Reliance Industries Limited Jamnagar at the time of major fire incident of VGO-HT2 plant. Total 1200 microstructures were prepared and evaluated at site to judge go no go condition of the refinery components. The dedicated team of TCR Advanced has worked round the clock and completed the marathon assignments in the record 15 days time. The metallurgical experts from TCR Advanced had provided the judgments based on our vast experience of evaluation of different Refinery components and failure investigation related expertise.

To derive at critical decisions simulated heat treatments conditions were done in the laboratory to generate the identical microstructural conditions pertaining to weld and other low alloy steel material exposed to accidental fire. Data on mechanical properties were generated vis-à-vis damaged conditions and risk based assessments was made to judge the integrity of the different components. The judgments on affected and unaffected structure were made by exercising the knowledge on location selection which is of paramount importance during damage assessments job.

Health assessment of entire Hydrogen plant for Godrej Industries limited Valia, Gujarat.

We had a bend failure in our hydrogen line in 2006 and we contacted TCR Advanced Engineering Pvt. Ltd., Vadodara to conduct an in- depth root cause failure analysis. The work carried out by the dedicated team of TCR helped Godrej Industries to take necessary corrective actions for the second hand plant of "Hydrogen Generation" procured form England. The entire plant was thoroughly assessed by NDT and metallography with Health Assessment approach by TCR. The components included Reformer section, Pigtails, SS pipelines /Carbon steel/Alloy steel pipe lines Heat exchangers etc. TCR's assessment approach is scientific by knowledge of anticipated degradation mechanism of different components with organized team work by trained and qualified man power.

TCR also provided services on Remaining life Assessment of aged components by distractive analysis and Repair Weld Procedures of aged Incoloy 800H header joints by TCR.

Remaining life assessments of Power and Utility Boilers of Hindustan lever limited.

Total 8-Boilers of different capacities were evaluated for their remaining life by detailed metallurgical approach. Based on the operational and design/construction of the boiler their damage mechanisms were anticipated. With NDT, In-situ metallograrphy and chemical analysis of Boiler feed water/scales and corrosion products vis-à-vis metallurgical degradations under microstructure were compared. The safer remaining life was evaluated based on microstructure degradations and thickness measurements criteria's. The recommendations were made to operate these boilers for safe and efficient use. TCR Advanced has very rich data based on different power boilers which are operated from 10Mw to 250 MW capacity. TCR

Advanced is also engaged by different RLA agencies to undertake metallography evaluation which is most critical in Life assessments.

Provided repair weld solution on used Incoloy 800H Header of Ammonia Plant of Gujarat state Fertilizers and chemicals limited- India's largest Fertilizers and Petrochemical complex.

M/s GSFC, Baroda has Fertilizer & Chemical Plants at Fertilizernagar, Baroda. In April-May 2007, TCR Advanced Engineering P Ltd was apprised about loss of weldability in the Tee components located between hot & cold headers of Primary Reformer, of Ammonia-IV plant. It was a dire need to formulate the welding procedure to achieve crack free weld joint, to put back the plant in operations at the earliest.. Considering fundamental inferences from microstructure degradations and reviewing of various reports of analysis / tests and discussions, the most probable reason for loss of weldability is judged with an objective to provide solution to improve the weldability and formulated weld procedure. Prima facie, the probable reason of loss of weldability seems to be associated with carbide coarsening & their agglomeration under the microstructure observations. Also, carbide alignment was noticed under the influence of complex stresses of operation. As per the fundamental understating if the carbide precipitations could be re-dissolved in the matrix by sending important alloying elements like Niobium and Chromium back in to the solution . An elaborate repair welding procedure is suggested in the report that principally accentuates on carrying out "Solution Annealing Heat Treatment". Finally, the effectiveness of solution annealing heat treatment has to be assessed to propitiate proper procedure for repair welding purely on metallurgical considerations which can only mitigate the grave situation as a result of post weld cracking that had put the production at grinding halt.

Consultancy to provide weld procedure to meet with stinger quality test requirements of snamprogetti specification for Urea Plant for a fabricator

As a requirement, to be used in a Urea plant the M.S. plate is to be overlaid with stainless steel welding. The base material is SA 516 Gr. 70. The weld over lay is of 6 mm thickness. As per the Snamprogetti specification, the chemical composition on the surface of over lay should be 2 RE69, which is equivalent to 310 MoLN. The essential requirement is that the surface shall be free from deleterious phases like carbides, delta ferrite and sigma phase, whose sensitivity for deterioration in presence of Urea is extremely high.

Several prototype trials were conducted at GMM Pfaulder Ltd Works. All of them were failing in IGC test as per ASTM 262 Practice 'A'. In view, of the critical nature of requirement, the matter was referred to TCR Advanced Eng. Pvt Ltd. They suggested different welding procedures having varying parameters. The aim was to achieve the faster cooling rates with low heat inputs. IGC and metallography was carried out on all the weld samples. The suitable welding procedure has been recommended that is passing IGC ASTM 262 Practice 'A' and showing freedom to sigma phase precipitation which cleared the most stringent corrosion test requirements.

In addition to this, an evaluation was made to find out effectiveness of the SR treatment which is done after the first overlay over carbon steel tube sheet. The approach of micro-hardness profile was adopted. These tests were conducted on sample having single layer and the one acceptable in the IGC practice A as per ASTM 262.

Crevice Corrosion & Electrochemical Study for ITER- India

As a service partner company of TCR Engineering Services Pvt. Ltd., TCR Advanced have undertaken the electrochemical study of the prestigious work which is useful for materials selection and evaluation for shielding materials of Boronated stainless steels. Electrochemical studies have been performed under the

pressurized system and using stainless steel autoclaves and at different temperatures. It provided the comparison with different grades of materials with respect to pitting tendency under the stipulated chemistry. The project is undertaken by the consortium of 8 countries as headquarters at the France. TCR got the opportunity to work under the ITER India.

Material selection for Corrosion service at Solvay

M/s Solvay Specialties India Private Limited is manufacturing products such as Veradel and PEEK. There werefrequent incidences of finding corrosion of varying degree in reactors & vessels used for the production. This was affecting the Quality of products produced by the plant. In view of seriousness of the matter TCR Advanced was approached to carry out laboratory accelerated corrosion tests on different samples at varying conditions. The purpose of the exposure tests was to find out suitability of SS 304, SS 316L Inconel600, Hastealloy C276, SS 2205, SMO 254 and Al 6XN materials for defined process conditions in welded and as received conditions in the actual reactors condition and monitor themregularly by destructive as well as weight loss method. This exercise is done to evaluate the different materials of construction in the actual process environment to deicide for suitable material for the given process.

RLA Study at Reliance Patalganga plant

The M/s. Reliance Industries Limited, Patalganga plant was commissioned in the year 1987. It deals with production of various commodities, including nylon and rayon. Some of the products Manufactured in Patalganga plant are

- Para - Xylene (Px) from raw material, Naphtha
- Purified Terephthalic Acid (PTA) from raw material, Para-Xylene
- Polyester Filament Yarn (PFY) from raw material, PTA & MEG
- Polyester Staple Fibre (PSF) from raw material, PTA & MEG
- Linear Alkyl Benzene (LAB) from raw material, Kerosene - n paraffin

The production of above needs multiple process handling and importantly heating furnaces. As the plants are aged, it is the need of time to assess various heaters for their safe operating life. The company has decided to carry out Remaining Life Assessment (RLA) of these heaters, and to continue them in service. TCR has successfully carried out the RLA of 4 heaters in the plant.

Fitness for service - Isomerization reactor of refinery:

An accidental temperature rise of 710 °C had occurred in the isomerization reactor which was designed up to 350 °C temperature. The reactor is 20 meter height with 3 m diameter used in hydrogen service. A team of experts from TCR decided the approach based on the API 579,ASME FFS-1. All the anticipated damage mechanisms were identified vis-à-vis future operational requirement. The plant had limitation not to open the reactor in view of platinum catalyst inside the reactor. The team TCR decided to take this challenge and detailed NDT approach was formulated by in-house NDT experts. The assessment was done with thorough metallurgical inputs as well as simulation study on the reactor material. All mechanical properties were evaluated with degradation in view of temperature exposure. With application of AUBT and ToFD techniques the reactor was thoroughly investigated. Based on the testing, assessment and FFS calculation the reactor was declared fit for service. The reactor is in use without any problems that has saved huge economic losses to the company.

Fitness for service – VGO reactor and exchanger:

HMEL experienced a major fire on VGO reactor and exchanger. The evaluation job of damage assessment was entrusted to TCR ADVANCED. An immediate mobilization was undertaken by TCR.

B. OVERSEAS ASSIGNMENTS:

Damage assessment of hydrocrack reactors of refinery Baiji, Iraq

Total 6 hydro cracker reactors manufactured by Kobe Steel Japan had developed blisters at the SS 347 weld overlay form Inside. The health assessment approach was undertaken with detailed microstructure examinations form OD /ID with different etching technique to find out extent of degradations in terms of sigma phase and carbide precipitations and other degradation due to prolonged use. The reason of blisters were identified and the inputs were provided to repair welding of the Reactors.

Metallurgical input for health assessment to procure second hand equipment from Taiwan for Gujarat Flurochemicals ltd.,

The high grade Inconel 600 Reactor were to be imported from Taiwan by GFL. TCR Advanced was deputed to judge the heath of these Reactors and recovery columns by undertaking various NDT Test. The health of these equipment were judged to provide the final decisions on procurements which helped the company to not only get the writhe equipment by find out the safe useful life.

Remaining life assessment for a package Boiler for Bangladesh lever limited:

RLA was conducted for package boiler at Unilever Bangladesh limited,. And certain tubes were asked to replace.

The ball mill assessment at Kuwait Cement company, Kuwait.

TCR Advanced was approached for metallurgical assessment of cracks observed on the Ball mill a very critical equipment for a cement mill. A detailed report were subjected with the reasons of carking by undertaking NDT approach of assessments.

Failure investigation of underground pipe line of NG. After hydro test the pipeline was filled with liquid nitrogen by mistake and the entire pipe line was burst open from the underground region. Root cause analysis was done to find out the reason of failure and remedial measures were suggested to find out the health of entire pipeline.

Shell Gas terminal Shrilanka,

Under the accidental attack from the terrorist a LPG bullet was damaged by the splinters and bullets. TCR Advanced had undertaken a detailed metallography and WFMPI study on the bullet hit regions and extent of damage was identified. A highly skilled team from TCR Advanced had visited the site and conducted onsite evaluation on the LPG bullet. A detailed report was submitted along with observations.

Nigeria

A fertilizer industry experienced a cracking problem at the bottom portion of the atmospheric storage tank of anhydrous ammonia. On site examination along with a sample was brought to the laboratory for root cause failure investigation. The root cause of the problem was identified as corrosion in the bottom part

during idling period of the plant. The entire plant was kept out of service for about 10 years during that time water got accumulated at bottom and provided the preferential corrosion from the HAZ region which appeared as crack. The client was M/s Proplant USA and work was conducted for Natore chemicals Nigeria.

OMAN,

Omaniffco, Oman faced a problem of repeated leakage in the ammonia discharge line with a pipe material of ASTM A333 Gr. 6 and failed from the weld joint. The pipe sample was received in the laboratory for root cause failure investigation. A detailed metallurgical approach revealed the cause of the problem as vibrational stresses and prevailing corrosive coastal atmosphere.

SWCC, KSA

As backend laboratory TCR Advanced provides the supports to TCR Arabia by undertaking Boiler RLA and health assessment jobs. Failure investigation and Remaining life assessment jobs are undertaken for power generation Boilers, high temperature and high pressure components.

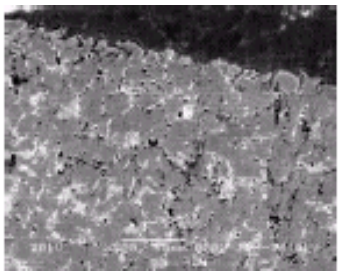
SABIC,KSA

Metallurgical root cause failure investigation are done from TCR Advanced to provide variety of plants having chemical, petrochemical fertilizers and refinery equipment's.

ANNEXURE A : BRIEF FAILURE INVESTIGATION & ANALYSIS CASE STUDIES

Primary Super Heater R-4 Zone Tube of a 140 Mw Boiler

The MOC of tube is TU 15 CD 205 .The service life of tube is 7 years before failure. The steam temperature & pressure of tube are and 450°C and 140 kg/cm^2 respectively. The tube has OD 63.5mm and ID 5.5mm. Tubes are located horizontally with flue gas passes vertically.

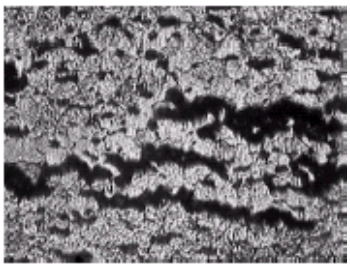


Scanning Electron Microscopy (SEM):

Upon SEM examination conducted by engineers at TCR, it revealed presence of inter-granular cracks and presence of numerous creep cavities at grain boundary. Presence of micro-cracks are observed more towards outer surface and nearby crack region. Severity of cracks and cavity reduces when we move away from the main crack.

Microstructure Examination:

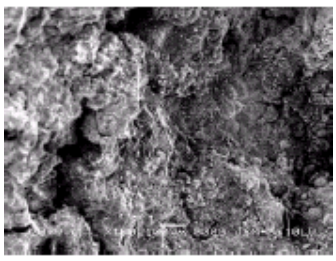
Crack displayed inter-granular nature of propagation with many small parallel cracks adjacent to main crack is observed. This examination was done at the TCR Engineering laboratory using a Leco Image Analyzer at 300X.



In present case the failure of tube seems to have occurred due to long term over- heating, above allowable design temperature, could be due to higher velocity of flue gas at this region or impingement of flue gases on tube surface facing flue gas or improper steam flow.

Radiant Coil of a Cracker Furnace H-130 Refinery

In a bottom fired furnace tube failure have experienced service of 14 months against the normal life of 6 to 7 yrs. MOC of tube is 25 Cr/35 Ni. The average tube metal temperature remains between 1000 to 1100 ºC temperatures. As per the manufacturer data, these tubes are designed for 1150ºC. The pressure inside the tube is 1 kg/cm^{2}g.

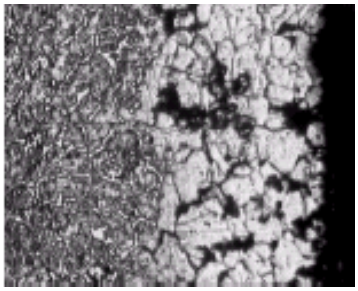


Scanning Electron Microscopy (SEM):

SEM analysis conducted by failure investigation team from TCR Engineering revealed a progressive nature of fracture especially towards OD side. However, majority evidences on fracture surface were masked under heavy scaling, which is generally expected under such service.

Microstructure Examination:

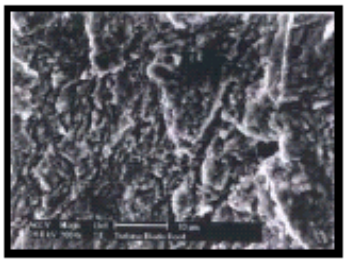
The crack is associated with carburizing more so at outer surface with decreasing the depth of carburizing toward ID. Another important evidence of crack originating outer diameter and progressing towards ID. This magnification was done at the TCR Engineering laboratory using a Leco Image Analyzer at 300X.



In present case the failure of tube has occurred due to localized overheating, which reduced ductility and failed under operational vibrations. TCR recommends looking in to the possibility of development of high temperature at the time of decoking operation.

8th Stage Blade of a Steam Turbine

After 8-years of useful service life, a steam turbine was reported to have been working with abnormal vibrations. When turbine was opened five blades of 8th stage were found in broken condition from the root. Steam turbine operates with steam temperature of 770°F & working pressure at 568.3 Psi



Scanning Electron Microscopy (SEM):

Fracture surface kept under SEM show multiple origins of the fracture and clearly shows progressive mode of failure. Fig. suggest rubbing of the metal surface where the failure had occurred.

Microstructure Examination:

Microstructure on cross section of blade and showing the defect of deformation. At higher magnification crack shows branching nature progressing in the forwarded direction i.e. perpendicular to the central axis seems to have followed trans-granular path.

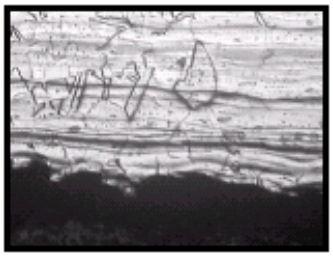
Failure of 8th stage blade has occurred due to corrosion fatigue, initiated at most stressed area. Only one blade was submitted for investigation. It is difficult to pin point which blade failed first.

Sac Plant Piping Going to V-801

In a Sulphuric acid concentration plant, as a part of process, condensate is chilled in a heat exchanger. The line, which is connected from heat exchanger (E08-3) to vacuum pump, one elbow was reported to have leaked and needed replacement. Severe corrosion was reported inside the replaced pipeline within 10 days of operation. The extent of corrosion was so severe that entire replaced pipeline reduced to paper thickness with punctures. The pipeline is operating with 1 to 2% H_2SO_4, 0.5% HNO_2 and 0.6 to 1.0 % HNO_3 at 10 to 20°C temperatures.

Low Magnification Examination:

Low magnification examination was done by the failure Analysis and Investigation team from TCR Engineering to find out the corrosion characteristics. Internal surface of pipe, weld and elbow showed severe corrosion on pipe. The close-up view of corroded surface inside the pipe show effect of general corrosion and flow pattern. Leakages observed in the form of openings between weld and pipe.



Microstructure Examination:

Uniform dissolution at ID is observed under microstructure examination at a magnification of 300x at the TCR Engineering laboratory in India.

The fluctuation in Nitric acid concentration did not allow to stabilize passivity on newly fabricated pipeline resulted into severe corrosion

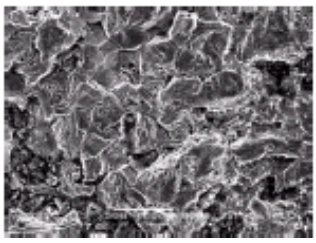
Integral Pinion Shaft of a Cement Mill

Premature failure of integral pinion shaft was reported a cement mill. The shaft failed after service life of approximately 15,000 hours (625 days) against intended design life of 30 years. The shaft is made from EN 10083-1 (1991) 30CrNiMo8 with through hardened and tempered to achieve 310-335 BHN. The shaft rotates at 133 to 134 RPM. The failure of the shaft noticed in form of cracks. Cracks were observed at 45° to the longitudinal axis of shaft.

relatively flat fracture whereas with chevron marks. Fracture surface multiple ridges with relatively coarse

Low Magnification Examination:

Fracture surface at thread region shows further fracture shows brittle nature below thread region at keyway disclosed fatigue striations.



Scanning Electron Microscopy (SEM):

SEM done by TCR Engineering reveal inter-granular fracture with inter-granular cracks. A fracture is brittle and shows inter-granular mode. Presence of fine cracks is observed.

Microstructure Examination:

Microstructure examinations at various sections reveled that general condition of shaft is in hardened and tempted condition. Further microstructure revealed presences of inter-granular cracks. The cracks are moving on prior austenitic grain boundaries and are observed filled with oxides. Presence of oxide inside the cracks is most important evidence in present case. This was done at a magnification of 560X at the TCR Advanced Engineering laboratory.

TCR Advanced Engineering concluded that the shaft failed due to pre-existing Heat treatment cracks under operational load.

ANNEXURE- B: NABL CERTIFICATES

NABL

National Accreditation Board for Testing and Calibration Laboratories

(An Autonomous Body under Department of Science & Technology, Govt. of India)

CERTIFICATE OF ACCREDITATION

TCR ADVANCED ENGINEERING PRIVATE LIMITED

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2005

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat

in the discipline of

CHEMICAL TESTING

(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Certificate Number T-1330

Issue Date 14/10/2015

Valid Until 13/10/2017

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the additional requirements of NABL.

Signed for and on behalf of NABL

N. Venkateswaran	Anil Relia	Prof. S. K. Joshi
Program Manager	Director	Chairman

NABL
SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Chemical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1330**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**1 of 6**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
	AT LABORATORY			
I.	**METALS & ALLOYS**			
1.	**Carbon and Low Alloy Steel**	Carbon	TCRADV/TM-01 Revision 09, dated 1/10/2015 IS 8811: 1998	0.05 to 1.10
		Sulfur		0.003 to 0.31
		Phosphorous		0.004 to 0.11
		Manganese		0.29 to 1.85
		Silicon		0.02 to 1.65
		Chromium		0.03 to 1.25
		Nickel		0.005 to 1.50
		Molybdenum		0.050 to 1.50
		Copper		0.005 to 0.26
		Titanium		0.01 to 0.40
		Tungsten		0.05 to 0.26
		Nitrogen		0.0025 to 0.0060
		Vanadium		0.005 to 0.26
		Tin		0.005 to 0.10
		Niobium		0.005 to 0.70
		Aluminium		0.015 to 1.05

Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL

SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Chemical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1330**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**2 of 6**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
2.	**Stainless Steel, Tools Steel**	Carbon	TCRADV/TM-01 Revision 09, dated 1/10/2015	0.013 to 3.75
		Sulfur	IS 9879: 1998	0.005 to 0.32
		Phosphorous		0.015 to 0.050
		Manganese		0.20 to 11.50
		Silicon		0.15 to 1.50
		Chromium		0.65 to 25.70
		Nickel		0.23 to 20.70
		Molybdenum		0.04 to 9.50
		Copper		0.03 to 3.40
		Vanadium		0.03 to 1.85
		Cobalt		0.015 to 8.00
		Titanium		0.05 to 0.51
		Tungsten		0.05 to 17.80
		Niobium		0.01 to 0.58
		Aluminum		0.005 to 0.17
		Nitrogen		0.01 to 0.27

Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL
SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Chemical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1330**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**3 of 6**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
3.	**Copper & Its Alloys**	Zinc	TCRADV/ TM-35 Revision 04, dated 1/10/2015	0.005 to 37.50
		Lead		0.005 to 6.10
		Tin		0.005 to 9.50
		Phosphorous		0.005 to 0.25
		Manganese		0.005 to 1.00
		Iron		0.005 to 4.10
		Nickel		0.050 to 4.60
		Silicon		0.005 to 0.30
		Aluminum		0.005 to 9.70
		Sulphur		0.005 to 0.05
		Antimony		0.01 to 0.34
4.	**Aluminium & Its Alloys**	Silicon	TCRADV/TM-01 Revision 09, dated 1/10/2015 ASTM E1251 -11	0.03 to 9.00
		Iron		0.070 to 0.80
		Copper		0.050 to 3.4
		Manganese		0.040 to 0.75
		Magnesium		0.025 to 2.90
		Nickel		0.040 to 1.85

Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL

SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Chemical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1330**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**4 of 6**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
	Aluminium & Its Alloys	Zinc	TCRADV/TM-01 Revision 09, dated 1/10/2015 ASTM E1251 -11	0.020 to 1.30
		Titanium		0.03 to 0.18
		Tin		0.030 to 0.26
		Lead		0.020 to 0.25
		Chromium		0.04 to 0.35
5.	**Nickel & Its Alloys**	Carbon	TCRADV/ TM-34 Revision 04, dated 1/10/2015	0.010 to 0.12
		Sulfur		0.005 to 0.14
		Phosphorous		0.005 to 0.014
		Manganese		0.050 to 1.6
		Silicon		0.010 to 2.50
		Chromium		0.50 to 21.4
		Molybdenum		0.040 to 19.50
		Aluminum		0.050 to 2.00
		Copper		0.06 to 20.80
		Iron		1.90 to 18.30
		Niobium		0.30 to 5.30
		Titanium		0.020 to 1.00
		Cobalt		0.13 to 2.50

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NABL
SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Chemical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1330**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**5 of 6**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
6.	**Metals Identification, Grade Verification**	Manganese Chromium Nickel Molybdenum Cobalt Tungsten Copper Titanium Niobium Lead Zinc Iron	TCRADV/TM-36 Rev 02, dated 15/03/2014 ASTM E 1476 -04 By Portable XRF Method	Qualitative (Identification With Approximate Composition)

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N. Venkateswaran
Program Manager

NABL
SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Chemical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1330**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**6 of 6**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
	AT SITE			
I.	**METALS & ALLOYS**			
1.	**Metals Identification, Grade Verification**	Manganese Chromium Nickel Molybdenum Cobalt Tungsten Copper Titanium Niobium Lead Zinc Iron	TCRADV/TM-36 Rev 02, dated 15/03/2014 ASTM E 1476 -04 By Portable XRF Method	Qualitative (Identification With Approximate Composition)

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Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL

National Accreditation Board for Testing and Calibration Laboratories

(An Autonomous Body under Department of Science & Technology, Govt. of India)

CERTIFICATE OF ACCREDITATION

TCR ADVANCED ENGINEERING PRIVATE LIMITED

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2005

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat

in the discipline of

MECHANICAL TESTING

(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Certificate Number T-1331

Issue Date 14/10/2015 **Valid Until** 13/10/2017

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the additional requirements of NABL.

Signed for and on behalf of NABL

N. Venkateswaran	Anil Relia	Prof. S. K. Joshi
Program Manager	Director	Chairman

NABL

SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Mechanical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1331**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**1 of 3**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
I.	**MECHANICAL PROPERTIES OF MATERIALS**			
1.	**Metallic Material**	Tensile Test Ultimate Tensile strength Proof stress Yield Stress Reduction in areas Elongation Load Test	ASTM A370-14, ASTM E8-15a, IS 1608: 2005, EN 10002: 2001, ASME (Sec IX): 15, EN 15614-1: 2008	0.5 kN to 600 kN
		Bend Test	ASTM A 370-14, ASTM E 190-14, ASTM E 290-14, IS 1599: 2012, EN 5173: 2010, ASME (Sec IX): 15	4, 6, 10, 12, 17, 20, 24, 25, 32, 40, 44, 50, 55, 60 mm mandrel dia
		Brinnel Hardness Test	ASTM E 10-15, IS 1500: 2005	100 HBW to 400 HBW 2.5/187.5 32 to 125 HBW 2.5/62.5 100 to 400 HBW 10/3000 100 to 400 HBW 5/750
		Vickers Hardness Test	IS 1501 (Part 1): 2013, ASTM E 384-11	40 to 800 HV5 100 to 1000 HV10 100 to 1200 HV 30
		Rockwell Hardness Test	IS 1586: 2000, ASTM E 18-15	30 to 100 HRA 30 to 100 HRB 20 to 70 HRC
		Micro Hardness Vickers	IS 1501 (Part 1): 2013, ASTM E 384-11	40 to 1000 HV Load 25 ,50, 100, 200, 300,500,1000 gms
		Charpy V notch impact Test (+)30 ° C to (-)196 °C)	ASTM E23-12, ISO 148-2: 2008, EN 10045: 1990	2 J to 350 J

Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL

SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Mechanical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1331**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**2 of 3**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
2.	**Metallic Materials**	**Micro Examination:** General Structure ASTM Grain size	ASTM E 407-07, ASTM E 3-11, ASTM E 1351: 96 ASTM A 247: 10 ASTM E 112- 13	Grain Size: 1 to 14
		Thickness of coating	ASTM B 487 (RA 2013)	0.01 mm to 0.8 mm
		Macro etch Test	ASTM E 340-15, ASTM A 381 (RA 2005) EN ISO 17639: 2013	Qualitative
		De carburization Depth	ASTM E1077-14, IS 6396: 2000 (RA 2007)	0.01 mm to 0.8 mm
		Quantative Metallography	ASTM E-562-11	1 % to 99 % LOD= 1 %
		Linear Measurements	TCR/ADV/TM-37 Rev 03 dated 05/10/2015	0.001 mm to 10 mm
3.	**Reinforcement Bar/TMT Bar**	Bend Test of reinforcement bar Rebend test of reinforcement bar /TMT bar	IS 1786: 2008	4, 6, 10, 12, 17, 20, 24, 25, 32, 40, 44, 50, 55, 60 mm mandrel dia
4.	**Metallic material (Tubes / Pipes.)**	Flattening Test	ASTM A/SA 370-14, ASTM B 111-11	OD 6 mm to 250 mm
5.	**Nuts**	Proof Load	ASTM A/SA 370: 14, ASTM A/SA 194: 15, IS 1367 (Part 6): 1994 (RA 2004)	0.1 kN to 600 kN

Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL

SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Mechanical Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-1331**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**3 of 3**

S.No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
6.	**Stud/Bolts**	FULL Size Breaking/ Tensile test/Proof load	ASTM A/SA 370-14, ASTM A/SA 193-15, IS 1367 (Part 3): 2002	0.1 kN to 600 kN
7.	**Tube to Tube sheet Mock up**	Pull out test/push out test	ASME (Sec VIII) Div-1: 2013	0.1 kN to 600 kN
8.	**Ferrous Material**	Nodularity in SGI iron	IS 1754: 2002	Qualitative
9.	**Wrought Metallic Materials**	Inclusion rating Method A Method D	ASTM E45-13	Qualitative
10.	**Stainless Steel**	IGC TEST Practice A	ASTM A 262-14, DIN 3651-1 & 2: 1998	Qualitative
		Practice B	ASTM A 262-14, DIN 3651-1 & 2: 1998	Qualitative
		Practice C	ASTM A 262-14, DIN 3651-1 & 2: 1998	Qualitative
		Practice E	ASTM A 262-14, DIN 3651 -1 & 2: 1998	Qualitative
		Pitting corrosion method A Crevice corrosion method B	ASTM G48-11	Qualitative
		Inter metallic phase in Duplex austenitic/ferritic stainless steel Method A Method B Method C	ASTM A 923-14 ASTM A 923 ASTM A 923	0 to 350 J
11.	**Metallic & Non Metallic Materials**	Salt Spray Testing	ASTM B-117-11 IS 9844:1981 (Ra 2006) ISO 9227:2012	Qualitative

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Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

NABL

National Accreditation Board for Testing and Calibration Laboratories

(An Autonomous Body under Department of Science & Technology, Govt. of India)

CERTIFICATE OF ACCREDITATION

TCR ADVANCED ENGINEERING PRIVATE LIMITED

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2005

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat

in the discipline of

NON - DESTRUCTIVE TESTING

(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Certificate Number T-2697

Issue Date 14/10/2015

Valid Until 13/10/2017

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the additional requirements of NABL.

Signed for and on behalf of NABL

N. Venkateswaran	Anil Relia	Prof. S. K. Joshi
Program Manager	Director	Chairman

NABL

SCOPE OF ACCREDITATION

Laboratory	**TCR Advanced Engineering Private Limited, 250-252/9, GIDC, Makarpura, Naren Hardware Lane, Vadodara, Gujarat**		
Accreditation Standard	**ISO/IEC 17025: 2005**		
Discipline	**Non – Destructive Testing**	**Issue Date**	**14.10.2015**
Certificate Number	**T-2697**	**Valid Until**	**13.10.2017**
Last Amended on	**26.10.2015**	**Page**	**1 of 1**

S. No.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
		AT LABORATORY & AT SITE		
I.	**METALS AND ALLOYS**			
1.	**Ferrous & Non Ferrous Metals & Alloys**	Ultrasonic Testing Detection of internal Flaws	ASME (Sec V): Article 4, Article 5(2013) SA609 (RA 2012), SA435 (RA 2012), SA 388: 2015 ISO 4386 (Part 1)	10 mm to 500 mm
2.	**Ferromagnetic Materials**	Magnetic Particle Testing - Detection of Surface Flaws and Sub- Surface Flaws by both visible and fluorescent technique using yoke, prod and coil wrap method	ASME (Sec V): 2013 SE 709: 2015	From surface to 4 mm depth
3.	**Ferrous & Non-Ferrous Metals & Alloys (Non-Porous Materials)**	Liquid Penetrant Testing - Detection of Flaws open to surface By both visible and fluorescent technique using solvent removal technique.	ASME (Sec V): 2013 SE 165: 2009 ISO 4386 (Part 3)	Flaws open to surface
4.	**Ferrous & Non-Ferrous Materials**	Eddy Current Testing (Tube testing)	ASME (Sec V): Article 8 (2013)	Tubes 12.7 mm to 50.8 mm ID and wall thicknesses 0.71 mm to 3.4 mm
5.	**Ferrous Materials**	Ultrasonic Thickness gauge	ASTM E 797: 2010	250 microns to 1 mm (25 MHz) 1 mm to 50 mm (5 MHz to 10 MHz) 51 mm to 200 mm (2 MHz)

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Gaurav Saini
Convenor

N. Venkateswaran
Program Manager

ANNEXURE- C : Certificates of IBR approval

Speed Post

संख्या /No. 8(22)/2017-Boiler
भारत सरकार
वाणिज्य और उद्योग मंत्रालय
(औद्योगिक नीति एवं संवर्धन विभाग)
उद्योग भवन, नई दिल्ली – 110 107
GOVERNMENT OF INDIA
MINISTRY OF COMMERCE AND INDUSTRY
(DEPTT. OF INDUSTRIAL POLICY & PROMOTION)
UDYOG BHAWAN, NEW DELHI-110107
दिनांक/ **Dated, the 29th June, 2017**

Fax : 011-2306 2626

To
M/s TCR Advanced Engineering Pvt. Limited,
250-252/9, GIDC Estate,
Makarpura,
Vadodara-390 010
Gujarat

Sub: Renewal of recognition as a "Well Known Remnant Life Assessment Organisation" under the Indian Boiler Regulations, 1950- reg. issue of Certificate of Approval

Dear Sir,

Further to the visit of Evaluation Committee to your organisation on 25th May, 2017 in respect of the above subject, this is to inform you that it has been decided to recognize your organisation as a "Well Known Remnant Life Assessment Organisation" under the Indian Boiler Regulations, 1950 for carrying out Remnant Life Assessment of boilers operating upto and above 120 Kgs./cm² pressure for a further period of five years w.e.f. 25th May, 2017 i.e. upto 24th May, 2022. Certificate No. 088 dated 29th June, 2017 in original in this regard is enclosed herewith. The recognition is valid subject to your adhering to the provisions of the Indian Boiler Regulations, 1950 as amended from time to time. You are also requested to send reports in respect of the assessment carried out from time to time.

Kindly acknowledge receipt.

Thanking you,

Yours faithfully,

29/06/12-17

(Sushil Kumar Jain)
Asstt. Secretary, Central Boilers Board
Tel.No.011-23063166

Encl: Certificate No. 088

Copy for information to:
Shri J. I Patel,
I/c Director of Boilers
4th Floor, Shram Bhavan,
Rustom Cama Marg, Near Gun House, Khanpur
Ahmedabad – 380 001,
Gujarat

FORM XVI-I

[See Regulation 4C (2)]

Serial No. RLAO/15/018 **File No.** **8(22)/2017-Boilers**

सत्यमेव जयते

Central Boilers Board

Certificate of Approval as

Well Known Remnant Life Assessment Organisation

This is to certify that after evaluation of the inspection and material testing system of the following firm, the Central Boilers Board has granted recognition to it under sub-regulation (2) of regulation 4C of the Indian Boiler Regulations, 1950 as a Well Known Remnant Life Assessment Organisation **for carrying out Remnant Life Assessment of boilers operating upto and above 120 Kgs./cm² pressure**

M/s **TCR Advanced Engineering Pvt. Limited,**
250-252/9, GIDC Estate,
Makarpura,
Vadodara-390 010
Gujarat

This Certificate is valid for five years, i.e. upto **24th May, 2022**

29th June, 2017
Date of Issue

Certificate No. **088**

CBB

Secretary