TCR ENGINEERING

Redefining On-time Quality

Material Testing | NDT | Inspection & Consulting

Company Profile: 1973 - 2018 | www.tcreng.com

TCR Engineering Services, India | ISO 17025, NABL, BIS, IBR Accredited Lab

Year Established	1973
Projects Completed	2000+
Clients Served	2500+
Services Offered	65+

About TCR

Founded in 1973, TCR is a pioneer and the most trusted laboratory for Material, Metallurgical and Corrosion Testing in India with NABL, ISO 17025 and BIS accreditation. TCR continues to serve over 2500 clients and their plant operations globally, each time setting a new industry standard for precision, transparency, and reliability.

Mission

Our mission is to provide trusted and unbiased solutions for efficiently managing plant operations of global organizations and build a better future for material testing driven by its highly credible thought leadership.

Vision

To be a significant transnational company by providing on-time repeatable solutions, impeccable quality and actionable results in material testing, inspection, and consulting services

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TCR: REDEFINING ON-TIME QUALITY

Headquartered in Mumbai, TCR Engineering Services is an ISO 17025 and NABL accredited independent Material Testing and Quality Assurance Laboratory serving 2500+ customers globally. Established in 1973, TCR has a trusted legacy with a strong presence in India and internationally in countries like Saudi Arabia, Kuwait and UAE. TCR enables organizations across the globe to develop and execute solutions for efficiently managing plant operations. TCR aims to innovate in a way that minimizes the gap between their offerings and their client needs.

TCR provides services that include Mechanical Testing. Metallography and Microscopic Sudies (SEM, Optical Microsocope, EDS, EDAX, XRD, TEM), Chemical Analysis, Positive Material Identification (PMI including onsite carbon detection), Non Destructive Testing (UT, DP, MP, PT, Automated UT using ToFD and Phased Array, Helium Leak Detection, Ferrite Measurement, Portable Hardness, Eddy Current Testing), Welder Qualification (as per ASTM, ASME and API), RoHS Compliance Testing, In-situ

Metallography (with SEM and EDAX), Corrosion Testing (HIC and SSC, Salt Spray, Inter-granular Corrosion), Risk Based Inspection as per API 581, Failure Analysis, Fitness for Service as per API 579, Vendor Evaluation, Factory Audits, Third Party Inspection, Metallurgical Product Evaluation, Post Weld Heat Treatment, Manpower Deployment, Training, Engineering Design and Analysis (CAD, CAM, CAE), Engineering Research, Reverse Engineering and Consulting using NDT Level III and AWS/CSWIP inspectors. TCR Engineering Services undertakes material testing as per international standards and specifications as defined by ASTM, NACE, DIN, AWS, API, ASME, BIS, IS, ISO and others. Testing can also be done as per client-supplied specifications.

For almost half a century, TCR has built an enterprise that is distinctly known for its honesty, reliability and transparency. TCR's team is distinguished by knowledge, imagination and experience gained across industries and that is reflected in every project they undertake. TCR, because of its global presence can rapidly assemble the right team with the right experience to help clients anywhere in the world. TCR has worked with several industries and verticals that include Automotive, Oil Refineries, Petrochemical plants, Chemical Processing, Defense, Electronics, Nuclear Power, Capital Goods, and manufacturing industries to determine material properties, improve product performance, assist in developing new and better products/ materials, evaluate remaining life of an industrial equipment, understand reasons for unmet expectation for a component's performance and or to identify why a product may have failed.

TCR delivers unbiased results on time, every single time. The multi-disciplinary certified and experienced team of professionals at TCR include metallurgical, mechanical, electrical, and chemical engineers; materials scientists; chemists; physicists; NDT inspectors and computer scientists who are skilled to meet rigorous standards in the testing field, to serve the Private, Public Sector, Government or the Military.

In the recent years, TCR is recognized as one of the fastest growing innovative and successful companies in India. The company won the prestigious award from NACE International for "Excellent Laboratory in Private Sector" in September 2007.

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

TCR LEGACY: Building Trust since 1973

TCR Engineering Services was incorporated in 1973 and has over the years grown to be India's leading material testing and research company. It was the vision of Mr. V. K. Bafna, the founder, a keen metallurgist to provide real, sustainable solutions to companies that would drive progress for them. He infused the principles of precision, transparency and reliability in all actions due to which, TCR today is a trusted service provider for top-notch companies across the globe.

TCR treats all its clients equally; whether it is Fortune 500 companies or Small-medium businesses, it delivers results with the same speed and efficiency without compromising on quality. TCR recognizes the significance of developing relationships that echo their culture of mutual respect and unwavering ethics. For over five decades, TCR is focused on bringing to life great ideas and business solutions that drive growth for their clients. The company has many 'firsts' to its credit and has become a thought leader in the industry because of its pioneering work. TCR has a growing global presence and is rooted in behaving ethically in all their interactions with their employees, partners, and their customers.

ADVANTAGE TCR

TCR believes that true success lies in empowering their clients for growth, where reports are more than just a report-they should deliver actionable insights, foresight to help navigate challenges and provide solutions to maximize performance. TCR strives to ensure that in all its services, responsiveness is fundamental, reliability and transparency are its strengths and repeatability is its reward.

1. **COLLABORATION:** This is the bedrock for TCR's service delivery approach. TCR aligns with clients, fostering engagements into long-term partnerships. No matter what the challenge is, TCR focuses on delivering practical, enduring results to equip their clients for growth.

2. **HIGHLY COMPETENT TEAM:** The quality of people is the cornerstone of TCR's ability to address the needs of its clients. TCR makes tremendous investments in identifying highly talented people, developing their skills and building an environment that encourages their growth. TCR can assemble a team with the most appropriate expertise and experience in the shortest possible time.

3. **DEEP SECTORAL EXPERTISE:** TCR brings its experience gained over the last 40 years in the field of material testing, inspection and quality assurance with strong commitment and adherence to the ISO 17025 standards. The technical teams are highly experienced having conducted over 1500 failure analysis projects. TCR is on the approved list of SABIC, Tasnee, APPC, Schlumberger and Reliance for Failure Analysis Services. The company has access to Scanning Electron Microscopy with EDAX and Optical Inverted Metallurgical Microscopes.

4. **DIVERSIFIED PROBLEM SOLVING:** TCR helps clients address their business complexities and deliver business value throughout the life cycle of any client initiative. This includes assessment, research, testing services, advisory capabilities, development and solution design, integration, deployment, inspection and support for long-term sustainability.

TCR's technical solutions provide tactical value by

Offering recommendations and insights based on deep domain knowledge and technical capability

Employing its experience and knowledge to evaluate, design, plan and implement solutions

Understanding the customer' business to help them benefit from industry-specific best practices and create processes to accelerate delivery and lower implementation costs.

Dramatically improving and certifying their products, validating material quality, ensuring innovation in the marketplace, and achieving significant competitive advantages for our customers all over the world. As a result, companies are bringing the right products to market, at the right time and at the right cost.

LABORATORY ACCREDITATIONS

TCR Engineering Services is a Bureau of Indian Standards and NABL accredited laboratory. The NABL certification is issued by the National Accreditation Board for Testing and Calibration Laboratories, Department of Science and Technology, Government of India. NABL provides accreditation to laboratories that perform tests / calibrations in accordance with ISO 17025. ISO/IEC 17025 includes quality system requirements of ISO 9001 and other additional requirements to demonstrate that the said laboratory is technically competent with the ability to produce technically valid data and results.

TCR is one of the select few testing laboratories in India to be on the approved list of organizations like Bharat Heavy Electrical Ltd., Nuclear Power Corporation of India Ltd. (NPCIL), Larsen & Toubro Ltd. (L&T), Engineers India Ltd. (EIL), Toyo Engineering India Ltd., Oil & Natural Gas Commission (ONGC), Bhabha Atomic Research Centre (BARC), Vikram Sarabhai Space Centre (VSSC), Department of Defense, DGS&D, Indian Railways, Mumbai Municipal Corporation, Department of Telecommunications, Electronic Corporation of India Ltd and others.

TCR is also approved by several international recognition bodies that include Halliburton, Schlumberger, Wartsila, American Bureau of Shipping (USA), Bureau Veritas (France), Lloyds Register of Shipping (UK), Det-Norske Veritas (Norway), SGS (India) Ltd. Indian Register of Shipping, Mercantile Marine Dept, Bureau of Indian Standards, and others.

TCR's in-house quality system (accredited to ISO 17025 for Mechanical, PMI, RoHS and Chemical testing) assures that all sample specimens are properly handled, machined, tested, examined and inspected in accordance with test requirements. The mission of the Quality Assurance Department is to maintain the ISO 17025 established standards of quality and for the development and application of the systems and procedures necessary to meet or exceed the quality requirements of all customers.

The Quality Assurance Department conducts frequent and vigorous internal audits to ensure the highest level of quality in all of the TCR service offering.

In the year 2014, TCR Engineering Services received an approval of "well known Material Testing Laboratory" by Central Boilers Board (CBB), Government of India, Ministry of commerce and industries. With this approval TCR's can carry out life assessment jobs and certify the fitness of boiler components as per Indian Boiler Regulation (IBR).

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


National Accreditation Board for Testing and Calibration Laboratories
(A Constituent Board of Quality Council of India)

CERTIFICATE OF ACCREDITATION

TCR ENGINEERING SERVICES PVT. LTD.

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

VKB House, Plot No. EL-182, MIDC, TTC, Industrial Area, Electronic Zone, Mahape, Navi Mumbai, Maharashtra

in the field of

TESTING

Certificate Number TC-5005

Issue Date 27/02/2018 Valid Until 26/02/2020

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

Signed for and on behalf of NABL

N. Venkateswaran, Program Director

Anil Agila, Chief Executive Officer


NABL

National Accreditation Board for Testing and Calibration Laboratories

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

CERTIFICATE OF ACCREDITATION

TCR ENGINEERING SERVICES 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

Plot No. EL-182, MIDC, TTC Industrial Area, Electronic Zone, Mahape, Navi Mumbai, Maharashtra

in the discipline of

CHEMICAL TESTING

Certificate Number [illegible] Valid Until [illegible]

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

Program Manager, Director, Chairman


NABL

National Accreditation Board for Testing and Calibration Laboratories

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

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for its facilities at

Plot No. EL-182, MIDC, TTC, Industrial Area, Electronic Zone, Mahape, Navi Mumbai, Maharashtra

in the discipline of

NON - DESTRUCTIVE TESTING

Certificate Number [illegible] Valid Until [illegible]

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

Program Manager, Director, Chairman


भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

ISO 9001:2015

Bureau of Indian Standards

Approvals

Indian Register of Shipping

ABS

Government of India
Bhabha Atomic Research Centre

ISRO इसरो

HALLIBURTON

Schlumberger

DNV

SGS

TÜV

ÄRTSILÄ

NPCIL


FORM XVI-B

[Regulation 4C (2)]

Central Boilers Board

Certificate of Approval as Well Known Material Testing Laboratory

This is to certify that after evaluation of the inspection and material testing reports of the following laboratory, 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 Material Testing Laboratory.

M/s. TCR ENGINEERING SERVICES PVT. LTD.
EL-182, TTC INDUSTRIAL AREA
MIDC, MAHAPE, NAVI MUMBAI-400 710

This Certificate is valid for five years, i.e. upto [illegible]

Note: The recognition will be as per standards specified under the provisions of the Indian Boiler Regulations, 1950

Director

Certificate No. 12

Secretary

I. MATERIAL TESTING SERVICES

TCR Engineering Services' ability to provide value to their metal testing customers, is based on congregating multiple talents into a focused set of technological capabilities. TCR provides a wide range of testing services and insightful solutions with new innovative equipment & testing methods, along with top-notch technical expertise. No matter which tests you choose, one can always count on TCR to not only adopt a meticulous approach but also provide the latest and cost-effective results.

Core Service Offerings

MECHANICAL TESTING
Tensile & Bend Testing
Impact Testing
Hardness Testing
Nick Break and Weldability
Component Testing and Fasteners

CREEP & STRESS RUPTURE TESTING

FATIGUE & FRACTURE TOUGHNESS

CHEMICAL TESTING
Chemical Analysis
Oil Analysis - Ferrography
RoHS Compliance Testing
Lead Inspection and Detection

CORROSION DETECTION
Inter-granular Corrosion Tests
Salt Spray
Sour Gas Corrosion (HIC/SSC)

METALLURGY EVALUATION

WELDER CERTIFICATION & QUALIFICATION

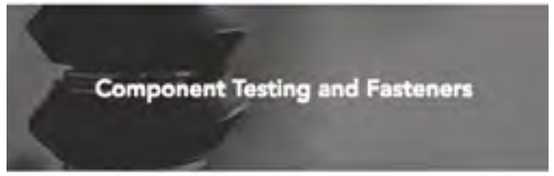
CIVIL TESTING
Soil, concrete, Asphalt Testing
Tor Steel/Rebar Testing
Structural Audit

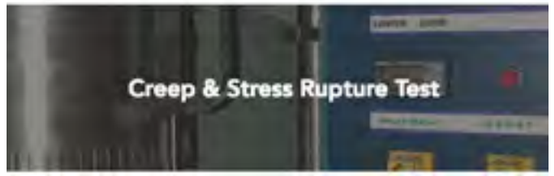
A. MECHANICAL AND PHYSICAL TESTING

TCR has a comprehensive range of Mechanical Testing services with a dedicated machine shop that assists in sample preparation. Test specimens are duly prepared for metallic and non-metallic materials for the evaluation of tensile, compression, impact, weldability, fatigue and bend properties.

With its Mechanical Testing Facility, TCR provides a precise determination of Proof Stress by the attachment of various Electronic Extensometers. The Tensile test at Elevated Temperature is a special service offered by TCR. Tests are conducted as per ASTM, BS, IS, DIN, NACE or other client-specified standards.

The Mechanical Testing Facility at TCR conducts tensile tests for understanding the strength and characteristics of a particular material. It provides a precise determination of Proof Stress by the attachment of various electronic controls and extensometers. Testing temperatures range from 50°C to 850°C and beyond, for particularly high-temperature applications. The Mechanical Testing department at TCR performs a range of Impact tests, including Izod and Charpy testing at temperatures from 100°C to -196°C. Highly specialized pressure test facilities are available at TCR's Mumbai Laboratory.





TECHNICAL CAPABILITIES

Mechanical Testing facilities at TCR conducts a range of physical tests

TCR Engineering has range of equipments available across different mechanical testing capabilities:

Universal Testing Machines
- Fatigue System Universal Testing Machine in capacity of 50 KN and 250 KN
- Universal Testing Machine (UTM) of 1000 KN capacity with Electronic Extensometer (Germany)
- Model EU 40 UTM of 400 KN capacity with high Temperature (Germany)
- Universal Testing Machine of 30000 lbs capacity with Electronic Controls and Extensometer (USA)

Hardness Testers
- Model MH 400 Micro Hardness Tester (USA)
- Model HPO 250 Brinell / Vickers Hardness Tester (Germany)
- Rockwell & Rockwell Superficial Hardness Testers

Impact Testers
- Model IT 30 Charpy Impact Tester as per ASTM standard
- Model IT 30 Charpy / Izod Impact Tester (ASTM E 23)

Test Equipment
- Erichsen Cupping Machine
- Shadowgraph
- Hydraulic Test Pump

Laboratory Facility
- Complete workshop facilities including Lathe Machines, CNC wire cut machine, Hacksaw, Stress-free grinding equipment, Saws, Shaping Machine, Surface Grinding Machines, Milling Machines and Drilling Machines
- Complete set of measuring and inspection instruments including Vernier Calipers, Micrometers, and Dial Gauges.
- Number of fixtures and attachments for various tests

Physical Testing Services
- Tensile / Transverse/Compression test
- Tensile test with 0.2% proof stress / strain diagram with electronic extensometer inclusive of sample machining charges
- Tensile test at an elevated temperature of up to 850 Deg C with Extensometer and without Extensometer upto elevated Temperature of 400 Deg C
- Tensile (n.k.r. value) / composite / plastic / fabric
- Tensile test for fine wires/foils
- Tensile test for steel bar up to 20mm and up to 36 mm dia
- Ball Test
- Bend test / Reverse bend / Re-bend / Root / Face / side bend test
- Flattening / Flaring Test
- Re- bend test including aging
- Proof load test on Nut: up to and over 40000 kg
- Full size breaking of bolt
- Wedge load test / Head soundness test
- Compression test of springs (up to 3 readings)
- Tensile test for fine wires/foils
- Charpy V notch Impact Test (a) R. T. inclusive of sample machining charges as per ASTM E23 (for a total set of 3 specimens and 3 readings)
- Impact Test up to – 60°C and below – 60°C
- Hardness test Rockwell A, B, C
- Vickers hardness test
- Brinell hardness test
- Jominy end quench test (without normalizing heat treatment)
- Sectional weight of CTD bars
- Surface characteristics of CTD Bars
- Hydraulic / Pneumatic Test inclusive of sample preparation charges
- Shear Test
- Proof Load / Slip Test on fabricated items such as clamps and assemblies
- Load test up to 40 Ton
- Peel test
- Residual Stress Measure

i. Tensile & Bend Testing

A tensile test measures the resistance of a material to a static or slowly applied force. A machined specimen is placed in the testing machine and a load is applied. A strain gauge or extensometer is used to measure the elongation. The stress obtained at the highest applied force is known as Tensile Strength.

The Yield Strength is the stress at which a prescribed amount of plastic deformation (commonly 0.2%) is produced. Elongation describes the extent to which the specimen is stretched before fracture. Information regarding the strength, stiffness, and ductility of a material is obtained from a tensile test. Other variations of the tensile testing include Room Temperature, Low Temperature, Elevated Temperature (ASTM E21), Shear, Temperature and Humidity, Combined Tension and Compression, Through Thickness, True Strain, Notched Tensile and R (ASTM E646) & N (ASTM E517) values.

All tests at TCR Engineering Services are performed in line with the ASTM E8, ASTM A370, ASTM B557 and IS/ BS Standards.

TECHNICAL CAPABILITIES

TCR has the expertise to determine the mechanical properties of materials and resolve a wide variety of technical problems for the industry:

1. **BEND TEST**
This procedure that determines the relative ductility of metal that is to be formed (usually sheet, strip, plate or wire). It is also used to determine the soundness and toughness of metal (after welding, etc.) The specimen is usually bent over a specified diameter mandrel. The four general types of bends are free bend, guided bend (ASTM E190), semi-guided bend (ASTM E290) and wrap-around bend.

2. **COMPRESSION TEST**
This is a method for assessing the ability of a material to withstand compressive loads. The test is commonly used as a simple measure of the metal workability, particularly in forging and similar bulk deformation processes. Engine mounts, bolster springs, cast products, and similar components are tested to determine load versus displacement.

3. **RING FLARING TEST, ASTM A513**
This procedure tests the ability of a section of a tube, approximately 4" in length to flare (with a tool having a 60° included angle). This is done through the tube as the mouth of the flare expands to 15% of the inside diameter without cracking or indicating any flaws.

4. **RING FLATTENING TEST, ASTM A513**
A tube sample, 4" - 6" in length is flattened between parallel plates with the weld 90° from the direction of applied force until opposite walls of the tubing meet. Applications for this test along with the flaring test, include situations where round tubing is to be formed into other shapes.

ii. Impact Testing

The impact test (ASTM E23 and IS/ BS Standard) is a method for evaluating the toughness and notch sensitivity of engineering materials. It is usually used to test the toughness of metals but similar tests are used for polymers, ceramics, and composites. Metal industry sectors include Oil and Gas, Aerospace, Power Generation, Automotive, and Nuclear.

The notched test specimen is broken by the impact of a heavy pendulum or hammer falling at a predetermined velocity through a fixed distance. The test measures the energy absorbed by the fractured specimen.

1. **CHARPY IMPACT TEST**
A test specimen is machined to a 10mm x 10mm (full size) cross-section, with either a “V” or “U” notch. Sub-size specimens are used where the material thickness is restricted. Specimens can be tested down to cryogenic temperatures.

2. **IZOD IMPACT TEST**
The test specimen is machined to a square or round section, with either one, two or three notches. The specimen is clamped vertically on the anvil with the notch facing the hammer.

3. **KEYHOLE IMPACT TEST**
The steel casting industry uses this type of specimen frequently. The notch is machined to look like a keyhole. It is tested in the same manner as the “V” and “U” notch

iii. Hardness Testing

Hardness Testing measures a material’s strength by determining resistance to penetration, measuring the permanent depth of the indentation. The test is extremely useful in material selection as it provides a hardness value, which indicates how easily a material can be machined and how well the material will wear. Simply put, when using a fixed force (load) and a given indenter, the smaller the indentation, the harder the material.

A. **BRINELL, ASTM E10 AND IS/ BS STANDARD:** This is a simple indentation test for determining the hardness of a wide variety of materials. The test consists of applying a prescribed load, usually between 500 kg and 3000 kg, for a specified time (10-30 seconds), using a 5 or 10mm diameter tungsten carbide ball on the flat surface of a metal sample.

B. **KNOOP, ASTM E384 AND IS/ BS STANDARD:** The Knoop indenter has a polished rhomboidal shape with an included longitudinal angle of 172° 30´ and an included transverse angle of 130° 0´. The narrowness of the indenter makes it ideal for testing specimens with steep hardness gradients and coatings. Knoop is a better choice for hard and brittle materials.

C. **VICKERS:** This testing is similar to Brinell, in which a defined indenter is pressed into a material. Once the indenting force is removed, the resulting indentation diagonals are measured. Micro indentation Vickers is per ASTM E384 and Macro indentation Vickers is per ASTM E92.

D. **ROCKWELL, ASTM E18 AND IS/ BS STANDARD:** This test differs from the Brinell test in the shape of the indenter and in the manner that the number is determined. The Rockwell number represents the difference in depth penetration between two loads. There are two types of Rockwell; Rockwell and Superficial Rockwell where minor and major loads applied to the specimen. The indenter used may be a diamond cone or a hardened ball, depending principally on the characteristics of the material being tested.

E. **MICRO HARDNESS, ASTM 3384 AND IS/ BS STANDARD:** A micro indentation is made on the surface of a metal sample. The hardness number is based on the measurements of the indent formed on the surface.

F. **PORTABLE HARDNESS, ASTM E110 AND IS/ BS STANDARD:** Facility for Portable hardness testing using rebound-type digital hardness tester is available for carrying out hardness testing at the site. This is particularly useful for large objects and where cutting the sample is not possible.

iv. Nick Break and Weldability

Nick break testing is another simple process that lends itself to learning welding, due to its speed and very low cost. It is also used in production runs, where quality is monitored at intervals throughout production. The principle behind it is to take a sample piece, partially cut through it and then break the remainder off. This allows one to 'see inside the weld'. Various defects and faults can be easily seen by visual inspection including lack of fusion, porosity, slag inclusions etc.

NICK BREAK

The principle of this test is to break the sample through the weld metal in order to examine the fractured surface. Applying a three-point bend load induces the fracture. The fractured surface is then examined and the type and location of any weld defect are reported.

WELDABILITY

The procedure consists of performing a chemical analysis and/or mechanical tests with metallography to provide data for the determination of weldability. Weld Engineering provides additional support and recommendations for material usage. If necessary, trial welds can be fully tested and examined to provide final data.

v. Component Testing and Fasteners

Testing components take on many forms depending on the application and the conditions present in service. TCR routinely tests components under fatigue, vibration, shock, pressure, high and low temperatures, humidity, solar, corrosion, impact, hydrostatic pressure and altitude conditions. Test capacity can vary from small (several inches in size) to large (vehicle size). Test fixtures can be made in-house via 3D drawings or FE models.

Frequently tested components include automotive parts and assemblies (i.e. axles, engine cradles, transmission shafts, shock absorbers, doors, locking enclosures, connecting rods as engine mounts and crankshafts) electronic displays, communication devices, packaged products, pressure vessels, pipes, and building products such as fascia and structural products. Aerospace components, in particular, electronic devices and landing gear assemblies are also tested.

1. **DYNAMIC LOADING:** Dynamic loading takes on many forms like impact, vibration, shock, fatigue and high strain rate to name a few. TCR is capable of performing many forms of dynamic tests on specimens, prototypes, and varied assemblies.

2. **FASTENERS - WEDGE, AXIAL, PROOF LOAD AND TORQUE-** Fasteners of all sizes used in every application are critical to the integrity of structures and finished components. In addition to dimensional, chemical composition and metallurgical properties, Mechanical Testing is of paramount importance in determining compliance with specifications and fitness for different purposes.

3. **WEDGE:** The wedge tensile strength of a hex or square-head fastener, socket-head cap screw or stud is the tensile load that the product is capable of sustaining when stressed with a wedge under the head. The purpose of this test is to obtain the tensile strength and to demonstrate the head quality and ductility of the product.

4. **PROOF LOAD:** Proof Load testing of a nut is assembled on a hardened, threaded mandrel or a test bolt, using the tension or compression method. A specified proof load is applied on the nut against the nut. The nut should resist this load without stripping or rupturing and should be removable from the test bolt or mandrel by hand after the load is released

5. **TORQUE:** The most common way to estimate clamping force is to observe the amount of torque applied to the fastener. This procedure assumes that the relationship between torque and tension is known. The most common measurement tools are hand-held torque wrenches.

6. **AXIAL:** The Axial tension of fasteners is tested in a holder with a load axially applied between the head and a nut, or in a suitable fixture

vi. Creep & Stress Rupture Test

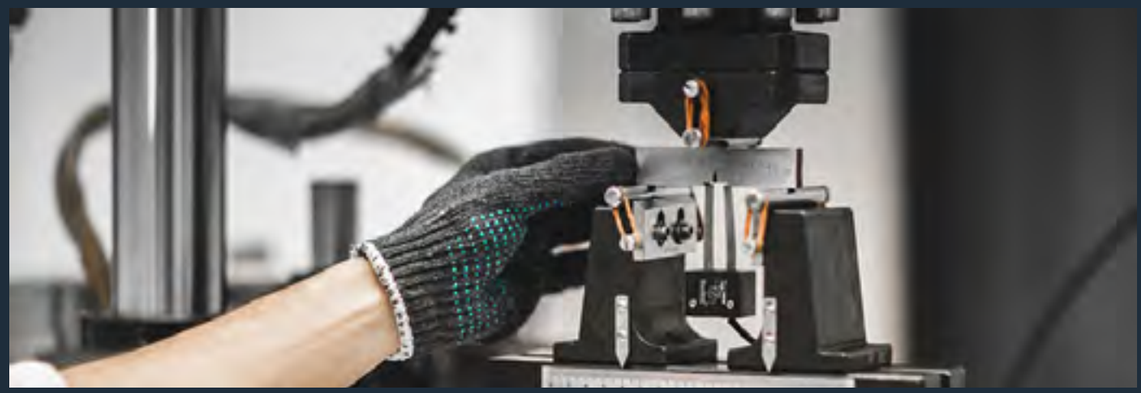
Creep is high-temperature progressive deformation at constant stress. The high temperature is a relative term that is dependent upon the materials involved. Creep rates are used in evaluating materials for boilers, gas turbines, jet engines, ovens or any application that involves high temperatures under load. The understanding of high-temperature behavior of metals is useful in designing failure resistant systems.

A creep test involves a tensile specimen under a constant load maintained at a constant temperature and measurements of strain are then recorded over a period of time. Like the Creep Test, Stress rupture test involves a tensile specimen under a constant load at a constant temperature. Stress rupture testing is similar to creep testing apart from the utilization of higher stress than that of creep testing. Stress rupture tests are employed to find out the time it takes for failure and hence stress rupture testing is always continued until failure of the material occurs. Data is plotted similar on a graph and a straight line or best-fit bend is normally obtained at every temperature of interest. The Stress Rupture test is used to determine the time for failure and elongation.

TCR has the facility for conducting Stress rupture test, Creep rupture/Creep test & Stress relaxation test as per ASTM/IS/ISO specifications

vii. Fatigue and Fracture Toughness Testing

Fatigue testing applies cyclic loading to a test specimen, to understand its performance under similar conditions when in actual use. The load application can either be a repeated application of fixed load or simulation of in-service loads. The load application may be repeated millions of times and up to several hundred times per second.



Many engineering metals and alloys display embrittlement at reduced (below sub-zero) temperatures. Structures fabricated from them fracture or shatter unexpectedly at low temperatures when loaded to stress levels at which performance would otherwise be satisfactory at room temperature. To avoid such incidents, selection of the right material can be done by testing them for their mechanical properties.

In the recent years tremendous interest has been generated in fracture toughness testing based on linear elastic fracture mechanics. Fracture mechanics principles have been used to quantify safety factors in structural design, taking into account crack propagation and/or brittle fracture. Most structural members, components, vessels, piping, aviation and aerospace are designed according to analysis criteria that guard against failure. CTOD testing requirement is most common in welded coupon as recommended in ONGC, EIL, DNV & API specification.

TCR Engineering has expanded its capabilities to include fatigue, fracture toughness, CTOD and high-temperature tensile testing with the addition of two fatigue systems, the Universal Testing Machine which has a capacity of 50 kN and 250 kN. The versatile Servo-hydraulic systems will allow the mechanical testing laboratory to perform numerous types of fatigue tests on different specimen sizes and orientations, in temperature range from ambient to 1000° C. TCR has the capability of applying linear displacements, utilizing linear and hydraulic actuators. Comparison fatigue testing of OEM and alternate source parts can also be performed to demonstrate equivalence of fatigue life.

TECHNICAL CAPABILITIES

TCR Engineering provides a diverse range of capabilities following ASTM/BS/ISO Specifications. Both ASTM E606 (Low-cycle fatigue, strain-controlled Fatigue Testing) and ASTM E466 (Load-controlled Fatigue Testing – High or Low-cycle fatigue testing) has been widely in use at TCR Engineering. Tests are also conducted for TMT RE-BAR, COUPLERS Fatigue test (100 Cycles test & 2 million Cycles test) as per IS 16172-2014.

FRACTURE TOUGHNESS TESTING: Fracture toughness determines the amount of stress required to propagate an existing flaw or defect in specific materials. Since traditional methods of destructive testing cannot always predict how a material will behave during defect fracture, toughness is very important at the design stage.

CRACK-TIP OPENING DISPLACEMENT TESTING: Crack- tip opening displacement is used as a type of fracture-toughness testing to determine if a material is appropriate for strenuous working conditions. CTOD testing is the measure of deformation, prior to failure in pre-cracked samples. This type of test is a variation of fatigue testing that has load rates more as representatives of in-service conditions.

FATIGUE TEST

ASTM E466: Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

ASTM E21 Elevated Temperature Tension Tests for Metallic Materials

ASTM E606: Standard Practice for Strain-Controlled Fatigue Testing

ASTM E647: Standard Test Method for Measurement of Fatigue Crack Growth Rates

ASTM E9 – Room Temperature Compression Testing of Metallic Materials

ASTM E 2714 – Standard Test Method for Creep-Fatigue Testing

ISO 12106: Metallic materials — Fatigue testing —Axial-strain-controlled method

ISO 12108: Metallic materials — Fatigue testing —Fatigue crack growth method

ISO 12108-2002 (E) – Metallic materials – Fatigue testing – Fatigue crack growth Method

IS16172-2014 Reinforcement Couplers for Mechanical Splices of Bars in Concrete- Specification

FRACTURE TOUGHNESS TEST

ASTM E1290: Standard Test Method for Crack-Tip Opening Displacement (CTOD) Fracture Toughness Measurement

ASTM E1820: Standard Test Method for Measurement of Fracture Toughness

ASTM E399: Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness KIc of Metallic Materials

Strain Fracture Toughness (KIC) for Metallic Materials

ASTM E1820 Measurement of Fracture Toughness (JIC-CTOD Measurement)

BS 7448 (Part 1 to part 4) Fracture Mechanics Toughness tests. Method for Determination of KLC, Critical CTOD and Critical J Values of Welds in Metallic Materials

Fracture Mechanics [K1c, J1c, CTOD] Testing

ASTM E1290 Crack-Tip Opening Displacement (CTOD) Fracture Toughness Measurement

IS 16172-2014: Reinforcement Couplers for Mechanical Splices of Bars in Concrete

Static Tensile Test

Cyclic Tensile Test

Slip Test

High Cycle Fatigue Test

TCR Engineering undertakes range of testing applications based out of its dedicated Fatigue Test Laboratory in Mumbai:

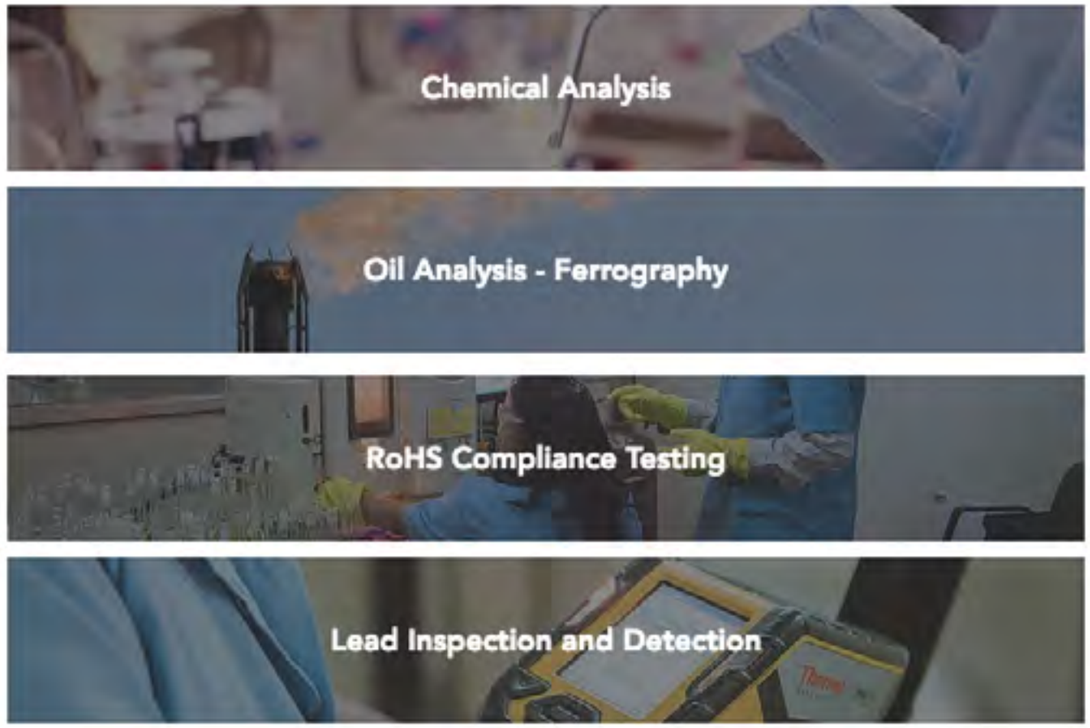
1. Fatigue crack propagation [da/dN vs ΔK Studies]
2. Fracture mechanics [K1c, J1c, CTOD] Testing
3. 3 – point bend testing of materials
4. Spring Fatigue Testing
5. Room temperature and high temperature tests [up to 1000C]
6. Tension/compression
7. Low/High cycle fatigue (LCF/HCF) Testing
8. High temperature tensile tests [up to 1000C]
9. High strain rate testing [300mm/sec on 50KN and 100mm/sec on 250KN UTM]
10. Slow strain rate testing [10-7 mm/sec on 100kN UTM]

ADVANTAGE TCR

1. Superior technology, responsive versatility, and exceptional performance ensure reliable and fast turnaround on all test results
2. A dedicated in-house sample machine shop ensures that all test samples are machined on site
3. Experts in the Machine shop are capable of low-stress grinding and machining sub-size specimens to very close tolerances
4. Highly qualified engineers in the machine shop are capable of undertaking custom-design fixtures, mount specimens for metallography examinations and custom-fabricate TOFD weld blocks for NDT operators
5. Routine testing of fasteners, chain materials, weld coupons, wire rope, castings, sheet, plate, forgings and other components is done in an effective manner, providing clients with an efficient and quality-driven service
6. At TCR, customers feel confident with its highly experienced engineers and technicians for not only handling routine but even the most diverse test requests

B. CHEMICAL TESTING

TCR has a state-of-the-art chemical analysis laboratory with expert chemists. It has the capability to analyze ferrous and non-ferrous metals, ceramics, glass, refractories, mineral and Ferro alloys in PPB or PPM level or in percentage. TCR's capabilities include: Wet Chemistry, Optical Emission Spectroscopy(OES), Inductively Coupled Plasma(ICP) Spectrometer, Automatic Combustion based Carbon and Sulfur determinator, Glow Discharge spectrometer for (GDS) chemical depth profiling, and more.



TCR ENGINEERING

i. Chemical Analysis

An inherent strength of TCR Engineering Services is the ability to successfully undertake analytical chemistry assignments. The highly qualified Analytical Chemists are experienced in using the full range of analytical instruments, which include state-of-the-art Spectrometers and Wet Chemistry laboratory facilities, catering to all the analytical requirements for Ferrous, Non-Ferrous Metals, Ceramics, Glass, Refractory, Minerals and Ferro Alloys. The chemical department analyzes samples in all forms including drillings or turnings, solid samples, and liquids.

The Classical Wet Chemistry (bench chemistry) Department uses Gravimetry (chemical species is determined by weighing) and Titrimetry (involves volume measurement of a liquid reactant) procedures to analyze the chemical composition of materials. It assists in the identification of unknown materials and gaining an understanding of their chemical composition, structure and function. Most classical wet chemical methods can accommodate comparatively small amounts of a sample in diverse shapes or forms. Fully compliant with the environmental standards of India, the wet chemistry department at TCR is highly sought-after by leading companies all over the world for right form trace chemical analysis to very low detection levels.

TECHNICAL CAPABILITIES

TCR has an extensive list of accredited testing capabilities that include:

CHEMICAL ANALYSIS BY CLASSICAL WET METHOD:

- Ferrous metals (including) C, S, P, Mn, Cr, Mo, Ni
- Non Ferrous Refractory, Ceramics and Minerals, Ferro alloys (Fe-Mn, Fe-Si, Fe-Mn-Si, Fe-Mg-Si, Low C Fe-Cr, Fe-Mo)
- Non Ferrous metals (each additional element)
- Elements such as Co, Al, W, Cu, Sn, Ti, Mg, V in steel
- Nitrogen / Boron / Palladium (each element)
- Purity of Cu
- Purity of Al, Zn, Pb, Ni, Bi, Cd, Sn, Mg, W, Ti
- Oxygen Analysis and Hydrogen Analysis

CHEMICAL ANALYSIS BY SPECTROMETERS

- EDAX analysis
- Complete Chemical Analysis upto 8 elements
- Impurities in PPM Level using AAS or ICP

i. Chemical Analysis

CHEMICAL ANALYSIS BY LECO
- Oxygen by LECO
- Nitrogen by LECO
- Hydrogen by LECO

STEEL AND CAST IRON
- Determination of any one element (%C)
- Determination of any one element (Mn, Si)
- Determination of any one element (Ni, Cr, S, P)
- Determination of C, Mn, Si, S, P
- Complete analysis of Low Alloy Steel up to 8 elements including C, S, P, Si, Mn, Ni, Cr, Mo
- Determination of any one element in Stainless Steel
- Complete Analysis of Stainless Steel up to 8 elements
- Determination of High Alloy element (Cr, Ni, Mn)
- Determination of some special element (Cu, Ti, Co, V, W, Al) per element
- Complete analysis of High Speed Steel (8 elements) per element
- Determination of Mo%
- Determination of V%
- Nitrogen in steel

NON-FERROUS MATERIAL
- Copper Base Alloys
- Determination of any one element
- Complete Analysis of 6 elements
- Purity Test of Cu
- Purity test of other non ferrous element

FERRO ALLOYS
- Analysis of Main Element
- Each Subsequent element

TIN, ALUMINUM, LEAD BASE
- Determination of any one element
- Complete Analysis of up to 8 elements
- Purity Test
- Only Aluminum %

OTHER TESTS
- pH Value Determination
- Sand Content (as Sio2)
- Acid Insoluble
- Sulphates, Chlorides, Silicates, Carbonates, Oxides of Iron per element Elemental analysis – Calcium, Magnesium, Potassium, Sodium, Iron per element
- Moisture Content
- Analysis on XRF per element
- Ash Content
- Material Certification
- Unknown Material Identification
- Trace Element Analysis
- Oil, Powdered Metal, & Chips/Shavings Analysis
- Solder Alloys (Tin/Lead)
- Quantitative and Semi-Quantitative Analyses
- Density of Powdered Metals
- Plating and Plating Solution Analysis
- Glass Analysis
- On Site Positive Material Identification (PMI)
- Coating Identification
- Coating Weights
- Particle Size Analyzer

EQUIPMENT

TCR Engineering has a wide range of equipment that is available for chemical analysis:

WET CHEMISTRY
Microwave Oven System | Electro Analyzers (4 Nos.) | Electronic Balances (3 Nos.) | Vacuum Pump, Muffle Furnaces and Heating Ovens and more.

SPECTROMETER

1. **Atomic Absorption (AA) Graphite Furnace Spectrometer:** The sensitivity of GFAA enables performances of elemental analysis that is virtually impossible using other analytical techniques. These are used to determine ppm and sub-ppm levels of residuals in metals. GFAA is also particularly useful for the determination of low boiling point tramp elements in aerospace alloys. This method is particularly pertinent in material analysis for the detection of trace metals.

2. **Inductively Coupled Plasma Spectrometer:** ICP is a spectrophotometric method carried out in solutions where high temperature argon plasma is used to reduce matrix effects, giving straight-line calibrations. This enables low sample weights to be analyzed and coupled with its wide calibration range, makes them the most flexible instruments that are available today, with parts per billion detection limits.

3. **Optical Emission Spectrometer:** These instruments enable the rapid quantitative determination of a wide range of alloys including carbon/low alloy steels, stainless steels, cast irons, aluminum alloys, nickel alloys and copper alloys. It entails a relatively simple sample preparation that allows a rapid turnaround of results using this technique.

4. **X-Ray Diffraction Spectrometer:** X-Ray Diffraction Analysis (XRD) investigates the crystalline material structure, including atomic arrangement, crystallite size, and imperfections. The X-rays are generated by a cathode ray tube, filtered to produce monochromatic radiation, collimated to concentrate, and directed toward the sample.

5. **Atomic Combustion, Carbon & Sulfur Determinators:** Combustion carbon and sulphur determination are accepted as the most accurate methods for determining carbon and sulphur in metal, ore or powder samples. These samples may be in the form of solid material, drillings or powders. This technique is mainly used to complement ICP or OES for a full chemical analysis of metallic samples.

ii. Oil Analysis - Ferrography

Ferrography or oil analysis is a series of laboratory tests that determine the condition of used lubricants in equipment components, over a period of time. A trend of wear particle distribution and their concentration typically presents the condition of the equipment. It allows organizations to be proactive as it gives them the opportunity to be prepared for breakdowns and also for investing in maintenance programs.

There are six basic Wear Particle types generated through the wear process, which includes metallic particles that comprise of Normal Rubbing Wear, Cutting Wear Particles, Spherical Particles, Severe Sliding Particles, Bearing Wear Particles (Fatigue Spall Particles, Laminar Particles) and Gear Wear (Pitch Line Fatigue Particles, Scuffing or Scoring Particles). Sand and dirt particles responsible for generating Wear Particles exist in the system too.

ADVANTAGE TCR

- Reduction in unscheduled downtime due to wear of rotary components like bearings and gears
- Effective maintenance scheduling
- Improved equipment reliability and safety
- Reduction in maintenance costs
- Maximization of oil change-out intervals that indirectly conserves environmental cleanliness
- Reduction in machine power consumption over a period of time

iii. Lead Inspection and Detection

The ill-effects of Lead (Pb) consumption is gaining significance all over the world. The Lead inspection service from TCR allows manufacturers of consumer electronics materials, children's toys and jewelry, cooking or edible materials, packaging, and several other materials in India, to create lead-free landfills and clean up hazardous sites.

TECHNICAL CAPABILITIES

TCR Engineering Services undertakes the classification of definitive positive/negative results for Pb using portable XRF instruments. TCR's XRF instrument can detect the presence of lead in paints & coatings, as well as in oils & liquids. The tests are done in-situ and it can help in establishing area contamination boundaries and depth profiles, including assisting in site investigations, delineation and contamination patterns.

iii. RoHS Compliance Testing

The RoHS Directive states that certain non-exempt products, as well as electrical and electronic products put on the market within the EU, must contain less than 0.1% lead (Pb), mercury (Hg), hexavalent chromium (Cr6+), polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE), and less than 0.01% cadmium (Cd). Product manufacturers including computer hardware, IT equipment, clock radios and toasters could find themselves banned from selling their product in the European market if they fail to comply with the new directives.

TCR Engineering Services has devised testing programs to help clients understand the rigorous RoHS restrictions. TCR has researched complex methodologies required for testing of compliance and has acquired specialized equipment to meet client needs. The RoHS Testing Team at TCR has the capability to analyze all restricted substances up to the required limits and ensure that the products meet all the requirements while retaining full product functionality.

Restriction of (certain) Hazardous Substances (RoHS) is a result of Waste Electronic and Electrical Equipment (WEEE) Directive, which addresses end-of-life issues on electrical components. The WEEE Directive is essentially concerned with the introduction of hazardous materials into the environment, during recycling or disposal

The RoHS Testing Team at TCR analyses concentrations of lead, mercury, cadmium, chromium, polybrominated biphenyls (PBBs), and polybrominated diphenyl ethers (PBDEs) in electrical and electronic components, right up to the required limits, to ensure that all the products meet the requirements while retaining their full functionality. TCR Engineering Services undertakes RoHS and WEEE-related compliance testing for electronic products and accessories using both:

Non Destructive RoHS screening (RFA method)

The screening provides indications about the presence of hazardous substances in the product according to RoHS. It is best suited to gain a quick overview of a goods receipt check or in preliminary inspections. Using a custom-tailored portable X-Ray Fluorescence Spectroscopy (XRF) spectrometer, the inspection team from TCR can simultaneously screen for all five restricted RoHS elements and chlorine (Cl), in a matter of a few seconds. Using a Portable XRF is non-destructive and an in-situ point-and-shoot screening method for PVC, PE, alloys, metals, solders, ceramics and packaging materials.

Chemical Analysis by ICP (Verification method)

RoHS testing is carried out using an initial screening test by XRF; if high levels of restricted substances are found, additional tests may be performed using Inductively Coupled Plasma (ICP) Spectrometer and wet chemistry. The Chemical Analysis Department at TCR provides all its clients with accurate, precise results that report the total level of RoHS elements and compounds, along with detailed information about their products meeting all RoHS requirements.

C. CORROSION DETECTION

TCR Engineering Services undertakes a wide range of corrosion and stress corrosion tests as per ASTM, NACE or those that are specific to an individual client's requirements. Senior technicians are available to provide consulting and advisory services on corrosion prevention and control services including material selection either in the laboratory or on-site inspection.

TCR's technical team has developed deep industry expertise to address a variety of corrosion problems that an organization encounters, such as oil and gas production & transmission, energy conversion systems and nuclear power systems. A wide variety of corrosion-related tests are undertaken to determine weight loss corrosion, intergranular attack, pitting corrosion, corrosion fatigue, stress corrosion cracking, sulfide stress cracking, and hydrogen-induced cracking. TCR offers a comprehensive range of material testing services for corrosion problems that include

INTER-GRANULAR CORROSION ATTACK IN AUSTENITIC STAINLESS STEELS
Oxalic Acid Etch test per ASTM A262 Practice A
Ferric Sulfate-Sulfuric Acid test per ASTM A262 Practice B
Huey Test, Nitric Acid test per ASTM A262 Practice C
Copper–Copper Sulfate–Sulfuric Acid test per ASTM A262 Practice E
Copper–Copper Sulfate–50% Sulfuric Acid test per ASTM A262 Practice F

INTER-GRANULAR CORROSION ATTACK IN STAINLESS STEELS
Oxalic acid etch test per ASTM A763 method W
Ferric sulfate-sulfuric acid test per ASTM A763 method X
Copper-copper sulfate-50% sulfuric acid test per ASTM A763 method Y
Copper-copper sulfate-16% sulfuric acid test per ASTM A763 method Z

INTER-GRANULAR CORROSION OF FERRITIC, AUSTENITIC & FERRITIC-AUSTENITIC (DUPLEX) STAINLESS STEEL
Intergranular corrosion of stainless steels per ISO 3651 Method A, B, C

METALLIC MATERIALS
Potentiodynamic Anodic Polarization Measurement per ASTM G5
Immersion Corrosion Testing per ASTM G31
Stress Corrosion Cracking in Polythionic Acids per ASTM G35
Preparing, Cleaning and Evaluating Corrosion Test Specimens per ASTM G1
Examination and Evaluation of Pitting Corrosion per ASTM G46
Corrosion Rates and Related Information from Electrochemical Measurements (Tafel slopes) per ASTM G102

CORROSION TESTS AS PER ONGC/EIL SPECIFICATION
Chloride Stress Corrosion Cracking in boiling Magnesium Chloride per ASTM G36
Chloride Stress Corrosion Cracking in boiling Calcium Chloride per ASTM G36

DETERMINING SUSCEPTIBILITY TO STRESS-CORROSION CRACKING OF ALUMINIUM ALLOY PRODUCTS
Stress Corrosion Cracking by Alternate Immersion Method per ASTM G44
Stress Corrosion Cracking of Aluminum Alloys per ASTM G47 Stress Corrosion Cracking Resistance of Al-Zn-Mg-Cu Alloys per ASTM G103

Exfoliation Corrosion Susceptibility of Aluminum Alloys (ASSET Test) per ASTM G66
Exfoliation Corrosion Susceptibility in Aluminium Alloys (EXCO Test) per ASTM G34

Intergranular Corrosion of Aluminum Alloys by Mass Loss (NAMLT Test) per ASTM G67

Intergranular Corrosion Resistance of Heat Treatable Aluminium Alloys per ASTM G110

PITTING AND CREVICE CORROSION RESISTANCE OF STAINLESS STEELS AND RELATED ALLOYS
Ferric Chloride pitting test G48 method A
Ferric Chloride crevice test ASTM G48 method B
Critical Pitting Temperature test for nickel-base and chromium-bearing alloys per ASTM G48 method C
Critical Crevice Temperature test for nickel-base and chromium-bearing alloys per ASTM G48 method D
Critical Pitting Temperature test for Stainless Steel ASTM G48 method E
Critical Crevice Temperature test for Stainless Steel ASTM G48 method F

DETECTING DETRIMENTAL INTERMETALLIC PHASE IN AUSTENITIC/FERRITIC (DUPLEX) STAINLESS STEEL
Sodium Hydroxide Etch test of Duplex Stainless Steel per ASTM A923 method A
Charpy Impact test for Classification of Structures of Duplex Stainless Steels per ASTM A923 method B
Ferric Chloride Corrosion test for Classification of Structures of Duplex Stainless Steels per ASTM A923 method C

NACE MR0175/ISO 15156: PETROLEUM AND NATURAL GAS INDUSTRIES- MATERIALS FOR USE IN H2S-CONTAINING ENVIRONMENTS IN OIL AND GAS PRODUCTION

Hydrogen Induced Cracking Test per NACE TM0284
Stress Oriented Hydrogen Induced Cracking Test (SOHIC) per NACE TM0103
Sulfide Stress Corrosion Cracking (Room Temperature) per NACE TM0177
Sulfide Stress Corrosion Cracking (90 Deg C, 16 bar) per NACE TM0177
Sulfide Stress Corrosion Cracking (120 Deg C, 20 bar) per NACE TM0177
Sulfide Stress Corrosion Cracking Double-Cantilever-Beam (DCB) Test per NACE TM0177 method D
Stress Corrosion Cracking (Four-Point Bend) of Materials for Oil and Gas Applications per NACE TM0316
Stress Corrosion Cracking (Four-Point Bend) per NACE TM0177 and ASTM G39

DETERMINING SUSCEPTIBILITY TO STRESS CORROSION CRACKING IN COPPER ALLOYS
Stress Corrosion Cracking (Ammonia Vapor Test) per ASTM B858
Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper per ASTM B577

METALLIC MATERIAL AND COATED METALLIC SUBTRATE
Salt Spray (Fog) per ASTM B117
Neutral salt spray (NSS) per ISO 9227
Acetic acid salt spray (AASS) per ISO 9227
Copper-accelerated acetic acid salt spray (CASS) per ISO 9227

i. Sour Gas Corrosion (HIC/SSC)

TCR's Sour Service Corrosion Testing Department undertakes Small Scale Tests and Full Ring Testing for SSCC (NACE TM 0177, EFC 16 and 17) and HIC (NACE TM 0284). The range of instruments available to perform these tests is extensive and unrivaled in the industry. Highly experienced and qualified engineers routinely undertake corrosion studies to include all observations as per NACE MR 0175.

NACE TM0284

Hydrogen-Induced Cracking (HIC) Test

TCR Engineering Services' corrosion testing laboratory performs HIC test to evaluate the resistance of pipelines, pressure vessel plate steels and hydrogen-induced Cracking caused by hydrogen absorption from aqueous sulfide corrosion. An unstressed test specimen is exposed to a solution at ambient temperature and pressure for a specified time, post which the test specimen is removed and evaluated.

NACE TM0284 specifies either Solution A or Solution B. Solution A is acidified brine. Solution B is simulated seawater prepared in accordance with ASTM D1141.52. In either case, H2S is bubbled through the solution constantly throughout the test period. NACE TM0284 specifies test duration of 96 hours.

PROCESS & OUTCOME
TCR Engineering issues a detailed written report on completion of each test. Each report includes a description of the test sample received, the test procedure used, and the pH values of the test solution, before exposure and after the exposure. The test bars are cut into sections and examined under a microscope for hydrogen-induced cracks. The dimensions of any such cracks are recorded and used to compute the values in percentage for Crack Length Ratio (CLR), Crack Thickness Ratio (CTR) and Crack Sensitivity Ratio (CSR).

SPECIMEN SIZE
To conduct the HIC test, the following sample sizes are required:

Plate - 150mm x150mm with rolling direction marked
If the plate is more than 80mm thick - 250mm x 250mm sample size is required

Pipe - upto 2" OD - 200mm long. If the pipe is more than 2" OD pipe - 100mm long sample size is required

Bars - Upto 3" dia - 300mm long. If the Bars are more than 3" dia to 5" dia - 200mm long sample size is required
If the Bars are more than 5" dia - 100mm long sample size is required

Number of pieces to be tested: Up to 88mm thick/dia - Set of 3 pieces to be tested. More than 88mm thick/dia - 5 pieces to be tested

NACE TM0177

Sulfide Stress Corrosion Cracking (SSC)

Sulfide stress corrosion cracking (SSC) is a form of hydrogen embrittlement cracking which occurs when a susceptible material is exposed to a corrosive environment containing water and H2S at a critical level of applied or residual tensile stress. TCR Engineering Services conducts the NACE TM0177 tests including Methods A and B for SSCC test at their corrosion testing laboratory.

NACE TM0177 tests at TCR includes both Tensile Test (Proof Rings) under Method A and Bent Beam Test (3 or 4 Point Bends) under Method B. NACE TM0177 specifies Solution A (acidified), Solution B (acidified and buffered) and Solution C (for martensitic stainless steel). Solution A is used in Methods A unless the properties of Solution B or C are specified. In any case, H2S is bubbled through the solution constantly throughout the test period.

Testing is performed in NACE solutions A and/or B, saturated with H2S at 24° and 90° Celsius. Stressed samples are exposed to sour environment for a predetermined time, after which they are removed and analyzed for crack detection. NACE TM0177 specifies test duration of 30 days (720 hours) for Method A or B test.

SPECIMEN SIZE
The SSC tests at TCR Engineering in India are performed routinely for customers, using tensile and bent beam specimens. For each stress level and temperature, the following sample size is required:

Plate: 16mm Thickness X 160mm long
Pipe: 160mm length, cut strip of 16mm width
Bar: 160mm length, irrespective of diameter

PROCESS & OUTCOME
TCR Engineering provides a printed report for individual or cluster of tests conducted at the laboratory. The report includes a description of the test sample, details of the testing procedure and pH values of the test solution before and after exposure, along with the result of each test. TCR Engineering requires 6 weeks to complete the SSC test.

ii. Intergranular Tests

Several methodologies are available at TCR Engineering Services for testing intergranular corrosion. To conduct these tests, TCR carefully chooses a method that is suitable for steel grade and grain boundary composition. Intergranular corrosion in stainless steels may result from precipitation of carbides, nitrides or intermetallic phases.

Only in the most highly oxidizing solutions can an intergranular attack be caused by intermetallic phases. When a test is restricted to carbides in materials containing nitrides or intermetallic phases, a less oxidizing solution is chosen.

TECHNICAL CAPABILITIES

TCR Engineering Services frequently carries out a number of tests in India as per the ASTM A262 specification:

Oxalic Acid Test, ASTM A262, Practice A (Oxalic Acid Etch)
The oxalic acid etch test is a rapid method of screening specimens of certain stainless steel grades which are essentially free from susceptibility to intergranular attack associated with chromium carbide participates. The test is used for acceptance and not the rejection of a material.

Ferric Sulfate - Sulfuric Acid, ASTM A262 - Practice B (Streicher Test)
This test is based on weight loss determinations and provides a quantitative measure of relative performance of the material evaluated. The procedure includes subjecting a specimen to a 24 to 120-hour boil in ferric sulfate - 50% sulfuric acid. This procedure measures the susceptibility of stainless steels and nickel alloys to intergranular attack associated with the precipitation of chromium carbides at grain boundaries.

Nitric Acid, ASTM A262, Practice C, (Huey Test)
The specimens are boiled for five periods, each for 48 hours in 65 per cent nitric acid solution. The corrosion rate during each boiling period is calculated from the decrease in the weight of the specimens. The results, when properly interpreted can reveal whether or not the steel has been heat-treated in the correct manner.

The customer must specify the maximum permissible corrosion rate and in applicable cases, provide the data on sensibilizing heat treatment.

The Huey test environment is strongly oxidizing and is only used as a check to ascertain whether the material has been correctly heat treated. This test is suitable for the detection of chromium depleted regions as well as intermetallic precipitations, like sigma phase in the material. The Huey test is also used for materials that come into contact with strongly oxidizing agents, e.g. nitric acid. This procedure may also be used to check the effectiveness of stabilizing elements and of reductions in carbon content in reducing susceptibility to intergranular attack in chromium-nickel stainless steels.

Copper - Copper Sulfate - 16% Sulfuric acid, ASTM A262 - Practice E (Strauss Test)
This procedure is conducted to determine the susceptibility of austenitic stainless steel to intergranular attack associated with the precipitation of chromium-rich carbides. Once the specimen has been subjected to the solution boil, it is bent through 180° and over a diameter equal to the thickness of the specimen being bent. This test is based on a visual examination of the bent specimen.

Copper - Copper Sulfate - 50% Sulfuric acid, ASTM A262 - Practice F
This test is based on weight loss determination, which provides a quantitative measure of the relative performance of the material evaluated. It measures the susceptibility of "as received" stainless steel to intergranular attack of "as received" stainless steels to intergranular attack.

iii. Salt Spray Services

The senior technical team at TCR Engineering Services has deep industry expertise in handling diverse corrosion problems encountered in oil and gas production, oil and gas transmission, energy conversion systems, and nuclear power systems. A wide variety of corrosion related tests can be undertaken at TCR Engineering Services to determine weight loss corrosion, intergranular corrosion attack, pitting corrosion, corrosion fatigue, stress corrosion cracking, sulfide stress corrosion cracking, and hydrogen-induced corrosion cracking. TCR also performs tests listed under 3rd party inspection of LRS, TUV, DNV, ABS and other inspection agencies at their laboratory.

TECHNICAL CAPABILITIES

1. **Salt Spray (Neutral / Fog), ASTM B117**
This is the most commonly used salt spray for testing inorganic and organic coatings, especially when such types of tests are used for material or product specifications. Salt Spray testing is a tool for evaluating the uniformity of thickness and the degree of porosity of metallic and nonmetallic protective coatings. A number of samples can be tested simultaneously depending on their size

2. **Pitting Corrosion Test, ASTM G48 Method B**
This procedure is employed to assist in the selection of test methods that can be used in the identification and examination of pits as well as the evaluation of pitting corrosion to determine the extent of its effect. The ASTM G48 Method B, Ferric Chloride test involves exposing a specimen to a highly oxidizing acid chloride environment. The importance of this evaluation is to be able to determine the extent of pitting, either in a service application where it is necessary to predict the remaining life in a metal structure or in laboratory test programs that are used to select the most pitting-resistant materials for service

3. **Corrosion test as per ASTM G 35**
The polythionic acid (sulfurous acid and hydrogen sulfide) environment provides a way of evaluating the resistance of stainless steels and related alloys to intergranular stress corrosion cracking. This practice can be applied to wrought products, castings, weld metal of stainless steel or other materials that are used in environments containing sulfur or sulfides.

D. METALLURGICAL EVALUATION

The metallurgists at TCR have deep expertise in Metallographic preparation and examination to evaluate the characteristics of metals. They are highly skilled to assess a particular 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.

The Metallography department employs the Inverted Metallurgical microscope, Olympus GX51 and the Leco 500 microscope with an Image Analysis System. The technical team has indigenously developed a microstructure characterizer software that assists with the analysis of images to determine microstructural degradation due to creep. The software can also calculate the graphitization, depth or width of decarburization, phase/volume percentage, grain growth, inclusion rating, particle size, volume percentage, particle count, porosity and coating thickness.

TECHNICAL CAPABILITIES

TCR undertakes metallurgical evaluation using SEM, EDAX, XRD and TEM technologies. The ambit of frequently tested services in TCR metallography lab include:

1. Microstructure Examination (Routine) with two photographs
2. NDT microstructure with two photographs
3. Microstructure with Comment on Heat Treatment
4. Microstructure examination for failure related study
5. Grain size distribution chart on Image Analysis (With print out)
6. Prior austenite grain size measurement (including heat treatment charges)
7. Prior austenite grain size measurement by Mc Quid Ehn method (including carburizing)
8. Oxide-scale/Nitriding/ Carburizing/Decarburizing/ Coating – Measurements. (Avg. of 3 readings), over and above microstructure examination charge
9. Grain size Measurement as per ASTM E112 with photograph
10. Linear measurement, up to 3 measurements, over and above macrostructure/microstructure examination charge
11. Each Additional linear measurement
12. Inclusion Rating as per ASTM E45 Method A with photograph
13. Inclusion rating as per ASTM E45 with photograph
14. Color Metallography (With two Photos)
15. Delta ferrite from SS weld microstructure, Sigma phase, volume fraction by microstructure examination (Avg. 3 frames)
16. % Nodularity, Nodule Count as per ASTM A247 and IS 1865
17. Porosity Analysis as per ASTM A 276
18. Decarburization level as per IS 6396 and ASTM E 1077
19. Phase Distribution as per ASTM E 562 / 1245
20. Powder particle size measurement (Avg. 5 frames)
21. Coating Thickness Measurement as per ASTM B 487
22. Retained Austenite measurement with electro polish and copper deposition method, and calculation on image analysis software from microstructure examination. (Avg. 3 frames)
23. Micro-Hardness Testing
24. Micro hardness profile for case depth measurement (max. 10 readings)
25. Macro Etch Test up to 100 mm (Including Photo & Comments)
26. Macro Etch Test Between 100 to 200 mm (Including Photo & Comments)
27. Macro Etch Test Over 200 mm (Including Photo & Comments)
28. Fractography by Stereo Microscope
29. Fractography by SEM
30. Coating thickness by SEM
31. Microstructure Examination Test With Photographs, Grain Size Comment on Carbide Precipitation, Nitrides & Intermetallic Phases In Haz, Parent, Weld As Per A-923 METHOD A, ASTM E-45 for Inclusion Rating
32. Hydrogen Embrittlement on Copper
33. Ferrite as per ASTM E562 per phase per sample
34. Intermetallic Phase (Chi, Sigma, Laves Nitrate Carbide) per phase per sample
35. Intermetallic Phases in Weld, Parent Material (PM), Heat Affected Zone (HAZ) per phase per sample
36. Microstructure test with photograph (for Sigma Phase)
37. Microstructure test with photograph (for Ferrite content)
38. Analysis of a given SEM Image for particle size and particle size distribution (max/min, size/frequency information) of the dispersed phase in a continuous phase matrix.
39. Cost to prepare the sample for placement in SEM sample chamber
40. SEM Analysis with single image
41. Delta Ferrite Measurement by Ferritscope
42. Pit Dimension Measurement
43. EDAX / EDS Analysis
44. XRD Analysis
45. In-situ Replica interpretation only on a client supplied replica.

46. Structural Examination Charges (As per 6.1)
47. Structural Examination (each additional measurement)
48. Inclusion rating as ASTM E45 – Method D (Set of six specimen)
49. Volume Fraction measurement (30 Frames) as per ASTM E 562
50. Microstructure as per A 923 Method A
51. Microstructure carbide network as per SEP 52100 chart (Heat Treatment charges are extra)
52. In-situ Metallography
53. Step Macro without photograph – each step
54. Step Macro with photograph – each step
55. Macro Measurement (MLP/Penetration) -each
56. Depth of Attack
57. Banding Index
58. Inter-metallic Phases – Charges on request
59. Coating/ Plating Thickness/ Mesh Size
60. Austenitic Grain Size with photographs (up to 3 samples)

Microstructure Characterizer Software

Metallurgical Image Analysis Software

TCR Engineering has developed Microstructure Characterizer Software, an image analysis tool. Using this software, a Metallurgist or a Material Science engineer can characterize different types of micro structural images for grain size, coating thickness and phases; get images from one or more files; and intensify the image using the filtering and enhancement features.

Microstructure Characterizer Software 3.0 (MiC) characterizes micro structural features using standard methods of material characterization such as ASTM grain size measurements, coating thickness, linear and angular measurements, comparison of superimposed grain size reticules, inclusion rating as per IS and ASTM standards, nodularity measurements, powder particle size distribution and so on. It helps generate custom-made formatted reports of live and stored images and offers results as the computer display as well as hard copy multi-color printouts.

ADVANTAGE TCR

Extensive deployment experience; the software has been deployed at more than 295 commercial laboratories and universities till date. Custom modifications to this software can be done in conjunction with the engineering consulting team at TCR

Metallography Tests at TCR

A

MACRO-EXAMINATIONS: Macro-etching is the procedure in which a specimen is etched and macro-structurally evaluated at low magnifications. It is a frequently-used technique for evaluating steel products such as billets, bars, blooms and forgings. There are several procedures for rating a steel specimen by a graded series of photographs, showing the incidence of certain conditions and is applicable to carbon and low alloy steels. A number of different etching reagents may be used depending upon the type of examination. Steels react differently to etching reagents because of variations in chemical composition, the method of manufacturing, heat treatment, and many other variables.

Macro-Examinations are also performed on polished and etched cross-sections of welded material. During the examination, a number of features can be determined including the weld run sequence, which is vital for weld procedure qualifications tests. Apart from this, any defects on the sample are assessed for relevant specifications and compliance. Slag, porosity, lack of weld penetration, lack of sidewall fusion and poor weld profile are among the features observed in this type of examination. It is procedural to identify such defects, either by standard visual examination or at magnifications of up to 50X. It is also routine to photograph the section to provide a permanent record and this is known as a photomacrograph

B

MICRO EXAMINATION: This is performed on samples that are either cut to size or mounted on a resin mould. These samples are polished to a fine finish, typically a one-micron diamond paste and prior to an examination on the metallurgical microscope, it is usually etched in an appropriate chemical solution. Micro-examination is performed for a number of purposes, the most common of which is to assess the structure of the material. It is also customary to examine for metallurgical anomalies such as third phase precipitates, excessive grain growth, etc. Many routine tests such as phase counting or grain size determinations are performed in conjunction with micro-examinations

Metallography Tests at TCR

C **WELD EXAMINATION:** Metallographic weld evaluations take place in many forms. In its most simple format, weld deposits can be visually examined for large-scale defects such as porosity or lack of fusion defects. On a micro scale, the examination can take the form of phase balance assessments from weld cap, weld root or can even be checked for non-metallic or third phase precipitates. Examination of weld growth patterns is also used to determine the reasons for poor mechanical test results. For example, an extensive central columnar grain pattern can cause a plane of weakness, giving poor charpy results

D **CASE DEPTH:** Case hardening may be defined as a process for hardening ferrous materials in such a manner that the surface layer (known as the case) is substantially harder than the remaining materials (known as the core). This process is controlled through carburizing, nitriding, carbonitriding, cyaniding, induction, and flame hardening. The chemical composition and mechanical properties are affected by these practices. The methodology utilized for determining case depth can either be chemical, mechanical or visual and the appropriate one is selected based on specific requirements

E **DECARBURIZATION MEASUREMENT:** This method is designed to detect changes in the microstructure, hardness or carbon content, at the surface of steel sections due to carburization. To determine the depth, a uniform microstructure, hardness or carbon content of the specimen interior is observed. This method detects surface losses in the carbon content due to heating at elevated temperatures

F **COATING / PLATING EVALUATION (ASTM B487, ASTM B748):** A coating or plating application is used primarily for the protection of the substrate. Thickness is an important factor in the performance of the coating or plating. A portion of the specimen is cut, mounted transversely and is prepared in accordance with acceptable or suitable techniques. The thickness of the cross section is measured with an optical microscope. When the coating or plating is thinner than .00020, the measurement is taken with the scanning electron microscope. Cross-sectioned metallographic examinations of substrates with plating, surface evaluations, thickness measurements, weight per volume and even salt spray testing can aid in the evaluation of plating

TCR ENGINEERING

Scanning Electron Microscope with
EDS ANALYSER

TCR has the state of the art Scanning Electron Microscope (SEM) that is attached with an 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 a simple and an extremely user-friendly operating console equipped with a turbo-molecular pumping system to achieve a high vacuum that requires absolutely no time to start-up. The EDS Analyzer X-Max 20 is a versatile X-Ray spectrometer system, which does not require liquid nitrogen for its operation. This reduces the start time for EDS-accelerating voltages and lower spot sizes resulting in improved accuracy and quantification of elements that sometimes, can be a limitation of the conventional EDS detectors with 10-mm² areas

G **SURFACE EVALUATION:** Surface inspection includes the detection of surface flaws along with the measurement of surface roughness. One of the methods used to perform this test is the use of a laser light. Measurement and analysis is possible when scattered light is reflected off the surface of a sample, An alternative method is the use of a motorized stylus (profilometer), where the stylus is placed on the surface and the texture of the material is measured in micro-inches or millimeters.

H **GRAIN SIZE DETERMINATION:** In order to establish a scale for grain size, ASTM E112 shows charts with outline grain structures for various dimensions. These universally accepted standards range from 1 (very coarse) to 10 (very fine). A material's grain size is important as it affects its mechanical properties. In most materials, a refined grain structure gives enhanced toughness, and alloying elements are deliberately added during the steel-making process to assist with grain refinement. Grain size is determined from a polished and etched sample, using optical microscopy at a magnification of 100X

E. WELDER CERTIFICATION & PROCEDURE QUALIFICATION

TCR Engineering Services provides a comprehensive welder certification and welding procedure program. The program offers:

1. Welder Qualification Testing for performance qualification and certification of welders (a welder / welding operator performances qualification - WQT) to ASME, ANSI, AWS, API code

2. Preparation of Weld Procedure Qualification that is relevant for both, a project or client's requirements

3. Coupon Testing as per Weld Procedure Qualification including visual examination, mechanical testing, metallographic examination and non destructive testing

4. Documentation of the Procedure Qualification Record as per ASME, ANSI, AWS, API codes

5. Detailed weld inspection including review of the qualification e.g. weld procedure specification, welder performance qualification and validity for process materials and consumable items, equipment, setup and other factors including certificates of calibration and/or conformity governing the work

6. Ascertain safety of operations for self, welder and other workers in the vicinity, particularly ultraviolet radiation from arc during welding

TCR ENGINEERING

TECHNICAL CAPABILITY

Welding Procedure Program

The welding inspector deployed on-site by TCR is responsible for monitoring and verifying conformity of tasks against all the relevant requirements including codes, specifications and/or standards:

- Ascertain the weld procedure(s) employed
- Review weld procedure and welder qualifications
- Supervise weld profile preparation
- Inspect joint fit-u
- Oversee filler metals and consumable materials
- Ensure correct welding performance parameters are maintained
- Perform visual examination upon completion of welding
- Monitor specified pre and post weld heat treatment
- Monitor the physical examination including non-destructive test, hydrostatic test, mechanical test
- Based on the requirement, the inspector may choose to send test samples to the TCR Engineering Services' material testing laboratory
- Verify all necessary visual inspections are completed and all other necessary non-destructive examinations are executed as specified

Based on the requirements, the inspector may employ equipments to accelerate the process:

- Inspection mirrors
- Torch or other electrical lighting facilities (permitted by safety codes eg. 24V system etc.)
- Physical size measuring instruments such as welding gauge, rule, vernier etc.
- Electrical parameter measuring instruments such as ammeter, voltmeter etc.
- Temperature measuring instruments (thermometer)/ aids (thermo chalk)

Advantage TCR

All TCR welding inspectors are certified in accordance with the requirements of one or more of the following schemes:

- Certification Scheme for Weld Inspection Personnel (CSWIP)
- ASNT Level II VT
- American Welding Society (AWS)
- British Gas (BGAS ERS)
- Section IX,API Standard 1104
- ASME B&PV Code
- ANSI / AWS D1.1

F. CIVIL TESTING

TCR Engineering provides superior end-to-end solutions for civil testing across all elements and parameters of a building structure.

1. Structural Audit Services
2. Soil Testing Services
3. Concrete Services
4. Concrete Mix Design
5. Bitumen Testing Services
6. Tiles Testing Services
7. Ceramic Testing Services
8. Brick Testing Services
9. Cement Testing Services
10. ToR Steel Testing Services
11. Mortar Testing Services

TCR ENGINEERING

1 Structural Audit Services

A structural audit entails evaluating the overall health and performance while ensuring that the building and its premises are safe and are at no risk. A structural audit is done by an experienced and licensed structural consultant who analyses and suggests appropriate repairs and retrofitting measures required for the buildings to perform better in its service life. TCR Engineering has recently undertaken various structural audit services for both residential and commercial buildings including Vikas Complex in Thane West, KC College in Thane and Essential Power Transmission in Andheri.

As per clause No.77 of revised Bye-Laws of Cooperative Housing Societies: The Society shall cause the 'Structural Audit' of the building as follows:

1. For building aging between 15 to 30 years once in 5 years
2. For building aging above 30 years Once in 3 years

Purpose of Structural Audit

- To save human life and buildings and warn against any potential threats or failures
- To understand the condition and health of a building and to project the expected future life
- To find critical areas that need to be attended or repaired with immediate effect
- To comply with statutory requirements of municipal authorities
- To proactively assist the residents and the society to understand the seriousness of the problems and the urgency required to attend to the same
- To enhance the life cycle of a building by suggesting preventive and corrective measures like repairs and retrofitting

Users

- For insurance
- For bank mortgage
- For valuation
- For structures that shows distress
- For damage assessment due to earthquake, fire, blast, vibration, corrosion etc.
- For proposing additions, alterations and/or extensions in building / structure

Process

Part A – Visual Inspection

- Visual inspections of individual building / structures from inside and outside and to study present status of different structural members
- Study of Architectural / RCC / Structural drawings (If available)
- Photographic Survey

- Capturing multiple details including:

1. Load transfer system,
2. Structural framing system,
3. Structural deficiencies,
4. Settlement if any,
5. Cracks in RCC members,
6. Cracks in masonry / plaster
7. Leakages,
8. Loads on structure,
9. Defects in non-structural elements etc.

- Identification of broad areas / locations in the structure requiring further detail investigation and for conducting various Non-Destructive Tests

Part B – Non Destructive Evaluation

- In addition to visual inspection, the real strength and quality of a concrete structure need to be checked with non-destructive tests.
- A number of non-destructive tests (NDT) for concrete members are available to determine present strength and quality of concrete
- To Conduct Non-Destructive tests as required in detail visual inspection

Part C – Repair & Rehabilitation Consultancy

For preparation of detailed report for range of visual inspection & ND tests

- For Interpretation of ND test results
- For Diagnosis & Root cause analysis of the problems / observations
- For preparation of Repair & Rehabilitation scheme to make structure durable, healthy and to stand for a long life
- For preparation of technical specifications & draft tender document for repair and rehabilitation
- For preparation of cost estimates for the same
- For scrutinizing the tender documents
- For periodic inspection of work
- For issuing Structural Stability Certification after completion of entire job

2 Soil Testing Services

Soil is formed by the combination of rock, organic matter and pieces of minerals, air, and water. It is considered to be the skin of the earth's crust. The quality of soil varies depending on its composition, strength, and type. Poor quality of the soil is one of the critical issues faced by builders. Before starting any construction on land, it should be ascertained that the land is suitable for the planned infrastructure and the soil can bear the load of the proposed building, roads, etc. Problems and errors can be greatly avoided by conducting a study on soil and site characteristics.

The quality of the soil is judged by analyzing those properties which limit a planned use. Various soil and site factors need to be determined in order to check the limitations before constructing a building or a structure. Some of these include: Surface texture, Permeability, Water table, Erosion hazard and Depth of soil and bedrock

TESTS CONDUCTED:

CR Engineering provides world class services for soil testing in the laboratory as well as on site. Some of the tests conducted routinely are:

CBR In situ
CBR Laboratory, Soaked Single Point
Chloride Content
Electrical Resistivity
Linear Shrinkage
Modified Procter Compaction Test
Organic Matter Content
Particle Size Distribution by Hygrometer, Sieve Analysis and Hygrometer

3 Concrete Testing Services

Concrete is a construction material that is composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement aggregate (generally a coarse aggregate that has gravel, limestone, or granite, plus a fine aggregate such as sand), water, and chemical admixtures. There are various methodologies for concrete testing to ensure that it maintains adequate strength and durability. If major repairs are to be executed in the concrete structure, it is often useful to check the bond strength of the material used in the concrete structure.

Mechanical and physical testing is performed on hardened concrete to determine values such as electrical conductance, the compressive strength of a concrete core, cube or cylinder and classify its durability. Mixing design trials are also carried out to ensure the concrete will exhibit values that are within the normal ranges.

TESTS CONDUCTED:

TCR Engineering provides a wide range of concrete testing services that are conducted both, in the lab and on site. Some of the tests include:

Chloride Content, Permeability and Ponding
Core Compressive Strength
Coring: 10cm and 15cm diameter
Cube Compressive Strength
Depth of Carbonation
Drying Shrinkage/ wetting Expansion
Flexural Strength
Hammer Sounding
Porosity
Rebound Hammer Survey
Sulphate Content
Ultrasonic Survey
Water Absorption and penetration

4 Concrete Mix Design

Concrete Mix Design is a method of selecting suitable ingredients for concrete and analyzing their relative quantities for the production of concrete. The produced concrete should be made as economically as possible with minimum properties, significant workability, durability, and strength. An accurate determination of mix proportions by using computer data is usually not possible as the materials used are essentially variable and their properties are not assessable quantitatively.

Concrete Mix is an extremely flexible building material which can be exclusively designed for strength and it may range from M10 to M100. A mix selection needs appropriate knowledge of concrete properties as well as experimental data especially for the person who is conducting the mix design. The objective of preparing a design mix is to achieve good quality concrete in the most economical way. Good quality concrete is dense, homogeneous and imparts better strength and durability. dense and homogeneous concrete

TESTS CONDUCTED

TCR Engineering offers a range of concrete mix design testing services that are conducted both in the laboratory as well as on site. Some of the routine tests are:

Abrasion resistance
Abrasion value
Accelerated cube strength
Air content & alkali content
Bleeding test
Block density
Bridge load test
Compressive strength
Core cutting
Permeability test
Rapid Chloride Penetration Test (RCPT)

5 Bitumen Testing Services

Bitumen is a mixture of organic liquids that are highly viscous, black, sticky, entirely soluble in carbon disulfide, and composed primarily of highly condensed polycyclic aromatic hydrocarbons. It is principally obtained as a residual product in petroleum refineries after higher tractions like gas, petrol, kerosene and diesel, etc., are removed generally by distillation from suitable crude oil.

Indian standard institutions define Bitumen as a black or dark brown non-crystalline soil or viscous material having adhesive properties derived from petroleum crude either by natural or by refinery processes

TESTS CONDUCTED

A range of bitumen testing services is available both on-site and in the laboratory at TCR Engineering Services. Some of the tests TCR routinely conducts are:

Bitumen Content
Bitumen Penetration
Flash Point
Specific Gravity
Softening Point
Paraffin Wax
Loss on Heating
Water Content
Ductility Test
Bitumen Emulsion

6 Tiles Testing Services

Tiles are the construction materials or the Tiles are manufactured pieces of materials like stone, ceramics, glass or metals and are considered construction materials. Their major application is for usage in floors, roofs, walls, tabletops and other similar objects. Tiles are categorized on the basis of the applied manufacturing process and are classified as per their water absorption level.

TCR Engineering is proficient in evaluating the performance of glass tiles, acid resistant tiles, ceramic tiles, stones, marbles, slates, limestone along with their respective installations. TCR provides testing facilities for all types of tiles as per various National and International Standards. Standards.

TESTS CONDUCTED

TCR tests tiles on many parameters and some of them include:

Dimension
Flexural strength
Surface quality
Breaking strength
Abrasion resistance
Compressive strength
Impact resistance
Thermal expansion
Chemical resistance
Bulk density
Staining resistance materials

7 Ceramic Testing Services

Ceramic materials possess a combination of properties which make them unique and suitable for high-performance applications. Most ceramic materials are metallic oxides like zirconium oxide and aluminum oxide. Metallic carbides are one of the most important classes of ceramics.

TCR Engineering offers a complete range of testing services for all the construction materials including the raw materials and final products as well as quality control services according to the National & International Standards.

TESTS CONDUCTED

Ceramic material testing done at TCR Engineering includes:

Refractories & Allied materials
White wares which includes table wares, tiles, cook wares and sanitary ware
Structural including bricks, pipes and tiles
Engineering ceramics

8 Brick Testing Services

Bricks are categorized as the building blocks of any structural building. Thus, the quality of each and every brick has to be top notch to avoid any serious damage to the building. A brick is a single unit made from clay bearing soil, lime, and sand or it may also be made up of concrete material. Bricks are named depending upon their composition such as Burnt clay bricks, Concrete bricks, Sand lime bricks, Fly ash, Clay bricks and Fire clay brick

TESTS CONDUCTED

To analyze the quality of bricks, TCR performs several tests that include:

Apparent Porosity and Density
Cold Crushing Strength
Permanent Linear Change (PLC)
Abrasion Resistance
Creep Test
Refractoriness under load (RUL)
Modulus of Rapture
Compressive Test
Water Absorption Test

9 Cement Testing Services

Cement testing is performed to determine if there is alteration/loss of material when in its solid state. Methods of testing include subjecting it to a high temperature to determine loss of material, compressive strength, hand fineness among other factors to ensure that they meet the relevant international standards.

TESTS CONDUCTED

TCR Engineering offers testing services for cement inclusive of:

Chemical analysis
Compressive strength
Fineness
Heat of Hydration
Loss On Ignition
Physical Analysis
Setting Time
Soundness

10 ToR Steel Testing Services

TOR steel is one of the best grades of steel that is used in reinforced concrete and is a high adherence steel. Other types of steel are used for less resistant concrete. Thermo-mechanically Treated (TMT) bars are a type of corrosion resistant steel reinforcing bar used in concrete construction.

TESTS CONDUCTED

TCR Engineering provides world class services for ToR Steel testing in lab as well as on site. Some of the routine tests are:

Bend Test
Chemical Analysis
Elongation
Ultimate Tensile Strength
0.2% Proof / Yield stress
Mass per meter run
Rebend Test Soundness

11 Mortar Testing Services

Mortar is a mixture of lime or cement or a combination of both with water and sand. It is a paste used to bind together building blocks like stones, bricks, etc. It fills the irregular gaps between the blocks and seals them completely. Mortar is also used to add patterns or colors in the masonry walls. Cement mortar is composed of sand and aggregates of water and is used as a building compound. Water is used to hydrate the cement and hold the mixture together. It also finds application in creating smooth surfaces on walls made up of bricks and another masonry.

Mortar when mixed is a much thicker substance than concrete and this makes it ideal to act as glue for building materials. It hardens into a stone-like mass and distributes the load evenly over the bonding surfaces providing tight joints.

TESTS CONDUCTED

Few of the routine tests conducted at TCR Engineering for mortar testing include:

In Situ Metallography
Reduced wastage
Accurate content of cement
Consistent strength and quality
Enhanced health and safety on site
Reduced mixing and labour costs

Advantage TCR

Our in-house structural audit teams have carried out several evaluation engagements. The TCR advantage includes:

Decades of Experience: TCR Engineering has expertise built over two decades and has partnered with several developers to undertake testing, inspection and auditing services

Registered Service Provider: Registered and certified by various municipal corporations, TCR has been providing services across Government and private sectors

In-house Capability: TCR is a knowledgeable and customer oriented service provider with a full-fledged set up to undertake all types of structural audit activities

Cost Estimates: With TCR's expertise, structural irregularities are identified with ease and this mitigates the cost impact resulting from the deterioration of the building.

II. NON-DESTRUCTIVE TESTING SERVICES

NDT Testing is an essential requirement for all the industrial verticals ranging from manufacturing, automobiles, oil and gas, refining to the power industry, etc. In addition to conventional NDT Testing services, TCR Engineering provides advanced NDT Testing services like ToFD/PAUT, Videoscopy, Eddy current testing, Helium leak testing, Acoustic eye for tube inspection, UCI hardness testing and in-situ metallography.

Core Service Offerings

CONVENTIONAL NDT
- In-Situ Metallography
- Positive Material Identification (PMI)
- Ultrasonic Inspection
- Leak Testing
- Liquid Penetrant Examination
- Magnetic Particle Testing
- Dye Penetrant
- Paint and Coating Thickness
- Certified Weld Inspectors
- Visual Inspection Services
- Portable Hardness
- Radiography Inspection

ADVANCED NDT TESTING
- Thermography
- Alternating Current Field Measurement
- ASNT Level III consultancy in India

TUBE INSPECTION
- Eddy Current Testing
- Acoustic Eye

HIGH TEMPERATURE INSPECTION

BOILER INSPECTION
- Electro-Magnetic Acoustic Transmission (EMAT)
- Automated Reformer Tube Inspection System (ARTIS)
- Internal Oxide Scale Boiler Measurement

PIPELINES AND WELD INSPECTION
- ToFD and Phased Array
- Long Range Guided Wave Ultrasonic Testing (LRGWUT)
- Post Weld Heat Treatment

STORAGE TANKS AND STATIC EQUIPPMENT INSPECTION
- Helium Leak Testing
- Robotic Inspection Of Tanks

A. CONVENTIONAL NDT SERVICES

i. In-Situ Metallography
ii. Positive Material Identification (PMI)
iii. Ultrasonic Inspection
iv. Leak Testing
v. Liquid Penetrant Examination
vi. Magnetic Particle Testing
vii. Dye Penetrant
viii. Paint and Coating Thickness
ix. Certified Weld Inspectors
x. Visual Inspection Services
xi. Portable Hardness
xii. Radiography Inspection

TCR ENGINEERING

i. In-Situ Metallography

TCR Engineering under the NDT service performs In-Situ Metallography to determine in-service degradation of critical components of process and plants operating under high temperature, high-pressure and corrosive atmospheres. The technique enables real-time component condition monitoring and health assessments. TCR's metallurgists have strong experience in the interpretation of microstructures and have more than 15,000 replica microstructure interpretations, logged and captured in its proprietary database. These databases contain extensive information from various plants, captured over the course of four decades of service. The database also includes rare collections of varying microstructure damage levels from various industries such as power, oil and gas, petrochemical, fertilizers among others.

The In-Situ Metallography team at TCR is highly skilled in the art of replica preparation. TCR has custom-developed special purpose in-situ polishing devices that assist in metallographic polishing under 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 the following areas:

- To undertake microstructure survey for critical components viz., Boilers, Pipelines, Reactors and Vessels for condition monitoring/health assessment
- To provide suggestions about their welding used components of process plants
- To check the quality of the microstructure of components for intended service, before putting it into use
- To find out in-service degradation of critical components of the process plants operating under high temperature/high pressure/ corrosive atmosphere
- To conduct damage Assessment of fire-affected equipment of the plants
- To develop a data bank of critical components of process plant equipment by periodical monitoring for preventive maintenance and planning for inventory control

TCR also provides microstructure survey for critical components viz., Boilers, Pipelines, Reactors and Vessels for monitoring and health assessments. TCR has developed a data bank of critical components of process plant equipment by periodical monitoring for preventive maintenance and planning for inventory control. With this, TCR can provide suggestions on repair and welding of used components of process plants.

In-situ Metallography and replication is used for microstructural analysis while examining large components that cannot be easily moved or destructive sample preparation is difficult or not permissible. The testing allows quick on-site evaluation of a component's metallurgical and heat treatment condition and assists investigators while carrying out a remaining life assessment study or a failure analysis project.

Core capabilities for Metallurgical Replica Interpretation

TCR Engineering Services, India adheres to the guidelines presented in ASTM E 1351 (Standard Practice for Production and Evaluation of Field Metallographic Replicas). Replicas for TCR team analysis are developed with or without gold sputtering. Using the replication methods, experts at TCR can verify microstructures of a given component.

At material testing laboratories in Mumbai and Baroda, India, TCR has a state-of-the-art Inverted Metallurgical Microscope, GX51, from Olympus Corporation, Japan. This Inverted Metallurgical Microscope allows expert metallurgists at TCR to perform Volume Fraction Measurement by point count method as per E-562 used for Duplex Steel and Carbide Morphology Distribution as per STAHL-EISEN-PRUFBLATT 1520 (SEP-1520) German chart for checking microstructure.

TCR Engineering Services has undertaken In-situ Metallography projects at major plants of reputed clients including, Alstom Projects India Limited, Vadodara (Worked on more than 20 RLA projects), BARC (Mumbai), Heavy Water Board (Mumbai), BARC, Reliance Industries Limited (Jamnagar and Hazira), SPIC-SMO, Gujarat Electricity Board, Ahmedabad Electricity Board, GSFC Limited, GNFC Limited, IOCL (Vadodara), L & T, Hindustan Lever Limited (9 Boiler RLA Work), Narmada Chematur Petrochemicals Limited, Bharuch and many more. TCR performs Metallurgical Replica Interpretation for NDT Corrosion Control Services (NDT-CCS) in Saudi Arabia as well.

EQUIPMENTS

At TCR, the 5 following sets of In-Situ Metallography kits and equipment are available:

- Insipol 2000 and advanced electrolytic flow type polisher and etcher

Portable rough grinder with self-adhesive papers

- Portable fine polishing (mini grinder)

- Portable microscope capable up to 400X magnification

- Replica kit: Used with specialized plastic based slides for replica preservation (for longer durability and ease of handling on site)

KEY INFORMATION FOR REPLICATION INTERPRETATION

- Objective of In-situ Metallography - Condition assessment, fire/damage assessment, remaining life assessment, or baseline data generation
- Material of construction with exact specification
- Location of replication with sketch
- Process parameters and design parameters
- Service life of the component at the time of replication
- Any history of previous failures at the location of replication

ii. Positive Material Identification (PMI)

The PMI division at TCR Engineering Services has an expert engineering and inspection workforce to undertake incoming material inspection and can provide on-site alloy verification for quality control and stock control purposes. TCR can analyze both melt and weld for comprehensive maintenance assessment.

TCR provides PMI services to a number of metal producers, foundries, metal fabricators, scrap yards, scrap traders in the industry, electric utility companies, fossil and nuclear power plants, refining and petrochemical industry, construction engineering, and the Chemical process industry.

The range of equipment available at TCR for undertaking Positive Material Identification (PMI) is unparalleled in India. TCR's on-site inspection and the testing team have over 12 highly sophisticated Portable Alloy Analyzer Spectrometers which can in-situ non-destructively and accurately measure the chemical composition of materials. Using these spectrometers, TCR's engineers can provide elemental identification and quantitative determination regardless of form, size, and shape. . No samples need to be cut for PMI. TCR can also deploy the portable optical emission spectrometer that can detect C, S, P, Mn and Si. Elements that can be identified using PMI include Ti, V, Cr, Mn, Co, Fe, Cu, Zn, Ni, Se, Nb, and Mo.

The team also conducts positive material identification test to detect Carbon composition on-site using the ARC Met 8000, a portable optical emission spectrometer. The portable optical emission analyzer is designed to identify all the key elements in metals, especially where highest accuracy, analysis of light elements (like C, Al, S, P, Mg, Si) or sorting of low alloys and aluminum is needed. For example, it is ideal for separation of 316 H (>0.04% C) and 316 L (<0.03% C).

Using portable XRF analyzers, TCR offers scrap traders in India all the necessary data needed to take fast, informed decisions about material purchases along with the input and speed required to sort large quantities of materials, and hence utilize sales opportunities efficiently. Inspection services team of TCR supports the recycle and resell scrap traders in enhancing their profit margins by measuring precious metals in electronics - Pt, Ir, Ru, Rh, Pd. TCR also supports a scrap trader to perform scrap classification service efficiently. From titanium alloys to stainless steels to nickel superalloys to red metals to exotics, TCR can quickly provide fast, reliable results that the industry demands.

TCR's Positive Material Identification service is fast becoming an integral part of the safety management process in petroleum refining, petrochemical, and electric power generation industries. TCR has provided PMI services to over 700 projects including major oil and petrochemical installations in India, Hong Kong, China, Singapore, Malaysia, Indonesia, Russia, Dubai, Kuwait, Saudi Arabia and other parts of Middle East in addition to serving North America and significant parts of Europe. Some PMI projects were undertaken in conjunction with the third-party inspection of EIL, Lloyds, KTI, TUV, DNV & BARC.

EQUIPMENTS
A wide range of alloys can be analyzed on site using PMI including:

1. Carbon and low alloy steels
2. Copper Alloys
3. Stainless and High Alloy Steels
4. Aluminum Alloys
5. Nickel Alloys
6. Austenitics Duplex and Super
7. Titanium Alloys
8. Zirconium Alloys

TCR Engineering's PMI equipment includes

Portable X-Ray Florescence (XRF) based Instruments:
1. XMet 3000TX (2 Nos.) from Metorex, Finland
2. Niton XLt (2 Nos.) from Niton Corporation, Finland
3. XMet 53000TX and 3000T from Metorex, Finland
4. Innov-X Alpha Analyzer from Innov-X Systems, Netherlands
5. Metal Master 2000 (3 Nos.) from Metorex, Finland

Portable Optical Emission Spectrometer (OES) Instrument:
1. ARC-MET 8000 MobileLab

iii. Ultrasonic Inspection

Ultrasonic methods of NDT employs the use of beams of sound waves (vibrations) of short wavelength and high frequency that is transmitted from a probe and detected by the same or other probes. Usually, pulsed beams of ultrasound are used and in the simplest instruments a single, handheld probe is placed on the specimen surface.

An oscilloscope display with a time base shows the time it takes for an ultrasonic pulse to travel to a reflector (a flaw, the back surface or other free surfaces) in terms of distance traveled across the oscilloscope screen. The height of the reflected pulse is related to the flaw size as seen from the transmitter probe. The relationship of flaw size, distance and reflectivity are complex, and a considerable skill is required to interpret the display.

At TCR, complex multi-probe systems are also used with mechanical probe movement and digitization of signals, followed by computer interpretation.

Ultrasonic examinations are performed for the detection and sizing of internal defects, flaws or discontinuities in piping, castings, forgings, weldments or other components. Exact sizing techniques have been developed to detect and monitor progressive cracking in a variety of equipment.

TCR has in-house capability to undertake Automated UT using Time of Flight Diffraction technique (ToFD) in India as per code case 181 for piping, code case 2235 for pressure vessels and API 650 appendix U for storage tanks.

iv. Leak Testing

Helium Leak testing in India is performed to detect and locate leaks in pressure containment parts and structures. This includes welded, brazed, adhesion-bonded and other assemblies

v. Liquid Penetrant Examination

Various liquid penetrant examination methods are utilized to detect open or surface cracks or defects in materials. Red dye or fluorescent penetrants, as well as various types of wet and dry developers, are utilized under this method of examination by TCR

vi. Magnetic Particle Testing

The Magnetic Particle Inspection method of Non-Destructive testing is a used by TCR for locating surface and subsurface discontinuities in ferromagnetic material. Depending on its operation on the face when the material or part under test is magnetized, discontinuities that lie in a direction generally transverse to the direction of the magnetic field. This causes a leakage field, and therefore, the presence of the discontinuity is detected by using finely divided ferromagnetic particles applied over the surface, some of these particles being gathered and held by the leakage field. This magnetically held collection of particles forms an outline of the discontinuity and indicates its location, size, shape and extent.

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vii. Dye Penetrant

With the dye penetrant method, a penetrating liquid is applied to the surface of the component in order to enter the discontinuity or crack. Subsequently, after clearing the excess penetrant from the surface, the penetrant that exudes or is drawn back out of the crack is observed.

Liquid penetrant testing is applied to any non-porous clean material, metallic or non-metallic, but is unsuitable for dirty or very rough surfaces. Penetrants can contain a dye to make the indication visible under white light, or a fluorescent material that fluoresces under the suitable ultra-violet light. Fluorescent penetrants are usually used when maximum flaw sensitivity is required.

TCR can detect cracks as narrow as 150 nanometers using this method.

viii. Paint and Coating Thickness

TCR undertakes inspection of paint and/or coating, applied to metal surfaces. The paint and coating inspection team at TCR is fully equipped and has at its disposal, Wet paint thickness gauge(s), Dry paint film thickness gauge(s), Holiday detector(s), Hygrometer with Dew Point calculator and Metal surface thermometer.

The expert paint and coating inspectors at TCR are responsible for monitoring and verifying to ensure that all the work inspected comprehensively conforms with the requirements of the relevant code, specification and/or standard with respect to the paint/coating procedure, the physical application as well as the physical examination, including testing.

Senior TCR paint inspectors are qualified BGas (British Gas Corporation) and are NACE certified. The inspectors are responsible for verifying the following requirements:

1. The blasting and coating materials
2. The blasting and coating equipment
3. The temperature and humidity
4. The surface condition
5. The application procedure(s)

TCR's expert inspectors are responsible for the preparation of precise, yet comprehensive records that include all critical aspects of:

- *Materials control and identification*
- *Climatic conditions and Surface condition*
- *Details of abrasive(s) and application procedure*
- *Abrasive/wire brush standard*
- *Details of coating and application procedure*
- *Equipment calibration*
- *Inspection results*

ix. Certified Weld Inspectors

TCR's team of Certified Welding Inspectors in India (CWI) can pinpoint exactly which testing is necessary to qualify a weld, weld procedure, or individual welders. Each welding code follows three main categories of Welding Qualification viz. Welding Procedure Specification (WPS), Welding Procedure Qualification Record (WPQR), and Welder Performance Qualification (WPQ)

x. Visual Inspection Services

At TCR, non-destructive visual inspections are performed on-site or at the laboratory facility based on the requirements of the client and as per their specifications. Industries utilizing this service include Fabrication, Construction, Automotive, Power Generation and Transportation. Inspections can be performed at the laboratory facility or on-site. These inspections are performed to meet IS, BS, ASTM, AWS, ASME (American Society for Mechanical Engineers) and many other standards

xi. Portable Hardness

As per ASTM E110, the testing is done by TCR for on-site applications as well as for very large samples. TCR's portable hardness unit performs the hardness testing by applying a 5 kg vickers load indenter and electronically converting the values to a preferred scale

xii. Radiography Inspection

PHYSICAL: TCR's state-of-the-art laser alignment devices, microprocessor controlled x-ray machines and automatic film processors, ensure high quality, rapid speed, and hence offer the most efficient radiographic services in the industry.

DIGITAL USING COMPUTER AIDED RADIOGRAPHIC TESTING (CART): TCR with its computer-aided generation of radiographic images, uses linear array detector systems in place of traditional film. The CART Industrial Inspection System works on the basis of differential densities. When a product passes through the conveyor system, a grey scale X-Ray image of the product is created. Different densities/thicknesses show up in the image as shades of grey. The image is captured from the data and displayed through the control panel monitors. It offers several Image enhancement controls including zoom, contrast, brightness, etc. Advanced Software Algorithms clearly and accurately highlights discontinuities in the image in order to qualify samples as per standards.

B. ADVANCED NDT SERVICES

i. Thermography

TCR uses these tests to find temperature anomalies present in the equipment during their TCR uses thermography tests to find temperature anomalies present in the equipment during their operation. This is based on remote viewing and is a non-contact method of testing. As a recent addition to the NDE, helicopters may be used for testing in large regions. Any hot object that emits heat radiation is captured with an infrared sensor, which picks up the 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 in applications such as deposits or blockages in pipelines carrying hot or cold fluids, refractory or insulation deterioration in furnaces, boilers, heaters, converters etc. It is also utilized with Electric sub-stations for control panels, transformers, switchgear etc. for overloading, loose or damaged contacts, Overheated bearings in rotary equipment, e.g. motors, generators, turbines, etc.

ii. Alternating Current Field Measurement

Alternating Current Field Measurement, also known as ACFM is a one-pass method to inspect welds and to locate and size surface breaking cracks. An electromagnetic field is induced into the surface being inspected. When the probe is passed over a surface breaking crack, the electromagnetic field is disturbed allowing detection of the anomaly. This field is measured using the proprietary software which allows crack depth and length measurements on a real-time basis. Probes of almost any configuration can be customized for nearly any application imaginable.

Digital Crack detection method covers:

- Sizes Cracks (Length & Depth) Applications
- Detects through Coatings, Paint & Scale
- No Recoating required
- No Metal Contact required
- More Precise than Conventional methods
- High-Temperature Applications

TCR performs ACFM in association with its international partner. This technique replaces conventional dye penetrants, magnetic particle testing and ultrasonic testing for size defects. Applications of ACFM includes:

- Structural Welds on Platforms
- Structural Welds on Drilling Rigs
- Pipeline Girth Welds and Supports
- Pressure Vessel System Welds
- Cooling Tower Welds
- Compressor Fin Surfaces and Threads
- Drill Collar Threads

iii. ASNT Level III Consultancy in India

TCR Engineering has a strong advanced NDT inspection team that currently maintain ASNT level 3 certifications in Eddy Current (ET), Ultrasonic Testing (UT), Magnetic Particle Testing (MT), Infrared Thermography (IR), Mass Spectroscopy Leak Testing (MSLT), Radiography (RT), Liquid Penetrant Testing (PT), Visual and Dimensional Evaluation (VT) methods. In addition to this, the team has the capability to undertake projects on Automated Ultrasonic using the Time of Flight Diffraction technique (ToFD). TCR experts are also certified in AWS/CSWIP 3.1 and 3.2 CSWIP Painting inspection.

All of TCR's ASNT Level III certificate holders have the skills and knowledge to establish techniques, to interpret codes, standards, and specifications, and to prepare or approve procedures/instructions.

All TCR's NDT inspectors are qualified to meet the requirements of the American Society for Nondestructive Testing Practice SNT-TC-1A as well as CP-189 guidelines. Each non-destructive examination is performed to the requirements of major Codes, including the ASME Boiler and Pressure Vessel Codes, the ASME/ANSI Codes for Pressure Piping, the American Petroleum Institute Codes, American Welding Society Standards and Aviation/Military specifications.

TCR's strengths in metallurgy combined with advanced NDT services is helping global companies like Shell, Reliance, Saudi Aramco, IOC and BPCL to achieve an increase in plant availability resulting in cost saving, minimizing shutdown time, change in inspection strategies and intervals and improved safety compliance. The TCR team is well versed in reliable assessment and calculation of risk profile of items in a plant based on its "active" and "potential" Damage Mechanisms ensuring that the resulting inspection interval for the item is reliably optimized in a safe and cost-effective manner.

C. TUBE INSPECTION

1 Eddy Current Testing

Eddy current testing is a rapid and accurate technique used to detect discontinuities in the tubing, heat exchangers, condensers, wires, plates, etc. TCR uses electromagnetic induction to detect flaws in conductive materials. Eddy current testing can detect very small cracks in or near the surface of the material. The surfaces need minimal preparation, and physically complex geometries can be investigated using this method. Eddy current testing is also performed for alloy separation, for the determination of treatment conditions, for making electrical conductivity and for measuring coating thickness. The location of repair welds, girth welds, and seam welds may also be detected on ground-machined surfaces.

TCR has an in-house team of Eddy Current Testing professionals with deep expertise in inspecting a number of tubing in heat exchangers. TCR's testing devices are portable, contact-less and provide immediate feedback.

2 Acoustic Eye

TCR Engineering Services engages in advanced NDT inspection of heat exchangers and boiler tubes by employing the latest Acoustic Eye tube inspection technology to discerning users for the safety and integrity of their process equipment. Acoustic Eye tube inspection is fast (10 seconds per tube, up to 2000 tubes inspection in one shift of 12 hours), non-invasive and provides inbuilt computerized signal analysis tools to quickly identify tube faults (e.g. pitting / wall loss, erosions, holes / leakage, blockage, bulging) in heat exchangers / condensers / boilers / chillers / reactor tubes.

Acoustic Eye's breakthrough, non-invasive solution for today's hard-to-inspect tubes up to 4" inner diameter enables ultra-fast, accurate inspection of boilers, Fin Fans, and other heat exchangers, regardless of the tube shape or the type of material.

USER BENEFITS:

1. Fast and accurate detection of tube faults and type, position/ location and size/extent of faults
2. Resultant time-saving in taking corrective actions on tubes with defects
3. Faster turn-around of equipment contributing to faster unit/plant startup

D. HIGH TEMPERATURE INSPECTION

High-temperature hydrogen attack (HTHA) is observed in steels exposed to a temperature of 200 °C or more. At such high temperature, atomic hydrogen diffuses in steel. This hydrogen reacts with carbon present in the steel and forms CH4. The methane so formed bubbles and forms voids at the grain boundary.

MC + 4H = M + CH4

These bubbles exert pressure and also coalesce resulting into fissures. The growth of voids and fissures weakens the metal, leading to a major crack. This reaction decarburizes the steel, produces micro cracks/fissures and lowers toughness of steel but not necessarily cause a loss in thickness.

Advantages
- Supports in inspection of large and wide areas
- Convenience with accessibility as only one side external access is required (opening of equipment or removal of catalyst is not required)
- Depth of attack can be estimated

Limitations
- Deep expertise required in interpretation
- Very initial micro level degradation (decarburization) cannot be estimated

HTHA relies on detecting the scattering of ultrasound energy

The technique detects the presence of fissures on the internal side of the low-alloy steel metal surface exposed to hydrogen at high temperature by scanning from the outside surface.

The extent of damage by HTHA can be assessed using the above techniques as well as other internal techniques such as WFMPI (Wet fluorescent magnetic particle inspection), in-situ metallography and hardness testing. Testing from both sides overcomes the limitations encountered while testing only from outside.

The procedure for testing is based on API 941 using different approaches like:
- Attenuation measurement
- Velocity measurement
- Spectral analysis
- Analyzing scattered signals
- Testing weld joints and HAZ using high-frequency shear wave ultrasound
- Advanced ultrasonic testing like Phased array and ToFD

E. BOILER INSPECTION

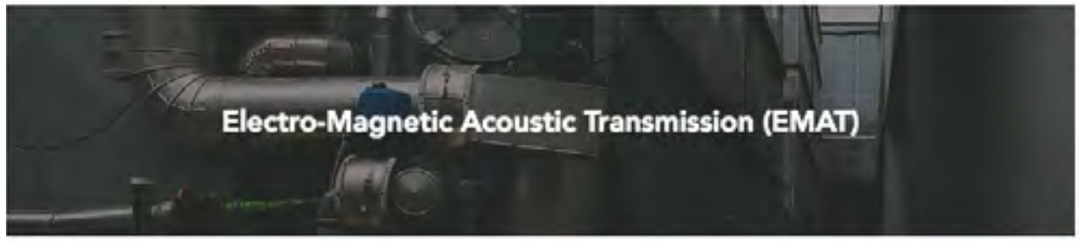
TCR Engineering Services is a Bureau of Indian Standards and NABL accredited laboratory. TCR Engineering is among the few organizations in India that have been recognized by Central Boilers Board as a “well-known Material Testing Laboratory as per Indian Boiler Regulations Act of 1950.


FORM XVI-B

(Regulation 4C (2))

Central Boilers Board

Certificate of Approval as Well Known Material Testing Laboratory



i. Electro-Magnetic Acoustic Transmission

Using EMAT technique with panametric probes, TCR can measure the high-temperature (up to 325° C) surface thickness. Above this temperature, the thickness readings become unstable, unreliable and non-repeatable.

The surface for thickness measurement needs to be fairly smooth, free from rust, scale or any other kind of deposits. To get a clean surface for thickness survey, a metallic file, wire brush, small chisel and emery paper can be used for cleaning. Hammering is strictly not advisable for removal of scale/deposits. In case the above method does not yield the desired cleaning, then mechanical cleaning by power brush should be used. Under exceptional circumstances, grinding is used as a method for cleaning, with prior permission from the inspection engineer.

Thickness can be measured on painted surfaces, provided the surface paint is visible without any blisters. For critical measurement where the corrosion rate calculations are important from the remaining life point of view, paint removal is done before doing thickness survey.

Thickness measurement across different mediums

1

PIPING

For all on-site piping, corrosion loops are the basis for carrying out thickness survey whereas, for offsite and tank farm piping, special loops are made for thickness monitoring:

1. Each corrosion loop (for on-site piping) have a combined isometric where Thickness Management Locations (TML) are serially marked
2. If any base readings are taken before commissioning, it is done with random values measured on the components
3. Routine, on stream or shutdown thickness measurement at these locations, is done in the form of a scanning. The scanning format is in a grid of size 1.5" x 1.5", with each component marked with chalk before thickness scanning
4. Out of all the locations, few TMLs are identified for regular scanning. The selected TMLs are identified by the inspection engineer, based on the probability of corrosion at these locations (as compared to other locations in the loop) and accessibility considerations.
5. Respective maintenance departments provide access to ladders, scaffolding or portable trolleys for thickness scanning. In case corrosion is observed in these TMLs, then other TMLs in the loop are included for thickness scanning

2

HOT TAP LOCATIONS

In case of thickness survey of equipment and piping for hot tap locations, following steps are undertaken:

- The maintenance team marks the location of the new nozzle as per the exact type and dimensions of the component to be welded on the parent pipe
- The Inspection engineer verifies the type of component to be welded viz. weldolet, pipe of pipe connection, a nozzle with reinforcement pad, split sleeve nozzle etc. The Inspection engineer marks the centerline of the proposed weld joint: A width of 1.5" to 2" shall be marked on either side of the proposed weld centerline. A close thickness survey is undertaken along the centerline and on either side and the minimum thickness measured is reported in the hot tap file.

If the thickness measurement is comparable to nominal or previously measured values (if available at the same locations or at different locations in the same pipe), then it could be assumed that there is no corrosion at the location.

If the thickness measurement indicates severe corrosion, and thickness measured is very close to the minimum allowable for hot tapping, then hot tapping should be avoided at the location, as it will be difficult to pick up a thickness point with minimum thickness through this procedure.

Minimum thickness required for hot tapping is 4.8mm. If the pipe is corroded and actual thickness is in the range of 6 – 8mm, then alternate methods should be used to check the pipe thickness and certify the same fit for the hot tap.

3

THICKNESS LOCATION IN TANKS

- In case of storage tanks, the thickness is measured from outside first, followed by shell course from the bottom

- In all the other shell courses, the thickness is measured along the staircases. Few thickness points are taken near the weld and few at the center of the shell course plate

- In case of roof plates, the thickness is measured on each plate, with two thickness points at the center of each plate and one thickness point at the corner of each plate

- In case of bottom plates, thickness measurement is possible only during an internal inspection. Under this, the thickness is measured on each plate, with two thickness points at the center of each plate and one thickness point at the corner of each plate.

Recording of Thickness Measured

The thickness is measured and recorded by TCR in a standard format that includes the following details:

- Plant
- Tag Number of equipment/pipeline or appropriate description (in case tag number does not exist for the component/job)
- Date of measurement
- Sl. No Meter used for thickness measurement
- Details of the meter used for thickness measurement like frequency etc.
- Identification number of the standard block used for calibration of the meter before starting the job
- Nominal thickness of the component being checked for thickness
- Name of the technician measuring the thickness

In case of piping where spot readings have been measured at Thickness Management Locations (TML), against each TML number, measured readings are filled in.

In case of equipment, a development drawing of the equipment needs to be submitted showing an approximate location of thickness measurements. The thickness may be entered on the sketch itself. Alternately the TMLs can be marked on the sketch and the corresponding thickness values for each TML submitted separately.

In case of close scanning of a location in equipment or a pipe, the readings can be submitted as a grid. The grid will have the orientation (N/S/E/W) with possible reference from a nearby nozzle, weld etc. The grid identification at the site is required in order to check the thickness at the same location and compare the same for corrosion if any. The grid size shall be clearly mentioned in the sketch.

Thickness Values More Than Previous Readings

It is also not unusual to record thickness values more than the previously measured readings at the same locations or in the same grid. This is done considering the inherent limitations of the thickness measurement technique. Some of the factors that contribute to the increase in thickness could be:

- Inability to put the probe exactly at the same location. Even If the probe is kept only a couple of millimeters away from the previous location, there could be a different and probably a higher reading
- Corroded surface profile on the inside surface of the component, from where the sound waves are reflected back
- Surface preparation prior to the thickness survey

The inherent accuracy of the thickness meter is +/- 0.1mm. Hence a thickness value that is 0.2–0.3mm more than the previously measured value is considered to be acceptable.

A measured thickness value more than the above-mentioned limits needs to be re-checked again especially in a grid scanning exercise. Based on the repeat thickness survey, the report can be verified and corrected if required. The following steps are undertaken for verification of the readings:

1. Checking for instrument calibration using a step wedge and a standard block of thickness close to the thickness range being measured
2. Checking of the thickness measured with another meter and probe at the same location
3. Checking of the surface preparation before taking readings

ii. Automated Reformer Tube Inspection System (ARTIS)

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

Few of the key advantages of using ARTiS:

The method follows a similar technique of manual ultrasound coupling making it an industry-wide proven technique of inspection

A macro-level view of the overall tube condition in the reformer is also reported, emphasizing troublesome areas/corner of the 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 for scaffolding, saves total tube inspection time and helps to achieve reduction in shutdown time of the plant

Automation deploys limited water source for coupling and nearly eliminates the need for overhead water drum arrangement, which overcomes additional issues related to drum filling, vacuum water clogging, etc.

iii. Internal Oxide Scale Boiler Measurement

The very high temperatures found inside steam boilers (in excess of 1000 degree fahrenheit or 500 degree centigrade) can cause the formation of a brittle iron oxide called magnetite on the inside and outside surfaces of steel boiler tubing.

Steam side: Water vapor will react with the Iron in the steel to form magnetite and hydrogen according to the formula: 3 Fe + 4 H20 = Fe3O4 + 4 H2

Fire Side: Flue gases react with the Iron in steel to form Magnetite and Sulfides (External Scale). Oxygen diffuses into the steel and Iron diffuses out of the steel to and combines to form magnetite

The thickness of Oxide helps predict tube life as the internal oxide scale builds above .013"(0.33mm) it impedes the heat transfer between the tube metal and the steam. Transducers:
- M2091 Normal Incident Shear 20 MHz (0.006" In. or 0.15 mm Min Internal Oxide): Measures and displays Oxide and tube thickness at the same time.

F. PIPELINES AND WELD INSPECTION

i. Time of Flight Diffraction (TOFD) and Phased Array

Time-of-flight diffraction (ToFD) technique is an ultrasonic NDT technique, which relies on the diffraction of ultrasonic energies from 'corners' and 'ends' of internal structures (primarily defects) from the component being tested. Using ToFD, the expert NDT team members at TCR provides amplitude-independent accurate flaw sizing on a wide coverage area. ToFD being an advanced and automated weld examination technique, it assists in Fitness For Purpose (FFP) inspections as well.

ToFD is a fast and effective method of scanning a wide weld area in a very limited time period. While ToFD is a very powerful and efficient technique, it suffers from limited coverage resulting from two dead inspection zones:

- The first dead zone: Near the surface, as a result of the lateral wave
- The second dead zone: At the back-wall, resulting from the width of the back-wall reflection.

By combining the use of ToFD and conventional pulse-echo methods, dead zones in proximity to the front and back surfaces can be improved substantially. TCR Engineering offers services of creating ToFD scan plans and procedures in India. This technique has many advantages including:

Wide coverage area using a pair of transducers

Accurate flaw sizing; amplitude-independent, Sizing technique using time-of-flight information

One-line volume inspection, provides highly efficient scanning

Setup is independent of weld configuration

Highly sensitive to all kinds of defects with no sensitivity to defect orientation

Amplitude-insensitive, acoustical coupling less critical

ToFD is a quick and accurate tool for flaw sizing

Phased Array technology (using a TCG or DAC) and flaw location indicators with experienced analysts is also recommended. The team has done a number of noteworthy ToFD projects:

- 100% weld inspection of Storage Tanks at Kuwait as per API 650 appendix U
- Random inspection of pipelines in Rabigh, Saudi Arabia as per ASME Code Case 181
- Pressure Vessel inspection in India as per ASME Code Case 2235-9

ASME Boiler and Pressure Vessel Standard Section VIII Code Case 2235-9 states that it is acceptable to use the ToFD for Ultrasonic examination in accordance with ASME Section V, Article 4. ASME Code Case 2235-9 mentions replacing RT with UT and has resulted in incorporating ToFD into pressure vessel work for both detection and sizing of flaws. This now allows ToFD to be used on all Section VIII pressure vessels. ToFD is perfectly acceptable to use as per Code Case 181 and Code Case 179 of ASME B 31.3 for piping products.

API 579 in its current draft form states the Recommended Practice for Fitness-for-Service (crack depth, length, angle and distance to other surfaces) where breaking or embedded cracks are determined using UT examination techniques, either ToFD or angle beam.

Draft-API 580 states the Risk Based Inspection Recommended Practice (Base Resource Document recommends automated ultrasonic shear wave testing as a highly effective inspection technique for crack detection and sizing). The capability of the Automated UT technique/type is evaluated using the probability of detection (POD curves from round-robins in the past where ToFD showed the best performance)..

British Standards Institute's welding standards policy committee has created BS 7706 as a guide for calibration and setting-up of the Ultrasonic Time of Flight Diffraction (ToFD) technique for defect detection, location and sizing of flaws. Another well-documented guide is the PrEN 583-6.

TECHNOLOGY & EXPERTISE

The team at TCR with its decades of experience have extensive clues to the characterization of various types of flaws using ToFD with the exception of few instances where definitive conclusions are rare. In the case of Phased Array technology, an experienced analyst has a greater chance of determining flaw type based on the percentage of sound transmitted back to the probe.

TCR uses products from Olympus's OmniScan technology, which has capabilities to indicate to the operator the exact location of a flaw with respect to the weld centerline and bevel face. An experienced analyst from TCR is able to characterize fusion flaws based on location and amplitude response.

ii. Long Range Guided Wave Ultrasonic Testing (LRGWUT)

The Long Range Guided Wave Ultrasonic Technique (LRGWUT) is designed to inspect 100% of a pipe segment from one single location.

Torsional or longitudinal guided waves are induced into the pipe body and propagated along the entire pipe segment under inspection. When these guided waves identify an anomaly or a pipe feature, they convert into laminar waves and reflect back to the tools' original location. Using a laptop, these signals are digitally captured. The time-of-flight for each signature is calculated to determine its distance from the tool. The cross-sectional area is calculated by amplitude followed by estimating the circumferential extent by the focused beams (broken down into octants) to determine the significance of the defect.

TCR performs LRGWUT in association with its international partner. This partner meets and exceeds the PHMSA 18 points to examine casings and crossings. LRGWUT's primary application is in the Oil and Gas Refining, Petrochemical, Storage, Offshore and Pipeline Transportation industries among others. More specifically, the tests are used as part of ECDA and ICDA methodologies where access to piping systems are difficult such as:

- Insulated Pipe in Refineries
- Offshore Pipeline Risers
- Cased Road or Railway Crossings
- Loading Lines and associated Pipework
- Tank Dyke Pipeline Crossings
- Above Ground or Buried Flow Lines
- River or Bridge Pipeline Crossings

iii. Post Weld Heat Treatment (PWHT)

TCR Engineering Services offers a diverse range of Heat Treatment Services including pre-heating, post-heating; stress relieving (SR), intermediate SR, normalizing, solution annealing, water quenching, tempering, step cooling and drying of the refractory material. The experienced technicians at TCR are capable of performing heat treatment on weld joints, piping, regenerators, stripper columns, pressure vessels, boiler headers, modules, deck pipelines and structure, boiler heater tubes, and DOTHERM testing. The team is also capable of carrying out 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. It can design, fabricate, calibrate and run a customized electrical furnace for clients.

Post Weld Heat Treatment Services (PWHT) is performed after welding/ machining, to improve the chemical and mechanical properties of weldment / machined surfaces. TCR offers post-weld heat treatment by using electricity as the 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 TCR's heating processes can be applied on-site or at client's facility.

Stress Relieving: For steel fabrication, the most common procedure used is Stress Relieving where machining and/ or welding induces stress in parts. The bigger and more complex the part, higher is the amount of stress. Stress Relieving is done by uniformly heating the fabricated equipment, a vessel or a part of the vessel to a sufficiently high temperature, but below the lower transformation temperature range. It is then subjected to a thermal retardation for a sufficient time depending upon the material thickness and then finally cooled uniformly.

TCR has specialized fully-automatic programmable equipments capable of controlling Heating rate, Holding time and cooling rate as well as carrying out a wide range of heat treatment processes like post-weld heat treatment of PQR test coupons and various components. TCR has at its disposal, well-equipped tools including electrical furnace with 220 and 80 Volts panel, latest 12 point recorder with digital display, coil and pad-type heating element, oil firing systems and extremely skilled technicians. The Heat treatment equipment is supplied with a chart recorder to record up to 8 thermocouples simultaneously to meet the critical requirements of heat treatment.

Oil Firing on Pressure Vessels

TCR Engineering has a talented crew that uses diesel fuel as the source of heating for stress relieving of pressure vessels with the sole objective of reinforcing process, component integrity, and high quality. The heat treatment specialists from TCR have all the necessary experience and equipment to develop a custom configuration as per specific processes. Our heating processes include low-Range, Mid-Range & High-Range Temperature Heating.

The heat treatment operation is affected by the firing of the furnace, using one or more gas/oil high-velocity burners with a nominal rating of 1,500.000 Kcals/HR (6,000,000 Btu/HR) per burner. Each burner is armored flexible hosing to Combustion Air Fan (s), with a maximum output of 2800/Nm³ per hour via a 150mm diameter outlet, at a pressure of 700mm W.G, will connect each The burner. Burner is fitted with a (25/20) stainless steel outlet nozzle designed to clear the furnace wall adjacent to the intended opening(s) and in such a way as to eliminate the possibility of any direct impingement on components.

TCR's high-velocity burners enable excellent temperature distribution and uniformity at all times because of the intense scrubbing action. They are also able to construct temporary furnaces at client sites where internal firing is not a practical or cost-effective option.

G. STORAGE TANKS & STATIC EQUIPMENT INSPECTION

1 Helium Leak Testing

The Helium Leak Testing unit at TCR utilizes a proven mechanical vacuum pump technology designed specifically for heavy usage under harsh industrial environments. The helium stability of the rotary vane pump guarantees excellent stability of the helium signal. The low rotational speed of the M.D.P. (Molecular Drag Pump) at 27,000 RPM keeps this unit completely insulated against accidental air inrushes. Further, it allows the leak detector to be moved while in operation. The high compression ratio of the M.D.P. facilitates the gross leak test at a high pressure (7.5 Torr / 10mbar) which speeds up the leak test process of outgassing parts. The internal layout of the unit allows easy access to all the components. TCR's Helium Leak Testing instrument has a roughing capacity of 10 m^3/h (7 CFM) with usable helium sensitivity in the 10-11 atm.cc/s range. The unit has a dedicated sniffing unit, based on a well-proven leak-testing concept and is available for outboard leak testing applications as well.

TCR's services include vacuum leak testing for any type of vacuum vessel as well as system and pressure probe testing for systems that normally operate at or above ambient pressure. Virtually any system that has a requirement for leak tightness or that is suspected of causing a problem due to leakage can be tested by one of these methods of helium leak testing with a high degree of reliability.

Additionally, the unit offers evolved features to assist the operator with daily test operation:
- Auto-calibration, with built-in temperature compensated calibrated leak (dedicated to the sniffing mode)
- Automatic signal correction
-Vocal synthesizer
- Helium background suppression with "floating" zero to keep the signal from going negative and to increase sensitivity
- Audio alarm with variable pitch (up to 90 dBA)

TCR has performed several leak tests on-site for industries that include nuclear carriers, polymer plants, oil refineries, gas and steam turbine power plants in Kuwait, Kingdom of Saudi Arabia and India. TCR's technicians are highly mobile and perform helium leak testing on heat exchangers, steam turbines and condensers, distillation towers, buried pipelines and many other systems and components.

2 Robotic Inspection Of Tanks

This technique uses an automatic robotic crawler to enter into the tank for collecting data such as thickness, ultrasonic soundness etc. The process allows visual inspection by a video camera while the 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 200,000 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. One of the salient features of this technique is the elimination of the high cost of taking down your tanks. The testing can be completed as per API 653 inspection in a few days as opposed to weeks or months. It reduces environmental hazards and is a safe process due to minimum contact with the tank.

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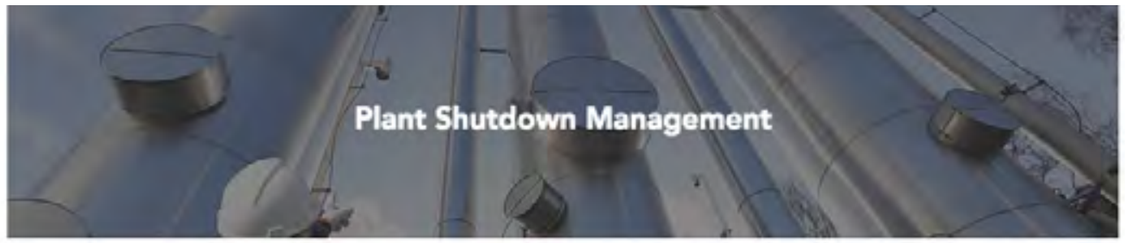
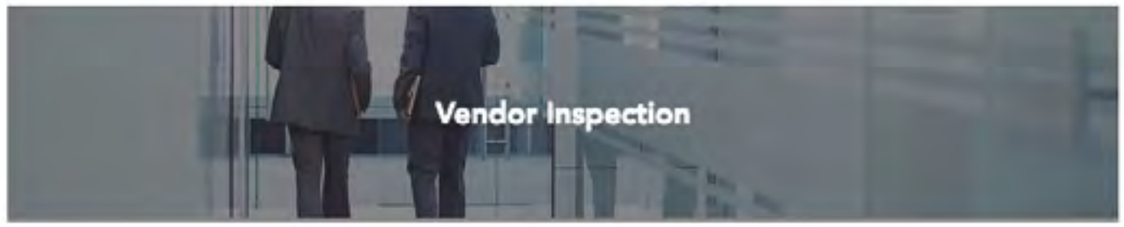
III. THIRD PARTY AUDIT & QUALITY INSPECTION

TCR is a trusted provider for independent Third-Party Technical Inspection and quality assurance services that include Factory Audits, OEM Development, Raw Material Inspection, Initial Production Check, In-Production Check, Random Inspection and Loading Supervision directly on-site at the supplier's location in India

TCR's ISO 17025 certified material testing laboratory delivers best-in-class services consistently to customers around the world. Their deep industry expertise ensures its performance and service quality are exemplary and they meet all requirements; compliance, regulatory or client specific. TCR helps in augmenting integrity and efficiency of equipment with safe working conditions for its employees. It's material testing laboratory provides full chemical, mechanical, non-destructive testing, metallography, positive material identification, corrosion testing and component testing services, including portable spectrometers, and digital photography. TCR also has access to scanning electron microscope and EDAX attachments





i. Plant Shutdown Management

TCR has the capability to rapidly source, engage and deploy talented NDT manpower across Petrochemical and Power industry in India. In the last few decades, TCR has easily deployed several engineering and NDT teams at various onshore and offshore locations within the Gulf/Middle-East area including Kuwait, Bahrain, Oman and Saudi Arabia.

TCR works with industry-specific organizations, research and development facilities, and clients to develop new inspection equipment, applications, and procedures. With its superior Project Management Solutions, TCR meets all client's project requirements at every stage of the business process either through the lifespan of a project or at different stages, while making sure that operating costs are in-line with the budget. TCR uses the latest technologies that help minimize downtime and ensure each of its clients get the most comprehensive information possible on the state of their equipment.

Manpower Deployment and On-site Placements

TCR Engineering supports plant shutdown projects with a diverse range of NDT skill-sets that include:

- API 510 Pressure Vessel Inspectors
- API 570 Piping Inspectors
- API 653 Tank Inspectors
- API 579 Fitness for Service
- Metallurgists including experts in RBI (API 580/581), Failure analysis, RLA
- ASNT Level III Experts
- BGas Paint Inspectors
- Mechanical Engineers
- Civil Engineers
- Instrumentation Design Engineers
- Piping Engineers
- Painting/Coating Inspection Professionals
- Corrosion Engineers
- IRATA (Rope Access) Technicians
- Multi-Skilled NDT Level II Technicians (ASNT/ PCN)
- CSWIP/AWS Certified Welding Inspectors
- QA/QC Inspectors and Engineers / Saudi Aramco Approved inspectors
- Chemists, Material Testing Lab Technicians
- Heat Treatment (PWHT) Technicians
- NACE Cathodic & Coating Inspectors
- NDT Level III in multiple subjects (with Welding Inspector Qualification)
- NDT Level II in UT with Auto UT, Phased Array and TOFD Experience
- NDT Level II with extensive experience on pressure vessels and Multi-Skilled Usage
- ASNT MSLT Level II with Leak Testing experience
- ASNT Level II in Eddy Current (ET)
- ASNT UT Level II with TKY experience
- Plant Process Engineers
- Project Managers
- Construction Managers
- Procurements Managers
- HSE Managers /Officers
- AutoCAD Operators/ Designers
- PDS/PDMS Designers
- Safety Officers/Engineers
- Process Design Engineers
- ASNT RT Level II and RTFI
- QA/QC Inspectors with Static and Rotating Equipment Experience
- Electrical Inspectors
- Ultrasonic Inspection (UT), Magnetic Particle Inspection (MPI), Radiography
- CSWIP Plant Inspector Level I (PL 11, PL 12)
- Positive Material Identification Operators
- Ferrite Assessment
- Rope Access Technicians

TCR inspectors are conversant with ASME/ANSI Codes and Standards across:

- ASME SECTION VIII, DIV. I and II Boiler and Pressure Vessel Code, Design and Fabrication of Pressure Vessels
- ASME/ANSI B16.5 Pipe Flanges and Flanged Fittings
- ASME/ANSI B16.9 Butt Welded Fittings
- ASME/ANSI B16.11 Screwed and Socket Welded Fittings
- ASME/ANSI B31.3 Process Piping
- AWS D1.1/D1.1M Structural Welding Code - Steel
- AWS D10.4 Austenitic Chromium-Nickel Stainless Steel Piping and Tubing, Recommended Practices for Welding
- AWS D10.8 Chromium-Molybdenum Steel Piping and Tubing, Recommended Practices for Welding
- AWS D10.10 Local Heating of Welds in Piping and Tubing, Recommended Practices
- AWS D10.11 Root pass Welding of Pipe Without Backing, Recommended Practices
- AWS D10.12 Welding Low Carbon Steel Pipe, Recommended practices and Procedures
- AWS D14.5 Pressure and Press Components, Specification for Welding
- AWS QC7 Standard for AWS Certified Welders
- AWS D1.2, 1.3, 1.4, 1.5 Structural Welding Code-Aluminum, Sheet Steel, Reinforcing Steel, Bridge Welding Code
- AWS D9.1 Structural Welding Code - Sheet Metal
- AWS D10.6 Titanium Piping and Tubing, Gas Tungsten Arc, Recommended Practices for Welding
- AWS D11.2 Welding Iron Castings, Guide
- AWS D14.5 Pressure and Press Components, Specification for Welding
- SSPC VOL I&II Steel Structures Painting Council Standard

ADVANTAGE TCR

An extension of your human resource team

TCR aims to become an extension of its client's human resource department. TCR has served as valuable source for understanding client's environment, developing and maintaining a search network and providing resources tailored to individual requirements. In addition to its own search networks, TCR assists the hiring authority in screening all solicited and unsolicited resumes for providing a comprehensive progress report.

TCR's on-site inspection team and associated manpower along with its state-of-the-art equipments and tools can be commissioned to work on contract as well as for on-site assignments. Alternatively, TCR can collaborate to work with other 3rd Party Inspection Agency

INDUSTRY EXPERTISE

TCR has extensive experience across all major industries. Its' highly trained teams provide clients with deep industry knowledge, best practices and expert perspectives for problem resolutions.

TCR aims to assist companies with breakthrough business insights and set new standards of excellence for them in their industries.

COMPETENT PROFESSIONALS

TCR's highly trained NDE professionals go through rigorous training and are qualified to meet or exceed all industry requirements. In addition to this, TCR provides extensive in-house training and ensures that all its NDT professionals are always updated with all relevant industry codes and regulations.

TCR has an ongoing commitment to continually bring new inspection solutions to their clients that will help them make informed decisions and minimize costs and thereby enhance their integrity management programs.

TCR helps augment the integrity and efficiency of equipment and assure safe working conditions for all its employees.

LATEST INSPECTION SOLUTIONS

TCR's highly qualified teams have significant experience in various projects, both in India and the Middle East across various disciplines of NDT including Radiography, Ultrasonic, Welding, MPI, In-situ Metallography & Positive Material Identification.

Inspectors have worked on design, fabrication, construction, inspection and erection of Pressure Vessels, Heat Exchangers, Towers, Stacks, Tanks, Plant Pressure Piping, Offshore oil wells and several other advanced projects.

LARGE POOL OF TALENT

TCR offers a large, experienced and highly qualified pool of professionals that can be deployed at any location in the shortest of time frames.

With over 100 professional NDT technicians, the sheer size and expertise makes TCR the obvious choice for meeting inspection requirements across all its clients

TCR provides best integrity management solutions across industries. TCR's talent solution caters to both daily inspection activities as well as large turnaround projects.

TCR inspectors can undertake visual inspection, ferrite assessment, PMI operations, etc and are conversant with ASME/ANSI, AWS, API, BS, ASTM and NACE Codes and Standards. Number of our inspectors are currently deployed with Saudi Aramco SAP as well:

- ASNT Level III personnel have a minimum of 7-15 years of experience
- ASNT Level II personnel have 5-10 years of experience
- Senior experience team members with over 25 years of experience
- Junior NDT inspectors have 2-5 years of experience

TERMS OF MANPOWER DEPLOYMENT

TCR STREAMLINES THE TRANSITION PROCESS TO ENSURE MINIMUM DISRUPTION

If a client needs highly qualified contractors for long-term, short-term projects and T/A's or independent contractors, TCR provides the same on per project basis at a flat fee.

PAYMENT TERMS

- Operating Shift: Work on a standard 8-10 hour shift
- Billing: Rates for the assignments are quoted on a per day basis
- Overtime Charges: Proportional to the daily manpower charges,calculated on an hourly basis
- Invoice Schedule: Invoices are raised on a monthly basis and the payment must be made within 15 days of submission
- Mobilisation charges: Needs to be paid in advance to mobilize resources, it will be set off against future invoices
- T&E Expenses: Client is responsible and has to bear all the T&E charges including food, accommodation, local travel, and round trip air ticket from Mumbai, India to the offshore location or inspection site
- Additional Charges: Material Testing (Destructive), if required will be extra

VISA MOBILIZATION

The client is required to provide visa and valid work permit. TCR will need a minimum notice of 3 weeks to mobilize the right inspector for the task.

CONTINGENCY FEES

Contingency searches are based on 25% of the candidate's first years 'anticipated annual salary'. However, this can vary depending on the geographical location, the industry, the specific talent that is being recruited and the number of positions being filled. Candidates in a contingency search are usually identified through an existing database or from public job boards. The search process is usually less structured than a retained search. This approach focuses less on an exact "fit" but more about short listing potentially qualified candidates for the client to make their own final assessment.

SAFETY & HEALTHCARE

All safety equipment, if required must be supplied by the client's on-site/

offshore QA department. The client is required to provide TCR inspectors with medical insurance except for eye refraction, eye glasses, dental treatment, plastic surgery, artificial limb etc. The client is not responsible for any treatment that includes chronic diseases such as Cancer, AIDS and Hepatitis or other such diseases that require long term treatment.

RETAINER PROJECTS

TCR provides solutions with dedicated efforts to address specific needs and fill a position or staff the entire project within a specific and critical time frame. For such projects, TCR charges a fee equivalent to 25% of the placed candidates first Years 'Anticipated Annual Salary', that includes bonuses and/or premiums. A retainer fee is charged for consulting services that are not contingent on the hiring of a candidate. One-fourth of the fee as an advance is due when the assignment begins, the second fourth is billed when TCR presents potential candidates and the remaining balance is due upon completion of the assignment.

Should a candidate placed by TCR on a retained search be terminated for cause within 6 months of placement, TCR guarantees to provide a replacement.

PROCESS KICK-OFF

TCR provides priority handling to all client assignments. After a thorough understanding of client's business operation and their specific needs, TCR will locate, screen, interview and select the right candidate that will be ideal for the requirements.

ii. Product Sourcing

TCR has over the years built significant relationships in the industry, By leveraging its years of expertise, TCR offers end-to-end sourcing solutions. It covers the entire sourcing process, right from finding right suppliers to transferring design specifications. TCR also helps in setting-up the right supply chain, control logistics and ensure that the shipment meets all export guidelines.

TCR's strength lies in its domain expertise in the material testing services that ensures stringent quality control measures across all engagements.

ADVANTAGE TCR

TRUSTED SOURCING PARTNER

TCR continuously forges strong relationships with manufacturers and traders by visiting their facilities and confirming "first hand" their capabilities. TCR has the capability to source, inspect and test ferrous and non-ferrous metals, casting & forging, sheet metal, bar, pipe, stainless steel, nuts, bolts, engineering goods, non-metallic materials such as polymer, ceramic, glass, machined parts and machine tool components from all parts of India.

TCR has a dedicated team of Engineers, Chemists, Metallurgists and Technicians to participate in the material and goods sourcing. It's Engineers are well versed in interpreting drawings and assist in the creation of "test" samples. TCR has developed a 5-step sourcing process tailored to ensure optimum results for its clients:

1. TCR seeks detailed information on the product type, drawing, material specifications, the required quantity and quality, along with target delivery date from the client
2. TCR goes into the marketplace and contacts metal manufacturers, traders and producers to determine their production capability, availability, quality, and unit price
3. TCR shares the product price quote in a FOB price format and directly negotiates with the manufacturer/ trader to provide the client with a competitive bid
4. Once the client is satisfied with all the parameters including price and quality, TCR confirms the order with the vendor for developing an appropriate prototype as a sample for approval
5. Physical samples are either shipped or shown in person for approval. TCR places the order post client confirmation and verifies all payment and shipping logistics during the process

iii. Vendor Inspection & Quality Assurance

TCR Engineering provides inspection and quality assurance services to help retailers, trading partners, importers and manufacturers assess product quality and meet the regulatory requirements of their specific industry vertical. TCR's independent third-party inspection and quality assurance services promote improved product quality and a massive reduction in customer complaints, non-compliance and product recall.

The on-site inspection team at TCR is available across all states in India at a competitive pricing model with its man-day framework.

ADVANTAGE TCR

HELPING CLIENTS WITH THIRD-PARTY INSPECTION

With over 45 years of experience, TCR Engineering Service has built a team that not only possess a strong engineering background but also has a track record of performing quality analysis (QA) on all engineering goods sourced from India and validate them as per ASTM, BS, GS, JS, IS and other international standards. The team offers consulting solutions based on the latest technological advances that incorporates all current national and international norms.

On successful completion of the final random inspection, a detailed inspection report is shared with the client. TCR Engineering Services Inspection Certificate is issued to the manufacturer/trader to validate the product quality and highlight the positive parameters.

A FACTORY AUDIT

TCR Engineering Services Factory Audit service verifies the capability of a manufacturer to meet the contract conditions on all parameters that include quality, quantity and delivery terms. These assessments are typically tailor-made as per the client's needs and requirements. When clients avail this service, they can rely on TCR and eliminate the need for their presence either on-site or at the manufacturer's plant or factory

B RAW MATERIAL INSPECTION

TCR conducts on-site visits to the supplier/ manufacturer's plant to determine and evaluate fabrication techniques, assembly procedures, quality issues and makes sure that the production process meets the client specified requirement. The Inspections can span from continuous on-site photography and logging, laboratory analysis to secure storage. Before initiating raw material inspection service, TCR obtains a detailed data sheet for the assignment. Material Inspection Services are essential to ensure that all the material supplied meets the client/ project defined specifications.

C SAMPLE PICK-UP FOR TESTING

TCR inspectors can select a predetermined number of samples at the production stage from a factory, seal them, label and send them to its material testing laboratory for testing based on customer requirements. At TCR Engineering Services, the material testing laboratory provides Mechanical Testing, Chemical Analysis, Positive Material Identification (PMI), Non-Destructive Testing, Metallography, Corrosion Testing, Failure Analysis, Raw Material Inspection, Metallurgical Product evaluation, Engineering Research and Consulting services

D INITIAL PRODUCTION CHECK

The inspection team from TCR Engineering Services, based on the client's instructions and Purchase Order specifications can perform a visual inspection of products that are available at the start of a production cycle. The "Initial Production Check" along with a "Final Random Inspection" and other in-line production checks assists in taking corrective actions at early stages of the production cycle. The inspection team sends out intermediary reports to the client and keeps them informed about the production progress relative to the delivery terms

E IN-PRODUCTION CHECK

The inspection team performs a visual inspection and random material testing of products during the production process. This in-production service check mitigates the failure risk at the final random inspection stage. The check can be done as an independent service or for a more stringent approach, it can be combined with the "Initial Production Check" and/or "Random Inspection."

F RANDOM INSPECTION

TCR Engineering Services inspection services team performs final random inspection that comprises of a stringent and detailed visual inspection of goods before any type of shipment. It is generally conducted on samples selected from the defined sampling procedures and on the premises of the manufacturer. The inspection criteria includes both quality and quantity, while the marking and packing are based on the client's specifications and reference samples.

G IN-PRODUCTION CHECK

To ease product delivery, TCR team offers Loading Supervision services including "as appropriate" the checking of the container condition, identification of the loaded packing units with the previously inspected consignment, tallying of the total number of shipping packing units and sealing of the container. Loading Supervision service is offered in combination with the Final Random Inspection

H LOGISTICS MANAGEMENT

Once the product is ready for shipment, TCR verifies all export logistics, including local documentation, customs, licensing and tariff requirements in the most efficient and cost-effective way to ensure on-time delivery

INSPECTION PROCESS FOR SOURCING

12-STEP AUDIT PROCESS

TCR has developed a detailed standardised inspection procedure to optimise efficiency and maximise performance in-line with client requirements.

TCR Inspection team seeks specific information from the vendor/ buyer on whose behalf the inspection is to be carried out:

1. i. Name, Address, Telephone & Fax No of Vendor
   ii. Details of the materials ordered along with specification (IS/BS/ ASTM etc), the quantity, testing requirements and other special needs
   iii. Sampling plan, if any
2. TCR´s inspection department will then get in touch with the supplier to ascertain the availability of material for inspection. If available, an inspection is fixed within the 24 hours
3. TCR reviews suppliers internal records, test certificates for different identified stages in the approved quality plan or material procurement for verifying conformance of requirements of the equipment's/ systems as per Purchase Orders, agreed upon technical specifications/ approved drawings/data sheets, approved Quality Plan and other documents available with the contractor
4. Based on the agreement, TCR carries out stage-based and or final inspection on it own or in conjunction with Customer's representatives
5. TCR's inspectors carry out normal visual inspection (capturing detailed size measurements) and mark each and every item (or random sampling, as specified by the client) with a "unique identification number" or TCR Test Certificate Number (if material testing is ordered as well) and a TCR Stamp. Extra stamping would be done on materials randomly drawn for testing as per sampling plan of the buyer. If no specific sampling plan is given by the buyer, it is normal practice at TCR to draw a minimum of 2 samples and one additional sample for a batch of 10. This ensures uniformity in assessment for the whole lot. The TCR inspector will also mark the material from which necessary length of the sample is to be procured
6. If the samples are to be cut by the vendor, it must be delivered to TCR´s laboratory making sure that TCR stamp numbering & identification markings are intact on the samples
7. TCR will test the sample at its laboratory and carry out all tests as specified by the buyer. The testing can also be performed in stages on request of the vendor if the material fails to meet some of the requirements. The testing can be stalled in such cases when it is established that a sample has failed a certain test
8. All samples drawn from a particular lot must pass all the tests as specified by the buyer. If any of the samples fail, the entire lot is rejected. To gain acceptance, the vendor must agree to test each and every bar/plate of the lot with respect to the failed test. Only samples that pass the test will be cleared for dispatch
9. All bills for testing & inspection charges are typically raised to the vendor and the buyer may reimburse the same to the vendor for all accepted materials
10. All materials dispatched from the vendor to the buyer will carry the TCR stamp and Serial / TC Number, for easy verification by the inspection department of the buyer
11. In case of failure, the vendor is advised to offer a new lot and entire procedure is repeated again once the supplier rectifies the deviation as per the proposed corrective actions. In case of minor deviation from standard specification, the vendor may get clearance from the buyer and such clearance is to be directly communicated to TCR by the buyer. Such items can then be cleared for dispatch
12. The inspection report is prepared in the prescribed format along with the necessary supporting documents are issued such as Stage Inspection Reports / Test Certificates, etc. confirming the acceptance of the sample and material as per approved technical documentation and quality plans. The same is shared with the client through courier and email

IV. CONSULTING & ADVISORY

TCR's dedicated engineering and metallurgical consulting team in India is the perfect partner for solving manufacturing and product quality problems. With several years of experience, TCR's advisory team supports welding engineering, corrosion, material selection queries and heat treatment problems as well. TCR's in-depth engineering consulting services ensure that clients produce the best possible product right from the initial product design to the final production.

The cost for engineering advisory and consulting services are billable on an hourly basis with a minimum of 4 hours

Core Service Offerings

ENGINEERING ADVISORY
Failure and Root Cause Analysis
Risk Based Inspection
Fitness for Service
RLA and Condition Assessment of Boilers

RESEARCH AND DEVELOPMENT
Contract Research and Development
Technical Help for Indigenization
Quality Improvement
Solutions of Critical Weld Problems

ENGINEERING DESIGN AND ANALYSIS SERVICES
Computer Aided Designing (CAD)
Computer Aided Engineering (CAE)
Training, Reverse Engineering and Prototyping

A. ENGINEERING ADVISORY

TCR's consulting team has deep engineering expertise and has access to a state-of-the-art material testing laboratory that enables them to uncover the root cause of failure and recommend the best solution to prevent recurrence. TCR Engineering provides consulting assistance in several areas that include:

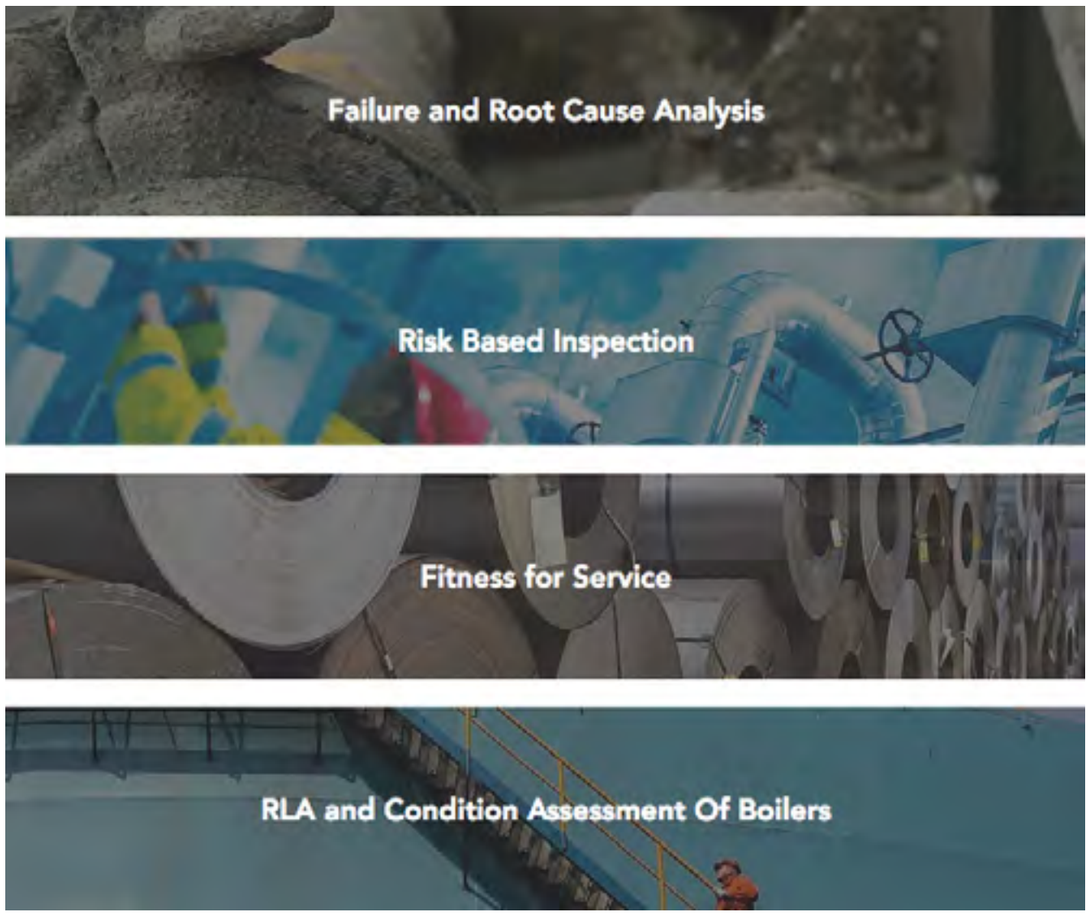
- Determining the right material for a product
- Corrosion engineering, corrosion testing and corrosion investigations
- Metallurgical failure analysis and welding evaluations.
- Investigate the effect of environmental conditions on a product or material
- Manage Quality Control Projects
- Prepare material and process specifications for in-house quality control
- Compare vendor or competitive products
- Estimate the remaining service life of a product or machine component

Develop Non Destructive Testing (NDT) Plan and ToFD/ Phased Array procedures
- Identify equivalents between Indian and foreign specifications
- Assist to solve product quality problems
- Assist in cost-benefit analysis post failure analysis
- Expert witness and opinion assistance in case of trade conflicts, materials disputes, and litigation issues
- Creating a custom Metallurgical Image Analysis Software
- Ensure product compliance with RoHS and WEEE

The consulting practice additionally offers advanced services that include::

- Finite Element Analysis and Stress Analysis
- Advanced materials & processes
- Fractography
- Surface Engineering
- Tribology
- Welding esp. repair welding and cast iron welding
-Atomized Powder Production

(technology, QA, application- wise requirements of powders)
- Life Cycle Analysis and Engineering Asset Management
- Global Warming-Role of Tribology & Surface Engineering
- Thermal Spraying
- CAD/CAM Modeling



i. Failure & Root Cause Analysis

TCR prides itself for its deep knowledge and has garnered best practices from success stories compiled from over 1800 failure investigation assignments, which include major projects in manufacturing and metallurgical failures on ASME boilers, pressure vessels, gas turbine engine components, oil and gas transmission pipelines, food processing equipment, heat exchangers, medical supplies, refineries, petrochemical plants, aircraft/ aerospace, offshore structures, industrial machinery, weldments and ships.

The Failure Analysis Team's strength lies in the evaluation of high temperature and high-pressure failures. The Failure Analysis Team at TCR Engineering has experience in the materials space, failure analysis, metallurgical, welding, quality assurance, and forensic engineering fields. The analysis is conducted by engineers holding advanced degrees in metallurgy, mechanical, civil, chemical, and electrical engineering.

TCR Engineering works with clients to draw up a plan for failure analysis to efficiently conduct the investigation. A large amount of time and effort is spent in carefully considering the background of failure and studying the general features before the actual investigation begins. The cause of failure is determined using state-of-the-art analytical and mechanical procedures that often includes simulated service testing. Analysis and physical testing, when combined together, locates problems and provides recommendations for effective solutions.

In the course of the various steps n 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 on 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 considers all aspects of 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 to conduct a Failure Analysis is summarized as under:

Evaluation Sequence for conducting Failure analysis

- 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 (Including recommendations)

Failure Investigation Report

The investigation team produces detailed written reports to ensure clients fully understand the implications and can independently examine the conclusions:

- 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
- Summary of failure causing mechanism
- Recommendations for prevention of similar failures

Latest Inspection Solutions

TCR team has in-house all the necessary tools for conducting a modern failure analysis. The complete range of equipment at TCR's network of laboratories include::

Metallurgical Optical Microscope with Image Analysis system LECO 500(USA) with 300X facility. For studying fracture surface at low magnification and to decide areas to be studied at still higher magnification

Scanning electron microscope with EDAX. For the study of high magnification fractography in critical situations. To study surface analysis of metal, corrosion product or localized areas

Stress Analyzer: To detect the level of stresses in metal

Complete mechanical and chemical testing equipment

Dilatometer: To measure volume change while heating and cooling

Equipments and accessories required for preparation of metallographic samples including Diamond saw cutter, Mounting press, Rough grinder, Belt polisher, Wheel or disc polisher, Electrolytic etcher polisher and a Microscope with attachments like micro-hardness testing.

Micro Hardness Tester

ii. Risk Based Inspection

The reliable and proven Risk-Based Inspection (RBI) technology process developed by PP SIMTECH (UK), with guidance from API 580/581 and UK HSE, has been accepted globally by leading international companies as a good engineering practice. PP SIMTECH has successfully implemented RBI at BP, Dow Chemicals, GPIC, ADNOC-Fertil, Norsk Hydro, BASF, INEOS. In India, PP SIMTECH (UK) has partnered with TCR Engineering Services and this partnership has resulted in the formation of a new joint-venture – TCR PP SIMTECH Pvt. Ltd.

rbiAsyst™, a fully auditable and transparent software system calculates the risk profile of an item, based on its "active" and "potential" damage mechanism. The technology ensures that the resulting inspection interval for the item is reliably optimized in a safe and cost-effective manner. Operating limits are also defined by the RBI team to prevent an increase in damage rate or initiation of a new damage mechanism. If business or safety risks are unacceptable, risk-mitigating options are also recommended as a part of the output. TCR's RBI team study improves both, the team's working and knowledge sharing at the plant site along with enhancing communication across all departments. Additionally, it captures valuable plant knowledge from senior engineers in the team, encourages training of junior engineers and augments corporate memory.

The technology is designed to facilitate successful implementation of RBI technology processes at plant sites across oil and petrochemical industries, chemical, fertilizer and power plants. The technology causes an increase in plant availability, ensures cost saving, allows for a minimum duration of shutdowns, encourages changes in inspection strategies and intervals, and promotes improved safety compliance.

The TCR PP SIMTECH has an experienced team of professionals that include Mechanical Engineers, Metallurgists, Corrosion Engineers, NDT Experts, RBI Experts and Project Managers, that provide plants with RBI, Fitness-For-Service (API 579), Material Damage Mechanisms Assessment, Metallurgical Investigation & Failure Analysis and In-service Inspection. The RBI team study, facilitated by TCR PP SIMTECH and rbiAsyst™ software, helps all plant management and operations team to identify and resolve complex technical issues associated with static equipment including reactors, furnaces, strippers, distillation columns, heat exchangers, pressure vessels, reformers, boilers, fired heaters with associated items such as interconnected piping and storage tanks.

Core Benefits of RBI

It must be recognized that it is the reliability of the RBI technology process, the inclusion of the best practices, the comprehensiveness of the team study method, the engineers involved from the plant site and the quality of the output, is equally responsible for delivering the set objectives and desired benefits.

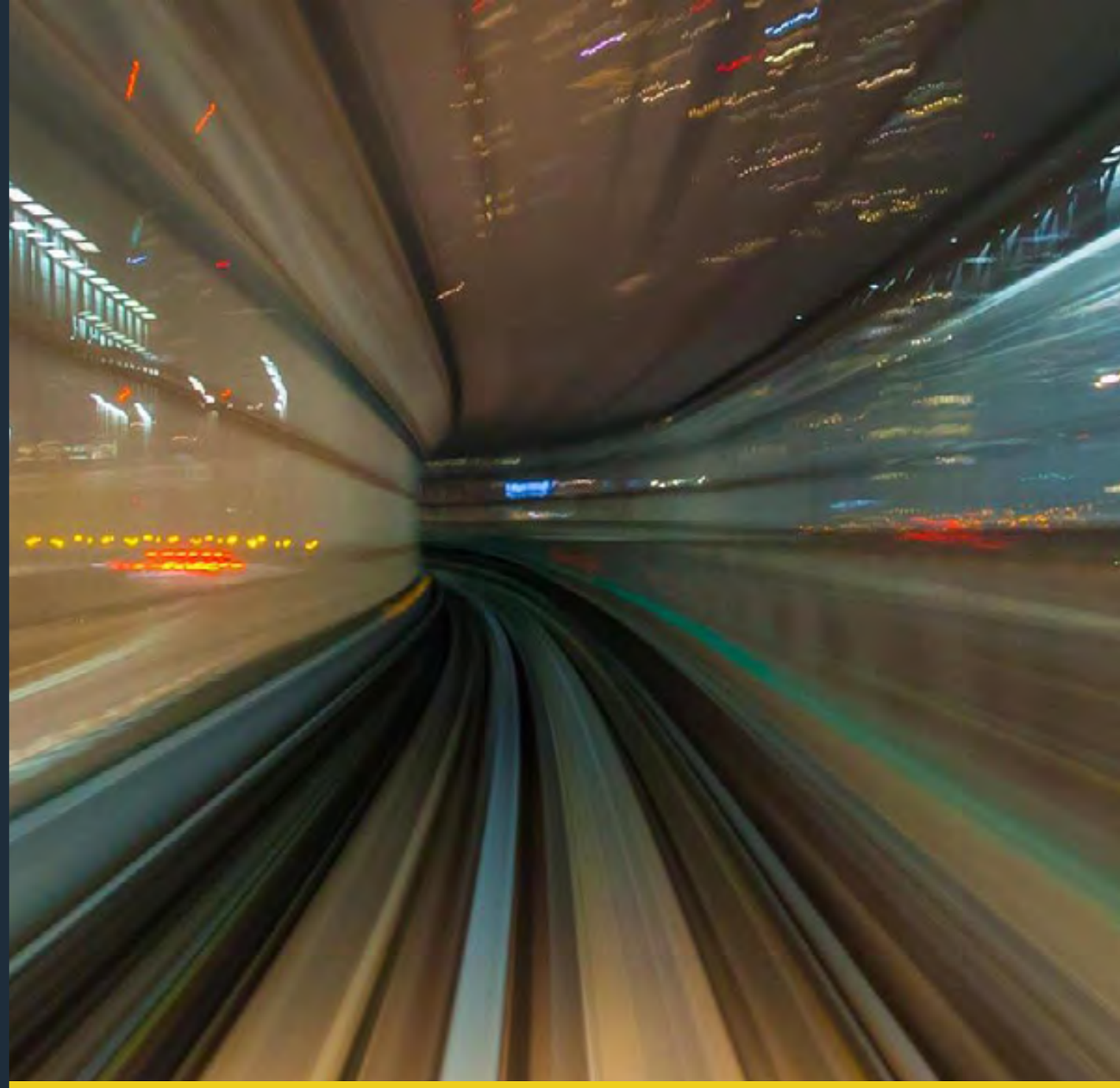
- Increased safety and equipment reliability
- Fewer planned shutdowns
- Fewer unplanned shutdowns
- Longer inspection intervals
- Reduction in inspection frequency and maintenance costs
- Effectiveness evaluation of inspection activities
- Increased consistency of inspection planning
- Identification of potential damage mechanisms
- Prioritisation of inspection
- Identification of key process parameters affecting degradation rates
- Assessment of proposed process changes that could impact degradation rates
- Documentation of current plant configuration and materials of construction
- Improved team working and communication between all departments

Plant and Equipment Under TCR's RBI Technology Process

- All types of pressure vessels including reactors, furnaces, strippers, absorbers, distillation columns, heat exchangers, crackers, crude heaters and other fired heaters, reformers, utility power boilers and associated equipment
- Interconnected Piping between these items within the plant site
- Over ground and buried cross country fluid (gas or liquid) distribution Pipelines
- All types of Storage Tanks

TCR's Continued Support for Plant Sites includes:

- RBI technology implementation services
- Total Asset Integrity Management technology support
- Fitness-For-Service (API 579, BS 7910) and Remaining Life assessments
- Root Cause Material Damage assessments, Metallurgical Investigation & Failure Analysis
- Training & Technology Transfer to in-house engineers to effectively manage plant integrity



ADVANTAGE TCR

The approach to risk-based inspection is based on developing a strong cooperation between the plant personnel and TCR PP SIMTECH experts. The adopted process of guided expert judgment is based on operational experiences and a strong technical basis for evaluation of possible degradation mechanisms. TCR believes that incorporation of these fundamental requirements in the evolution and development of the RBI technology process has made PP SIMTECH the global leader in this technology and positively different from the others and the evidence lies in published testimonials from various clients.

iii. Fitness for Service

TCR undertakes Fitness for Service (FFS) Assessment based on Level 2 BS 7910 standards (broader scope than API 579). Our fracture mechanics methodology and its application have been successfully proven worldwide across industries, including nuclear pressure vessels to high consequence items in the exploration, refining, petrochemical and construction industry.

A process, plant, and equipment are often exposed to corrosive environments and/or elevated temperatures. Under these conditions, the material used in the equipment can degrade or age with time. Important equipment such as pressure vessels, piping, and storage tanks become older, the plant operator must decide if they can continue to operate safely and reliably to avoid injuries to personnel and public, environmental damage, and unexpected shutdowns. Fitness for service assessment procedures provide a means for helping the plant operator make these decisions on established engineering principles.

Fitness for service assessment is a multidisciplinary engineering analysis that ensures all process and plant equipment such as pressure vessels, piping, and tanks operate safely and reliably for the desired period of operation and until the next turnaround or planned shutdown occurs in the future. API Recommended Practice 579 provides a general procedure for assessing fitness for service. This assessment procedure evaluates the remaining strength of the equipment in its current state, which may have degraded from its original condition. Common degradation mechanisms include corrosion, localized corrosion, pitting and crevice corrosion, hydrogen attack, embrittlement, fatigue, high-temperature creep and mechanical distortion. Methods for evaluating the strength and remaining service life of equipment containing these types of degradation are presented and reviewed.

Common Reasons for Assessing The Fitness for Service of Equipment Include::

- Discovery of a flaw such as a locally thin area (LTA) or crack
- Failure to meet current design standards
- Plans for operating under more severe conditions than originally expected

Outcome of Fitness for Service Assessment

A decision to run, alter, repair, monitor, or replace the equipment
- Guidance on inspection interval for the equipment

Fitness for Service Assessment applies Analytical Methods to Evaluate Flaws, Damage and Material Aging based on:

- Stress Analysis may be performed using Standard Handbook or Design Code Formulas or by means of Finite Element Analysis (FEA). With modern computer technology, the use of FEA is quite common.
- Fitness for Service Assessment requires both, knowledge of past operating conditions and a forecast of future operating conditions. Interaction with operations personnel is required to obtain this data
- Non-Destructive Examination (NDE): NDE is used to locate, size and characterize flaws

The material properties include information on material damage mechanisms and behavior in the service environment, especially on the effects of corrosion and temperature

iv. RLA and Condition Assessment of Boilers

TCR has developed expertise in assessing the current condition of boilers and also their remaining life. At TCR, both Level–II assessment and Level-III assessment is undertaken for RLA. Adopting a pragmatic approach, efforts are directed towards collecting data on the component/equipment history in addition to interviewing external experts familiar with the operation details. All the details are evaluated vis-à-vis the testing and studies are conducted at a later stage using either a:

CALCULATION BASED APPROACH

Calculation procedures are often employed to determine the expanded lives of components under creep, fatigue and creep-fatigue conditions. From plant records, information about temperature and cycling history is gathered and by use of standard material properties and damage rules, the fractional life expanded up to a given point in time can be estimated.

DESIGN APPROACH

Components which operate under creep regime are generally designed on the basis of yield strength, tensile strength and fatigue strength with suitable safety factors. Under normal conditions, deformation and fracture are not time dependent. As long as the applied stresses do not exceed the design stresses, these components should last indefinitely; but in practice, various factors cause the reduction in life.

Approach to Remaining life assessment

- Understanding the actual degradation mechanism
1. Fatigue
2. Thermal fatigue
3. Thermo mechanical fatigue
4. Thermal aging
5. Creep
6. Embitterment
7. Corrosion
- Visual examination of physical properties
- NDT involving In-situ Metallography, Ultrasonic Testing, Magnetic Particle Inspection, DP Test, Ferrite Measurement.
- Stress analysis: To know the strength of the material and check ruptures
- Non-Destructive Testing: To provide a good insight into the component integrity
- Laboratory Testing: To provide valuable information about the material soundness
- Judgment of fitness of the equipment: Based on available data
- Suggestions on repairing: If required, repairing of the equipment is suggested, for life extension
- Judgment of remaining life based on analysis: Estimates for remaining life is carried out
- In addition to this, periodic inspection procedures are spelled out to monitor the health of the equipment during the course of operation.
- If the results reveal an operational mistake, restriction in free movement by thermal expansion or any other prevailing damage mechanism, then preventive maintenance approach is formulated

Definition of Component Life

HISTORY-BASED CRITERIA

30 to 40 years have elapsed, statistics of prior failures indicate impending failure, frequency of repair renders continued operation uneconomical, calculations indicate life exhaustion

PERFORMANCE-BASED CRITERIA

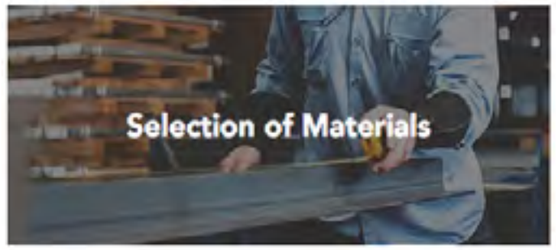
Severe loss of efficiency indicating component degradation, large crack manifested by leakage, severe vibration or other malfunction, catastrophic burst

INSPECTION- BASED CRITERIA

Dimensional changes have occurred, leading to distortions and changes in clearances, inspection shows microscopic damage, inspection shows crack initiation, inspection shows large crack approaching critical size

B. RESEARCH AND DEVELOPMENT

Research and Development assumes a pivotal role in the innovation process. It is an investment in building future capabilities and technology, which is perhaps used to transform into new products, processes, and services. TCR has the competence to effectively set up and manage an in-house laboratory for an organization and provide innovative, professional and superior service. TCR brings a strong process, deep technical expertise and a performance-oriented approach that rests on integrity and reliability.



1 Contract Research and Development

TCR's dedicated engineering and the metallurgical consulting team is the perfect partner for solving manufacturing and product quality problems. TCR's senior consultants with several years' of experience are available to support and advice on corrosion and materials selection queries. The team also provides advisory service on welding engineering and heat treatment problems. From initial product design to final production, TCR's in-depth engineering consulting services ensure that clients are producing the best possible product.

TCR also undertakes research projects in the areas of Computer-Aided Designing (CAD) including Engineering Design, Legacy Data Conversion, Detailing Plant & Process Layout, CAM and Computer-Aided Engineering (CAE) including Finite Element Mode.

Areas of routine research assistance include:

Determining the right material for a product

Undertaking corrosion engineering, corrosion testing and corrosion investigations

Conducting Metallurgical failure analysis and welding evaluations

Investigating the effects on environmental conditions

Preparing material and process specifications for in-house quality control

Comparing vendor or competitor products

Identifying equivalents

between local and foreign specifications

Assisting in solving product quality problems

Assisting in cost-benefit analysis post failure analysis

Reverse Engineering and Rapid Prototyping

2 Technical Help for Indigenization

In order to generate baseline standard for indigenization, multiple metallurgical studies are undertaken to identify status and properties of imported components by different methods including destructive/non-destructive studies. Technical help is provided to decide on the right manufacturing route or process and to develop quality checks on indigenously created components. TCR's proprietary approach seeks structural details from the client across several areas to optimize indigenization support:

- Working condition of component
- Type of loading and stresses
- Design and operation condition
- Service history of component
- Life of an important component

3 Selection of Materials

Weight loss experiments: Samples of different metals/alloys are exposed to simulated or actual process plant solution in the laboratory, with and without stirring. Coupons of different metals/alloys are exposed to actual plant environment and a systematic approach is formulated, based on the requirement of intended services, literate survey and relevant standards like NACE, ASTM and API. The laboratory study is performed on the exposed sample to categorize the performance and a suitable MOC is recommended. Electrochemical experiments to find out relative corrosion resistance is performed by accelerated testing under laboratory conditions. MOC selection is done with off the shelf database and is combined with the experience of other experts drawn from published literature.

4 Quality Improvement

TCR undertakes total quality improvements for stringent requirements against international specifications. A thorough survey is undertaken by auditing the existing manufacturing procedure followed by stage-wise investigations of raw material and other components required for product manufacturing. 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. The required quality control checks are suggested to ensure consistency for optimum and continuous production.

TCR deploys a team of expert metallurgists to perform this task. The specially designed report enlists the fundamentals of metallurgical processing variables on final properties of the components and includes recommendations for corrective measures.

5 Solutions of Critical Weld Problem

TCR prides itself on having a huge knowledge bank of success stories compiled from over 1800 failure investigations across several industries. The insights gained in the area of failure mechanism has augmented the knowledge of TCR's technical team and because of this, there is a direct implementation of repair weld solutions.

With its deep technical and market expertise, TCR is a leading player in solving critical weld repair solutions for the aged plant components. With limited material resources and increased value of new products, repair weld solutions can salvage critical components of process plant and ensure massive savings by mitigating production loss. The repair weld technology requires an in-depth understanding of metallurgical degradations, operating conditions, physical metallurgy and welding technology. There is a right solution for every problem that can be determined via strong fundamentals, technical competence, and engineering output.

When a plant with critical machinery component has a breakdown, an immediate problem resolution is necessary. There have been several instances when repair welding is done with little or no understanding of the metallurgical fundamentals and this proves to be disastrous. The management loses trust in its usefulness and technical competency. This philosophy promotes hasty decisions for replacing the components at a premium cost. Instead, a systematic detailed metallurgical investigation would provide the extent and nature of degradation, thereby utilizing the knowledge of metallurgy and a proper welding procedure can be devised. TCR has helped many industries by providing repair solutions on critical pump casing, shaft, nitride components reformers and many other such issues.

The TCR's engineering consulting team, when provided with a detailed history of the problem can reach the client's site within 24 hours and they start generating data and draw up the way forward for the components to be repaired.

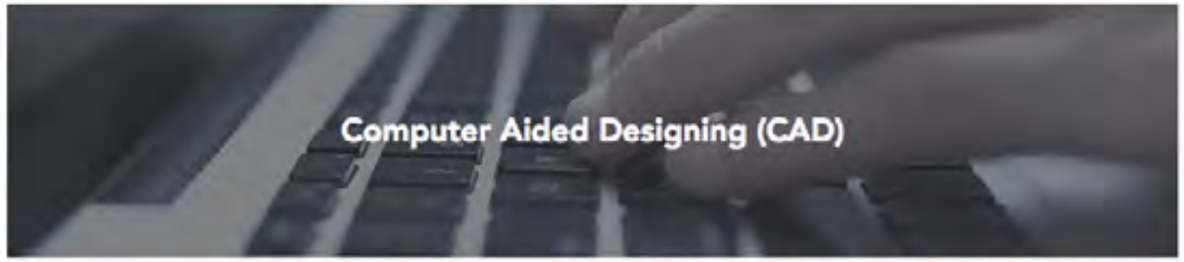
For successful repair, a mock test is necessary from the same material (or preferably for the aged material of similar grade). In case it is not available, virgin material of similar grade can also be used as an alternative. A mock test will establish the confidence in the welder and welding parameters.

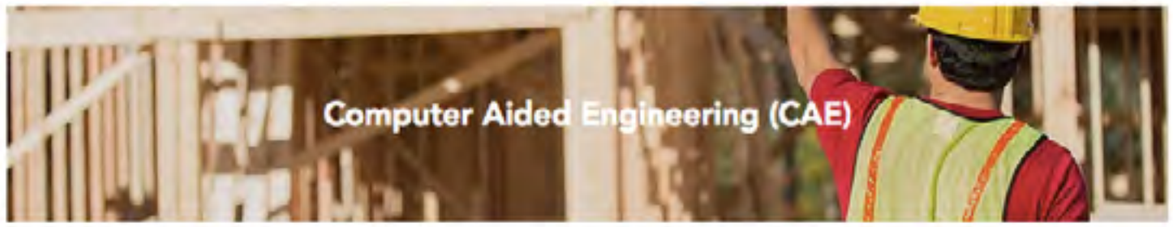
After successful welding, thorough NDT testing is recommended to ensure that the welding joints remain trouble free for future service.

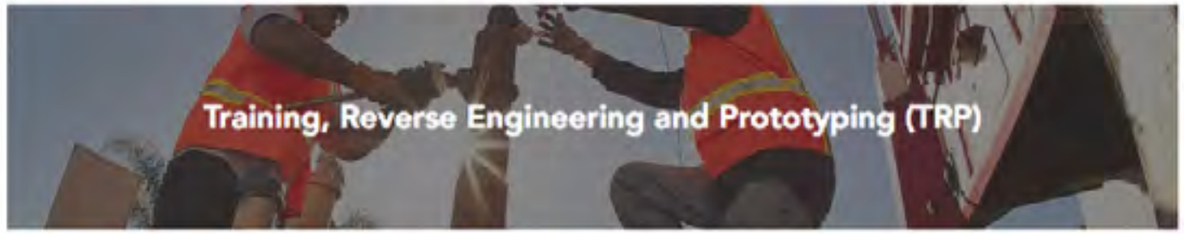
C. ENGINEERING DESIGN & ANALYSIS SERVICES

TCR Engineering provides design and analysis services such as Computer Aided Designing (CAD) Engineering Design, Legacy Data Conversion, Detailing Plant & Process Layout, CAM, Computer Aided Engineering (CAE) including Finite Element Modeling, Structural Analysis and Noise, Vibration, Harshness (NVH) analysis, and Project Management Services.

The team consists of a pool of highly qualified professionals armed with diversified technical skill sets. The experts have an optimum mix of experience, enthusiasm, extensive knowledge of design, product development and software domains.







I COMPUTER AIDED DESIGNING (CAD)

DESIGNING	LEGACY DATA CONVERSION	DETAILING	PLANT & PROCESS LAYOUT
Initial concept	Drafting Conversion	Part drawings	Structural
3D Modeling	from 2D to 3D	Assembly layouts	Mechanical
3D Surfacing	Data extraction	Manufacturing	Hydraulics
Concept layout	Data validation	drawing	Pneumatic
Product definition	Parametric models	GD & T	
	Castings	Process sheets	
	Plastic parts	Tool drawings	
	Sheet metal parts	Product drawing	
		Part lists	

II COMPUTER AIDED ENGINEERING (CAE)

FINITE ELEMENT MODELING	STRUCTURAL ANALYSIS	NOISE, VIBRATION, HARSHNESS (NVH)
2D Mesh	Linear & Non-linear	Sound Transmission
Hybrid Mesh	Static & Dynamic	Sound Radiation
Hexa Mesh	Contact Stress	Sound Quality Study
Tetra Mesh	Mold flow Analysis	Vibration
	Fatigue Analysis	Structure Borne Noise
	Failure Analysis	Air Borne Noise
	Impact and Crash Analysis	
	Steady State & Transient	
	Thermal Analysis	

III TRAINING, REVERSE ENGINEERING AND PROTOTYPING

CORPORATE TRAINING

CAD Fundamentals
CAE Fundamentals
Software Applications for CAD & CAE

REVERSE ENGINEERING

CMM
Micro Profile Tester
Roundness
Roughness tester
Profile Projector
CAD Modeling & Surfacing

PROTOTYPING

Rapid prototyping
CNC Machining
Jigs and Fixtures

WHAT WE BELIEVE
OUR CORE VALUES

TRUST: TCR is guided by its intrinsic value of building trust among all its stakeholders. For over four decades, TCR has displayed deep intellectual honesty to tell it like it is, in a direct and straightforward manner with uncompromised accuracy.

PASSION: Passion drives TCR. We are passionate about what we do and it is deeply reflected in all our activities. Our team of experts demonstrates the same passion and are committed to making a difference and ensuring business success for our clients.

INTEGRITY: At TCR Engineering, Integrity means being ethically unyielding and maintaining absolute honesty. We inspire trust by matching our actions to our words and take responsibility for our actions. We are committed to conducting business on a daily basis with fairness, integrity, and respect for the regulations and staying true to our values.

COLLABORATION: We foster a trusting, open and inclusive environment where each interaction is reflective of our values. We believe that respect builds trust and promotes collaboration. We treat our people and places around us with the greatest degree of care.

PERFORMANCE EXCELLENCE: TCR Engineering is united by a strong set of values that are focused on client impact. Our work is founded on a rigorous understanding of every client's business context, sector dynamics, and the macroeconomic environment. We have evolved into a trusted transformation partner who is focused on bringing to life solutions that drive progress for our clients.

ACCOUNTABILITY: We set high-performance standards and are accountable for the quality of work delivered to our clients and the results we achieve as individuals, as team members, and as a company. We ensure responsiveness, reliability, and repeatability and deliver on our commitments — to our clients, stakeholders, our partners, on time, every time.

WORDS THAT DEFINES US

- Responsiveness, Reliability & Repeatability
- Uncompromising Quality delivered on time
- Tangible Results that drive action
- Fiercely Unbiased with unwavering ethics
- Passionate experts equipped with latest technology

OUR MISSION: To provide trusted and unbiased solutions for efficiently managing plant operations of global organizations and build a better future for material testing driven by its highly credible thought leadership.

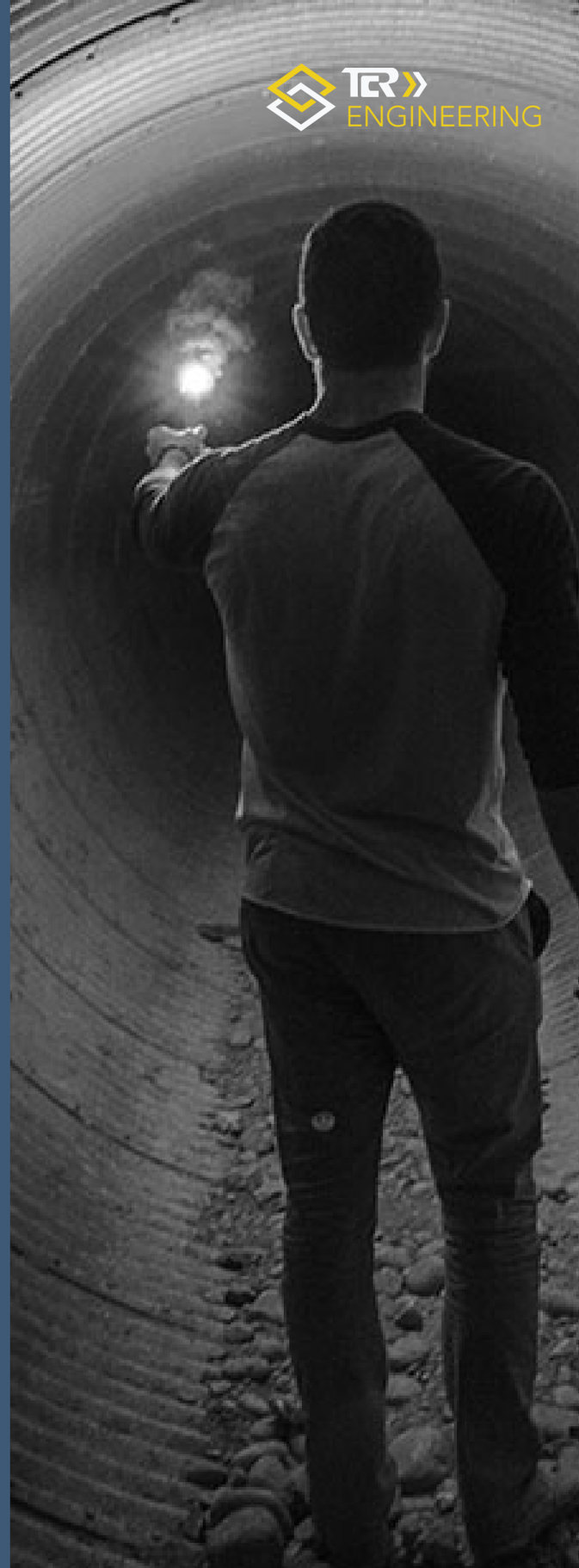
OUR VISION: To be a significant transnational company by providing on-time repeatable solutions, impeccable quality and actionable results in material testing, inspection, and consulting services

WHO WE ARE: Laboratory for Material Testing, Engineering Research, and Consulting Services

WHAT WE DO: Testing | Advisory | Inspection

WHAT WE OFFER
- 44 Years of Legacy
- Honest Intellectual Insights based on Deep Subject Matter Expertise
- Global Perspective that is Translated to Teams for Addressing Local Needs
- Diverse Local and International Clients
- Comprehensive Service Offering under One Roof

CLIENT ADVANTAGE: Reduction in plant shutdown time with on-time quality results



WHAT WE BELIEVE

TCR Health, Safety And Environmental Policy

TCR is committed to good Health, Safety and Environment (HSE) practices based on sound risk assessments and appropriate training. With its zero tolerance approach towards HSE compliance, TCR has an exemplary track record since the inception of the company with the absence of any major lost-time arising out of health, safety, or environmental accidents. With its proactive risk aversion approach, TCR remains as the safest chain of commercial laboratories in the region.

By setting high standards, TCR expects all its managers to be actively involved with respect to safety and protection of all stakeholders including its clients, visitors and contractors on company premises and the public at large. TCR ensures safety controls with procedures, records and maintenance contracts are in place to control safety including:

- Fire Alarm and extinguishers maintenance contract
- H2S Procedures
- Training Records
- Injury Records
- Control of flammable substances and acids

TCR is committed to conducting its activities as per the following guidelines:

Each TCR location will comply with all applicable Safety, Health and Environment Regulations within the territory in which it operates

While the Directors and Management accept their responsibilities for Health and Safety at work, they expect all employees to play their part and to fulfill their legal obligations under Health and Safety Legislation by taking reasonable care to avoid accidents to themselves and others and following company procedures. Full mutual cooperation will ensure common objectives are achieved

Every employee has the responsibility to maintain a safe working environment in which risks arising from the TCR's working practices are identified and controlled. Any willful violation of safety policy will result in disciplinary action.

On-Site Safety Readiness

Each member of the site team working on a particular project will be briefed prior to his or her first visit to site on the safety hazards associated with site work.

A site visit can be organized by the company representative to discuss the safety aspects with the site safety officer

In case a safety-training program is in existence on client site, staff will have to attend it mandatorily

The company representative carries out periodic site visits and regular safety reviews with site staff

TCR will supply all the required safety wear necessary to provide the required protection on-site, if the same is not provided by the client

TCR Environmental Protection Guidelines

As a responsible organization, TCR has over the years demonstrated a strong commitment towards environmental protection. Continuous improvement and sustainability has been the driving force of its environment policy. TCR acknowledges that its activities have an impact on the environment; therefore, it encourages all its employees to strictly comply with our internal policies by ensuring:

Zero disposal of untreated chemicals or other substances down internal drains. It's mandatory for all employees to check with their supervisor for the correct disposal procedure

Use of proper waste management system to ensure all classes of waste are disposed of in accordance with current legal requirements and local rules

Storage of all oils and chemicals including solvents and paints in designated bounded areas

Use of designated area especially for Refueling site transport, compressors etc.

Special training for site emergency procedure for spillage or leakage for all the employees handling substances hazardous to the environment

Only authorized personnel are allowed to fill or drain bulk storage tanks

Mandatory reporting of all spillages/leakages and other incidents including breakdown or malfunction of any plant, equipment controlling discharge into the environment and other housekeeping activity at risk

Breach of HSE Policy

The definition of a serious breach of Health, Safety and Environment Policy is very difficult to categorize objectively in a prescriptive sense and therefore circumstance will dictate the appropriate disciplinary action. There are of course specific instances where summary dismissal will be applicable:

Recklessness in the use of chemicals and radiation sources or any other hazardous materials

Intentional removal or deactivation of any safety device

Operating equipment under the influence of alcohol or drug abuse

Falsification of safety records or incident reports

Illegal disposal of any hazardous substance

Willful negligence to carry out proper maintenance of buildings, equipment etc.

TEAM TCR

TCR demonstrates a "one team" attitude that is reflected in its leadership in all practices and offices across TCR. TCR's strength lies in its people. They have driven individuals who work in teams with cutting-edge technologies set in an environment of transparency to deliver pragmatic action. The teams constantly re-engineer themselves to be more responsive to customer needs by identifying challenges and facilitating solutions that promote growth and deliver exceptional results for their clients, their communities and their people. Meet our exceptional talents by reading their profiles below:

A PARESH HARIBHAKTI, *Chief Failure Analyst and Managing Director, TCR Advanced Engineering*

Mr. Paresh Haribhakti is the Managing Director of TCR Advanced Engineering Services in Baroda, India (a TCR Engineering Services partner company).

With more than 250 failure investigation cases Paresh has an intensive and vast body of work to his credit. 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 weldments.

He 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 usable concepts. Paresh uses simple analogies and every day examples in laymen terms to explain data and findings to clients, corporate executives, government officials, or attorneys for them to understand engineering concepts.

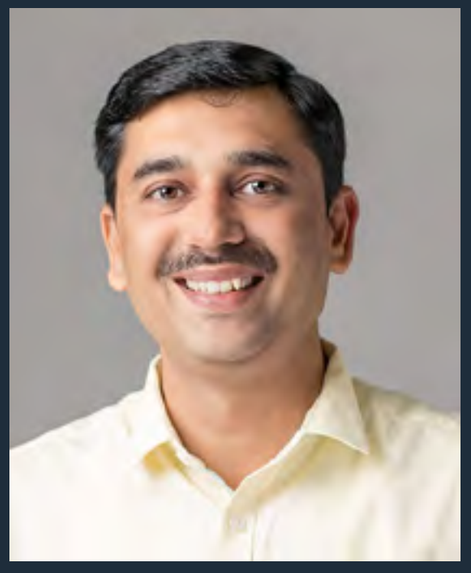
Mr. Haribhakti has specific experience in welding, heat treating and materials technology for oil & gas drilling and production applications, including production tubing, casing and down hole motor failures. Recently, Paresh was lead member of the Failure Investigation team consulting to Asia's largest refinery, RIL-Jamnagar, India for damage assessment work during a fire incident in their VGO-HT2 Plant. He has provided damage assessment of Hydro-cracker reactors at Baiji refinery Iraq and also helped a customer procure second hand equipment from Taiwan by a Health assessment approach.

He is skilled in the use and application of scanning electron microscopy (SEM) in support of failure analysis and fracture identification. Mr. Haribhakti also undertakes Optical metallography and interpretation of microstructures, Remaining Life Assessment, provides Heat treatment solutions and studies the degradation of microstructure under high temperature high pressure conditions. He has done extensive research in study of hydrogen embrittlement of steels and stainless steels.

Research oriented creativeness of Mr. Haribhakti spearheaded the development of a powerful image analysis software for Metallurgical use - the Microstructure Characterizer Software (MiC). He has also developed a well respected chemical composition mapping method for identification of dilution in weld zone. He performs color metallography to increase the capabilities of interpretation of microstructure. He has also developed custom electrolytic polishing for carbon and alloy steel material.

Mr. Haribhakti is a Founder member of Metallography Society of India. He is an active member of the Institute of Engineers, Institute of Foundry Man, Indian Institute of Metals and Indian Institute of Welding. Mr. Haribhakti is a B.E. (Metallurgy) and M.E. (Materials Technology) from M.S. University, Vadodara.

B GANESH SONAWANE, *Head of Quality Assurance*



An extremely sound broad-based technical understanding of the laboratory sector has made Mr. Ganesh Sonawane a key contributor in creating TCR Engineering Services into a quality oriented state-of-the-art laboratory.

With strong understanding of QA principals (NABL and ISO/IEC 17025) and excellent inter-personal skills, Mr. Sonawane has provided the edge to complete projects on time, within budget and with quality. His patience, business ethics and conduct has ensured that TCR's QA standards are never compromised.

Mr. Sonawane is trained as qualified internal auditor for carrying out audits by DNV. He has expert knowledge in Analytical Chemistry, materials identification of organics and inorganic materials. He has extensive experience in problem solving and method development for non-routine testing and possesses superb knowledge of classical and instrumental method of analysis. As a quality assurance manager, Mr. Sonawane ensures that the TCR laboratory stays compliant and accredited to all applicable standards including NABL, BIS and ISO 17025. He develops and maintains the Scope of Accreditation including conducting internal quality audits on calibration processes and correct test procedures. He also assists in conducting a technical audit on the technicians performing all material testing services.

Mr. Sonawane facilitates as a point of contact and escort for customer and regulatory audits. Mr. Sonawane has advanced knowledge of chemical sciences, especially analytical techniques and instruments with good decision making skills. He ensures accurate results reporting from all analytical instruments including the Optical Emission Spectrometer (OES), Inductively Coupled Plasma (ICP) Spectrometer, Automatic Combustion based Carbon and Sulfur determination, and Glow Discharge spectrometer.

Mr. Sonawane also performs Material Certification including Unknown Material Identification and Trace Element Analysis on Powdered Metal, Chips/Shavings and Solder Alloys (Tin/Lead), Coating Weight and Identification, Quantitative & Semi-Quantitative Analyses including Density of Powdered Metals. He also supervises the conduct of Restriction of (certain) Hazardous Substances (RoHS) testing using the Portable XRF and ICP spectrometers. Mr. Sonawane's analytical exposure also includes wet chemical analysis of copper ore, cobalt ore copper carbonate, cobalt carbonate , calcium carbonate , sodium carbonate, sulphuric acid, copper cathode, leach slurry and liquor from Ball mill samples. He has conducted personally analysis of raw material like copper concentrate, Rock phosphate, Ferric sulphate, sodium sulphide, River Sand, quartz chips , Lime stone, Quick lime, Hydrated lime ,Baryte etc by wet chemical analysis. He has also undertaken analysis of moisture , volatile matter, silica, ash content and fixed carbon content of coke and coal samples as well as complete analysis of Sulphuric acid for various parameters.

Mr. Sonawane is well versed in performing fire assaying of copper concentrate and baryte samples for precious metal content, analysis of copper matte ,copper slag, oxidation and reduction samples of copper metal, copper cathode, copper anode and blister samples of copper by wet and instrumental method, analysis of converter dust ,gas cooler dust and ESP dust for various impurity level by wet chemical and instrumental method of analysis as well as analysis of soft water ,Raw water, cooling tower water, DM water, copper electrode samples for various parameters.

Mr. Sonawane has a Bachelor of Science in Chemistry from Pune University.

C S. S. SHANBHAG, *Chief Metallurgist*

Mr. Shanbhag is a chief Metallurgist with over 26 years of experience. He serves as a technical expert on the most complex metallurgical testing projects.

Mr. Shanbhag is "Hands-on" in the laboratory and performs material testing, analysis and results interpretation of numerous samples analyzed through the laboratory including mechanical, chemical, metallography and corrosion. He is part of the investigative team that performs failure and root cause analysis of failed components.

He performs and assists in routine metallurgy, including micro preparation, etching, phase counting, grain size measurement, micro structural assessment etc. He administers the mechanical test laboratory when team members are conducting tests such as Tensile, Charpy Impact, Sour Gas corrosion testing including HIC and SSCC, and Microstructure Analysis.
He interfaces with the machining department to ensure that samples are prepared as per the ASTM, NACE, BS, IS or client-specified standards. Mr. Shanbhag reviews, recommends and implements new and enhanced testing equipment or protocols. He has the unique ability to research and analyze information of considerable difficulty and draw valid conclusions. He has a strong understanding of QA principals (NABL and ISO/IEC 17025) and good inter-personal skill.

Mr. Shanbhag is skilled in mentoring, supervising, evaluating, training and motivating employees. He provides guidance and counsel to fellow team members and is capable of cross-training department personnel to perform job functions in various testing areas. Interface with customers and vendors in technical issues related to materials and special processes. Assist the customer relations team and help resolve issues in a timely and effective manner. Contributes to the improvement of metallurgical testing department by advising on new test equipments and latest innovative procedures.

Mr. Shanbhag has a Bachelor of Engineering in Metallurgy.

D MUKESH KUMAR,
Sr. Metallurgist (B.Tech & M.Tech, IIT in Metallurgy)

Mr. Mukesh has extensive knowledge of failure investigations on metallic components related to chemical/refinery plants and to general engineering. Experience ranges from cast iron, engineering steels, aluminum, copper alloys, stainless steels, and nickel base alloys to titanium. This includes all aspects of metallurgical investigations of offshore, marine, refinery and automotive components such as; turbine blades, compressors, gearboxes, motors, pumps, rotors, shafts, valves, pipe work, fasteners, boilers, pressure vessels, plain bearings, rolling bearings, gears, pistons, spark plugs, crankshafts, camshafts, engine valves and associated valve components.

Mr. Mukesh is well experienced in the Microstructure Characterizer Software, which has been developed internally at TCR, for grain size measurement, volume fraction, nodularity assessment, case depth measurement. Mr. Mukesh has deep rooted understanding in metallurgy including micro preparation, etching techniques, phase counting, and microstructure assessment etc.

E AVINASH TAMBEWAGH,
Head of Advance Testing

Avinash leads the Advance Testing vertical and has nearly 20 years of experience in Corrosion Testing, In-Situ Metallography, Consultancy, Failure Analysis. He has extensive knowledge in carrying out corrosion testing, metallurgical activities, mechanical testing and fractography). Avinash is adept in failure analysis of industrial materials, evaluation of material characteristics for production & quality assurance, materials selection for specific end-applications. He has extensive knowledge in heat treatment of Industrial Ferrous Materials, Micro-structural Design for Steel / Alloy development. Avinash has completed B.E (Metallurgy) from Govt. College of Engineering Pune.

F Ms. GAUREE S. DEOLE,
B.E. Mechanical

Ms. Gauree has experience working with 'rotating equipment designs (especially pumps and mechanical seals)' in oil and gas industry. Analysing technical documents, understanding general arrangement drawings and reaching to a valid conclusion is one of her unique characteristics. Along with this industrial experience in designing field, she is good with material testing knowledge. She looks after all the third party inspections that take place at our laboratory, handles their technical queries efficiently and interprets/analyses the testing results. She also assists her seniors with machining department to make sure whether the machining of material takes place as per standards.

G ROHIT K. WAGHMARE,
B.E. Mechanical

Mr. Rohit has knowledge in the field of Fatigue, Fracture mechanics & Fracture Toughness. He has an experience in the field of Production as well as in the material testing laboratory. A sweetmouth person who knows how to get work done from workers. He has hands on practice in the fatigue testing which includes the components like springs , seat belts , Reinforcement Couplers etc. he is from production background which includes the Production,Erection, Commissioning and Inspection of FRP BLOWERS, HDPE TANKS, COOLING TOWERS , FRP CHIMNEY SYSTEM.

H SHEMI BASKARAN,
ASNT Level III NDT Inspector

Mr. Baskaran has 18 years of experience in QA /QC inspection in oil and Gas industry, Petrochemical and refineries and is qualified as a ASNT LEVEL III RT, MT and PT. He is experienced in static equipment inspection and Third Party Inspection of materials like plates, pipes, forgings, casting at a vendor's location. He also has hands on experience in NDT (RT, MT, PT) and Radiographic testing and film interpretation.

I AMIT BAFNA,
Middle-East Operations Manager at TCR Kuwait

Mr. Amit Bafna has over 5 years of strong NDT and QA/QC project management experience. He has the ability to read technical documentation, motivate team members and do resource allocation. He co-ordinates with team members to ensure that all client or vendor provided drawings and specifications, technical surveys and major equipment reviews are in compliance with corporate and international standards.
Mr. Amit Bafna has a degree in Science as well as an ASNT Level II certification in compliance with CP-189. He is trained in Canada on the use of Automated UT using Time of Flight Diffraction. He is well versed in writing NDT test procedures including conducting hands-on tests in UT, DP, MP, PT, Ferrite Measurement, Hardness Survey, Positive Material Identification and In-situ Metallography. Coupled with strong leadership skills, Mr. Bafna both metors and supervises fellow team members.

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.

As a Operations Manager for Middle East, Mr. Bafna leads his team members and provides quality assurance, quality control and quality monitoring functions to ensure that all purchased commodities comply with corporate and customer technical standards. His job also includes Performing / Coordinating Quality Control activities on company purchased materials and monitoring activities on contractor issued purchase orders, assessing capabilities of potential vendors as well as performing proactive inspections through increasing surveys, organizing strategy meetings with the client's Project Management Teams and contractors including coordinating pre-shipment inspections.

Experience in managing complex business relationships, both internal and external, where conflicting priorities of team members must be managed with customer satisfaction as a primary goal. Mr. Bafna has a strong understanding of the company operations to properly support and represent TCR in a mature and professional manner. He has developed oral and written communication skills to meet variety of communication needs (performance reviews, presentations, employee training and development, and leadership).

Mr. Bafna has strong interpersonal skills that foster open upward and downward communication built on mutual respect. Ability to remain calm when faced with mounting pressure related to deadlines and multiple priorities. He has the flexibility, and maturity to represent the company at a broad range of events in the community, with customers, and within the company.

J ROHIT BAFNA,
Director Global Sales

Rohit is currently Director Global Sales based in TCR World in Washington DC, 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 Rohit include Caterpillar, Enerflex, Hyundai, Aventech, Elliot Company, Elliott Company, 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 decades of Sales and Marketing in the Material Testing and Quality Assurance business. Rohit has undergone extensive training on Ultrasonic Testing using Time of Flight Diffraction (TOFD) at Olympus in Quebec, Canada.

Mr. Bafna has a Bachelors degree in Computer Sciences from DeVry Institute of Technology, Los Angeles, California and with over 3 decades of sales experience.

K SURESH ACHARYA, *Country Head*

Mr. Acharya has over 28 years of experience managing many projects including the ability to manage multiple priorities while retaining high professional and ethical standards with overseas clients. He maintains close interaction with third-party suppliers, external laboratories, customers and company staff / technicians as well. As Country Head, he receives and analyses scope and specifications for works and services to be contracted, clarifies work aspects and verifies technical evaluation criteria. He also proposes contract type, prepares tender document and finalizes them with Finance and Management input.

Mr. Acharya has managed a variety of projects and contracts from routine testing jobs to specialized projects in oil and natural gas companies

Mr. Acharya work closely with established clientele to maintain good standing and pursue additional opportunities. He maintains a keen entrepreneurial interest and participation in business growth and pursuit of new opportunities and offerings. At many occasions, Mr. Acharya suggests and pursues new technical offerings and is at all times aware of potential new clients and pursues relationships as appropriate. He develops business practices that encourage team building and participation by others within the organization.

Mr. Acharya's role also includes responsibility for technical performance, schedule, budget, coordination of proposal responses, and decision making in business development globally. He leads a multi-disciplinary filed services team within TCR and provides leadership, vision and direction. Mr. Acharya's expertise and guidance enables TCR recruiters to accurately assess potential job seeking candidates' abilities and interests.

Mr. Acharya has a Bachelor of Commerce degree from Mumbai University. He has completed Post Graduation Diploma in Computer Programming and System Analysis from Mumbai University.

L 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. In fact he has handled India's First Environmental Scanning Electron Microscope with EDAX analyser for more than five years.

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.

M KETAN UPADHYAY, *Reliability Engineering*

Mr Ketan Upadhyaya is a B.E. (Metallurgy) from M.S. University of Vadodara and has experience of 22 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.

SOHEL VAIDYA
Team Leader Advanced NDT Division

Mr. Sohel is an ASNT II Engineer in Ultrasonic testing, Interpretation of Radiographs, Liquid Penetrant Testing, MPT
(Magnetic Particle Testing). As an Inspector he performs daily Inspection of piping fabrication, Inspection of daily fitup, weld visual inspection and preparation of documents, Monitoring welder performance and weld repair status on weekly basis, Preparing QA/QC reports, Prepare the pre-punch list prior to hydro test, Documentation of Welding, NDT reports

Preparation of reports for client submittal, Welding material control, Welder control, Welding and welding repairs, Responsible to complete necessary documents for all witnessed items, Co-ordinating with construction supervisor / engineer, Reporting for poor workmanship and violation and Co-ordination with NDT crew and third party agencies.

He has over 10 years of strong project management experience. He has the ability to read technical documentation, motivate team members and do resource allocation. Sohel co-ordinates with team members to ensure that all client or vendor provided drawings and specifications, technical surveys and major equipment reviews are in compliance with corporate and international standards.

ANIL JOSHI
ASNT Level II in MSLT (Leak Detection)

Mr. Joshi is an ASNT Level II in Leak Detection. He is well experienced in working with the Alcatel ASM 140 and Varian Helium Leak Detection Machines. He has over 30 years of experience in Helium Leak Detection. He is capable of working in the two methods which are applied for leak testing and localization of leaks, the “Vacuum method” and the “Overpressure method”. He has detected leaks in-situ to prevent unplanned and expensive shut downs.
Mr. Joshi has tested components for Nuclear Power Corporation (NPC), Heavy Water Board (HWB), Bhabha Atomic Research Centre(BARC), Roll Metallizers manufactured by Gallelio, Italy, Applied Vacuum, Germany as well as Vacuum Furnaces. He has visited Varian, Palo Alto (USA), Torino (Italy), Zug (Switzerland) for training and inspection of Vacuum Coating Units.

TCR ADVISORY BOARD

TCR has assembled a strong team of external experts who will provide technical leadership to the company. TCR draws on this experience to provide the best solutions for their clients The highly talented team of experts includes:

1. **DR. G. E. PRASAD,** *Retd. Head Materials Characterization Section BARC, Ex Hon. Secretary of Indian Nuclear Society*
Dr. G.E. Prasad is a well known personality in the field of Metallurgical Investigations and Failure Analysis. He has been associated with Dept. of Atomic Energy till he retired in 2001. Dr. Prasad has also represented India in a 3 member team who was involved in Kanishka (Air India Jet) blast case. He has numerous investigations of failure in Heavy Water Project, DAE and governmental institutions around the country. Dr. Prasad has been a General Secretary of such renowned societies as Indian Institute of Metals (Mumbai Chapter), Material Research Society (Mumbai Branch) and Indian Nuclear Society (Mumbai). He is the ex. honorary secretary of the Indian Nuclear Society.

2. **MR. C.V. SRINIVASAN**, *UNDP Corrosion Specialist*
Mr. Srinivasan is the Technical Director, Nishi Engineers Pvt Ltd Chennai with over 42 years of professional experience. He has published 38 papers on Corrosion, Metallurgy, Welding, N.D.T in various International and National Conferences on Corrosion, metallurgy, Welding, Non-Destructive Testing, Vibration + Journals from 1965 onwards including UNDP conferences. His expertise includes conducting Third Party & Statutory Inspection / Certification of LPG/Butane/Pentane / Ammonia/ VCM/ Chlorine / Nitrogen/ Oxygen Static Storage Vessels (Bullets / Spheres), Petroleum / Methanol/ Diesel/ HSD/ LSD/ Kerosene etc Storage vessels, Used Pressure Vessels / Used Lifting Machines / Lifting Tools, Cranes, Hoists etc.

   He is an expert in conducting Risk Analysis and Safety Audit for Chemical, Fertilizer, Petro-chemical, Refinery, Steel Industries and also provides consultancy in Corrosion, Metallurgical Studies (including Failure Analysis) for Plant equipment / piping etc failures. He assists in guiding on Non-Destructive Inspection, In-situ Metallography of special equipment / piping during project stage or after some years usage as well as providing Vibration Engineering Consultancy for high speed turbo-compressor rotating machinery / high speed pumps, blowers, fans etc on a need basis.

3 **MR. K. RAVINDRAN**, *NDT Level III*

Mr. Ravindran has the unique distinction of holding the ASNT NDT Level III certification in 11 subjects including RT, UT , MT , PT, VT, ET, LT, IR ,AE, VR and NR. He also carried the AWS CWI certifications. He has an overall experience of 25 years in inspection field of castings, forgings, pressure vessels (Designing, fabrication inspection) and pipe lines inspection. He is familiar in Destructive and Nondestructive inspection technique, as applicable to Welds, castings, forgings etc as well as inspection of raw materials with relevant specifications. He is thoroughly familiar with all the relevant applicable Codes and Standards for Nondestructive Testing and well versed in the documentation procedures. He is a post Graduate in physics, Post Graduate Diploma in Radiation Protection by Bombay University BARC (INDIA). He has over ten years experience in conducting training courses and classes all most in all methods of NDT, welding technology and casting and foundry technology.

4 **DR. RAJENDRAKUMAR**

Dr. Rajendrakumar is a renowned metallurgist of our country. He is a doctorate from world famous University of Shefild, UK. Dr. Rajendrakumar was the Director of National Metallurgical Laboratory, Jamshedpur and a former Director of Regional Research Laboratory, Bhopal. Dr. Rajendrakumar 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.

5 **DR. P. B. JOSHI**

Dr. P B Joshi is 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”.

6 **DR. K. BABA PAI**

Dr. Baba Pai is the 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

since past 18 years. Under his able guidance more than 4 Students were awarded PhD. Presently three students are perusing PhD Under his guidance. He has more that 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.

7 **MR. JAGDISH BAAD, CONSULTANT**

Mr. Jagdish Baad is Bachelor of Technology in Metallurgical Engineering with First Class honors from IIT, Mumbai. He is having 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 Turn key 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 years running an independent consultancy, related to TQM-Product Management of Castings & Forgings and metallurgical related turnkey projects. 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.

8 **MR. PRAKASH BHRAMBHATT, CONSULTANT**

Mr. Prakash Brahmbhatt is Ex – GM inspection dept of M/s IPCL Erstwhile RIL. 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.

9 **DR. MUKESH PANDYA, CONSULTANT**

Dr. Mukesh Pandya is Ex-DGM (Research) from Gujarat State fertilizer Company (GSFC) Limited, India’s premier fertilizer company. He is having a Ph.D 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, Sweeden, M/s Krupp VDM Germany and M/s Cormon UK.

MARQUEE CLIENTS

TCR Engineering Services believes in establishing long-term, strategic relationships with customers as opposed to short-term, opportunity-based engagements. TCR has had the chance to serve across multiple industry verticals and has a long-standing track record of delivering quality assurance services to some of the best-known refineries and organizations in the field of oil and gas chemicals, electronics, construction, power generation, automotive, defense, aerospace, mining, pharmaceutical, biotechnology, manufacturing, process industry and all of the major public sector verticals.

TCR has established a successful Global Delivery Model. TCR's rapidly growing global delivery services model allows TCR to be the preferred back-end material testing laboratory for some of the world's largest corporations. This allows global customers to take advantage of reduced cost for material testing while maintaining the same quality standards that they expect in their country. Over the years, TCR has performed laboratory testing and inspection services for numerous customers in the North America, Europe, Africa, Middle-East and Asia-Pacific.

Over 3500+ customers in India and Overseas use TCR's services to dramatically improve and certify their products, validate material quality, ensure innovation in the marketplace, and to achieve significant competitive advantages.

MAJOR PROJECTS

Each one of the below listed jobs were part of a unique and interesting challenge to our teams at TCR Engineering Services. TCR's clients saw a measurable value and hence, companies were able to bring the right products/services to the market, at the right time and at the right cost. TCR's noteworthy projects include:

Failure Analysis Projects

Schlumberger Oilfield Servics
Failure Investigation (FI) of Mandrel Bypass of Equalizer Sub.

GAIL India
Root Cause Analysis at a Lpg Recovery Plant

Wartsila, Finland
Failure Investigation of Crank Shaft

Man Industries India
FI of Mechanical Expander Pull Rod

Thermax
Failure Analysis of Cupro Nickel Tubing of Chiller Unit

Siemens Ltd.
Failure Investigation of ESV Sleeve DN 200

Weir Mineral India
Root Cause Analysis of Shaft Failures in Vertical Pumps (Cantilever Design)

Hydril Jindal
Failure Investigation of Die Cracking In Swaging Process (Cold Forming Process)

Sterlite Industries India Ltd
Volute Casing, Crane Hook / Pump Failure Investigation

Welspun Gujarat Sthal Rohen Ltd
Failure Investigation of Api 5l Psl 2 X60, (Pipe No. 3612) Line Pipe Failed During Hydro Test at site

Torrent Power Ltd.
Failure Investigation Of Blade of Lp Rotor Stage 4A Of ESM 110MW Unit

Oil India Ltd.
Corrosion Evaluation of Oil Well Tubing through Root Cause Failure Investigation

Caparo Engg P. Ltd
FI of Axel A Rear Suspension Of Car

Munjal Auto Ltd.
FI of Exhaust Muffler KTPA

Godrej Industries Ltd.
Failure Investigation of Reformer Tubes

ALSTOM Projects
Failure Investigation of High Density Balancing Weight

Hindustan Petroleum Corporation Failure Investigation Of Radiant Heater Outlet Header Cap

Avtec Ltd.
Failure Investigation Of Crank Shaft Of Diesel Car Engine

Bombardier Transportation India
Failure Investigation Of Notching Spring Of Tap Changer

Ratnamani Metals & Tubes Ltd.
Failure Investigation Duplex R 2205 (50.8 X 2.13 Mm) Tube Failed During Hydro Forming Expansion

Positive Material Identification

Kuwait Oil Company
2 crews of PMI using portable XRF and portable Optical Emission spectroscopy

Hyundai Heavy Industries
Portable XRF on Pipe Joints

Cochin Refinery
PMI for Stock sorting purposes

Reliance Industries
Detection of Carbon using portable Optical Emission Spectroscopy

Petronas, Malaysia
PMI crew on assignment on behalf of L&T, India

Indian Oil Corporation
6 PMI crews deployed for a period of 2 years using portable XRF spectrometers

Bharat Petroleum
One PMI crew for identifying incoming materials at site

Larsen & Toubro, Mumbai | Godrej & Boyce Mfg., Mumbai | Oswal Petro Chemicals | Tyco Sanmar, Tamil Nadu | Virgo valves, Pune | Hawai valves | Endress+Hauser india pvt ltd, Mumbai
Bombay Fluid / Swagelok
Ongoing on-call PMI services provided using portable XRF spectrometers

Metallography Assignments

Constar, USA
SEM Analysis of Plastic samples taken on 3-4 KX, 20 KV voltage magnification

NDT-CCS
Evaluation of Metallographic Replicas

Reliance
Over 1200 metallographic replicas created and analyzed to evaluate post fire damage

Zamil Group
Micro Hardness Testing

Alsom
SEM and EDAX Analysis

Massod John Brown, Dubai
SEM analysis to characterize the carbide morphology types in cobalt based alloys such as FXS 414

Biosync Scientific Pvt. Ltd.
Measurement of drug Coating layer on Drug coated stent used in Angioplasty

Godrej Industries Ltd.
Remaining life assessment was carried out through Insitu Metallography route

Lupin Ltd.
Remaining life assessment of fermentor vessel was carried out by Evaluating microstructure at critical locations.

Gujarat Power Generation Co. Ltd. Bharuch
Microstructure evaluation at critical locations of HRSG Unit

National Thermal Power Corporation
In situ Metallography conducted on critical components of turbine.

Metallography Assignments (Cont.)

IFFCO
Insitu Metallography for evaluation degradation of microstructure of ammonia plant for remaining life assessment.

IPCL
Insitu metallography at critical locations of naphtha plant

L & T
Insitu Metallography for microstructure evaluation after various manufacturing stages of critical components

Bharat Petroleum Corporation Ltd.
Damage assessment of Scrubber column and condensor tubes.

Zuari Industries Ltd.
Metallography Work Conducted On Various Critical Locations Of Process Steam Supply Heater Outlet Piping

Hindustan Petroleum Corporation Ltd.
Insitu Metallography of reformer tubes

Suzlon Windfarm Services Ltd.
Damage assessment of windmill caught in accidental fire through Insitu Metallography route

Tata Power Company
Insitu Metallography work conducted on critical locations of Gas Turbine Unit -7 during outage.

Elecon Engineering Ltd.
Insitu Metallography at various locations of large size Gear

Gulbrandsen Limited
Damage assessment through Insitu Metallography route on ammonium chloride anhydrous vessel

Nagarjuna Fertilisers & Chemical Ltd.
Insitu Metallography of ammonia plant

United Phosphorous Ltd.
Insitu Metallography of evaporator support to assess the stress corrosion cracking

Indian Oil Corporation Ltd.
Insitu Metallography of FCC plant

Gujarat State Fertilizer Company
Insitu-metallography work on Reducer of Outlet Bottom Header of Reformer at Ammonia – IV Plant

Tata Chemicals Ltd.
Various critical locations of Urea Plant

Essar Steel Ltd.
Insitu Metallography on cooling coil of furnace.

Fatigue & Fracture Toughness

Naval Materials Research Laboratory, India
Crack tip opening displacement testing as per client Requirement

Jindal Steel & Power Ltd., India
Fatigue crack growth rate test as per ISO 12108

Amsafe Bridport, Sri Lanka
Fatigue testing of Bulk-Hold baggage nets (Belts) as per client Requirement

Remaining Life Assessments

Torrent Power
Remaining Life Assessment and Investigation of Blade failed from root for LP Rotor stage 4A of E Station 110MW Unit.

Zuari Industries
Remaining life assessment of steam pipe line and surface cracks.

Alstom Power
RLA study through Insitu-metallography work of critical components of 120MW Turbine at MSEB-KTPS, Koradi

Asha Cellulose
Health assessment work on R-1 Reactor at Mech Engineering, Valsad

Vanakbori Thermal Power station
RLA Study of various components of Boiler No - 2

Hindustan Unilever
- RLA study of critical components of MP Boiler No.- 1 (G-122) at Kundaim Ind., Goa
- RLA study of critical components of Boiler No - 1 at V.D.L. at Khed, Chiplun Location
- Insitu metallography work on various components of Boiler No. - 1 (UP – 4702) at Orai Location
- RLA study of various pressure components of Stein Mullar Boiler No. - MP-6495 at Sewri

Gujarat Fluoro-Chemicals Ltd.
- Metallurgical Assessment of CFC Reactor R-501 and Column C-513 at Formosa Plastics Company Taiwan Roc
- ondition Assessment work (VE, Metallography, U.T, MPI, Hardness & Thickness Survey) on AHF Bullet V-318
- Health assessment work on R-201 Main Reactor CFC plant (Metallography& hardness) at Alfa-laval, Pune

Unilever Bangladesh
RLA (Visual, MPI, DP, Metallography, Hardness & Thickness Survey) on critical locations of Package Boiler at Unilever Bangladesh Ltd, Chittagong, Bangladesh

Atul Industries Vapi, Gujarat
- RLA of Chlorine storage tank
- RLA Study (Insitu-metallography, MPI & Hardness) on Old Autoclave – G 2101

Alembic Limited, Vadodara
RLA of fermentor

Godrej, Valia, Gujarat
- Remaining Life Assessment of Used N9 Pipe for Alcohol Synthesis Plant
- Remaining Life Assessment Of Alcohol Synthesis Plant

IOCL
Health Assessment Study of C-0.5Mo Piping in Hydrogen Unit-I Plant

Siemens Ltd
Remaining Life assessment of turbine

Jaghadia Copper
Condition assessment of tandle furnace

Aarti Industries
RLA of turbine

Corrosion Detection

Caterpillar, USA
Weight loss corrosion test for over 35 sampl.

KPIOS, Kuwait
Hydrogen Induced Cracking Test as per NACE standard for over 15 plate samples

Enerflex Canada
HIC and SSC corrosion tests as per NACE TM 0177 and TM 0284 for over 20 samples

Ecolab Canada
Salt Spray test at a Coca Cola plant

GMMOS, UAE
HIC and SSC testing on over 15 samples

Larsen and Toubro (L&T)
- HIC testing as per NACE TM 0284 on an ongoing basis and Intergranular Corrosion of Aluminium Alloys by Mass Loss After Exposure to Nitric Acid As per ASTM G67

Jutal, China
SSC test based on Sinopec approved standard(closely adopted to NACE guidelines)

Xalloy, Thailand
Chloride Stress Corrosion Cracking, Inter-granular Corrosion as per ASTM A262

Johnson Screens, Australia
Weight Loss Corrosion Tests

Walchandnagar Industries
HIC and SSC Testing

Godrej , Mumbai
Stress Oriented Hydrogen Induced Corrosion as per NACE 0177 method D

Bay-Forge Pvt. Ltd. , India
Visual Assessment of Exfoliation Corrosion Susceptibility of Aluminum Alloys as per ASTM G66

Non-destructive Testing (NDT)

ONGC, Iran
40 team member crew deployed for shutdown activity including conventional NDT, scaffolding, and shutdown project management

NPCIL, Kota
Shutdown Crew deployed for NDT including 20 NDT Level II and 1 NDT Level III person

Unilever Bangladesh
Ferrite Survey, UT Thickness Measurement and Hardness Checking

Indian Naval Shipping
NDT and RLA Study of LPG Tanker

Several projects for EIL and L&T
Ongoing daily callouts for UT, DP, MP, PT, Ferrite Measurement, Portable Hardness

KOC, Kuwait
Automated UT using ToFD for Storage Tanks based on API 650 Appendix U. Project undertaken with HHI as EPC contractor

Tekfen, KSA
Automated UT using ToFD based on Code Case 181 undertaken at Aramco's PetroRabigh site

Mass Construction, India
Conventional Radiography by using X-ray source based on ASME SEC VIII Div. 1 Conventional Radiography by using Gamma ray source by API 1104

NMRL, Mumbai
NDT for WPS as per ASME SEC IX

Third Party Inspection Services

Saudi Chemanol
Third party inspection at various locations (Kolkata, Tarapur & Pune) as per Client provided ITP/QAP

Komline Sanderson, USA
AWS Welding Inspector as well as QA/QC Personnel deployed at a vendor site in India

EMC Sp. Z.o.o., Poland
QA/QC Inspection and Pre-shipment loading audit of electric light bulbs at a vendor site in Mysore, India

Permapipe, UAE
6-Month duration project for QA/QC inspection including dimensional verification and specification compliance of insulation material used in refinery piping

Aventech, Candada
Factory Audit and Sourcing Assistance of Casting Suppliers

Flowserve, UK
QA/QC inspection at Ashok in Chennai on an ongoing basis

Elliott Company, USA
Factory Audit and QA/QC inspection on behalf of the USA based company at their supplier site in western India for a 3-year duration project

Uniflex Cables, Kuwait
Inspection and Witness of Goods at a supplier site in India

Bloxwich, UK
QA/QC inspection with daily photographs and status reports advising client of vendor's progress and quality status

Metpost, UK
Inspection of fabrication and Factory Audit of casting and forgoing companies in India

American Industrial Supply, USA
Third party inspection, Stamp Transfer and Shipment Audit

RoHS Compliance Services

Sys Concept, Canada
Detection of RoHS restricted elements using the screening and verification methods

Birla Copper
Test of Lead content in samples

Emerson Climate Technologies
RoHS testing on an ongoing basis for over 500 samples

Parveen Industries
RoHS compliance for 28 plastic samples

Godrej Lawkim Group
RoHS testing on an ongoing basis for over 600 samples

MAJOR EQUIPMENTS

TCR invests in the latest equipment and uses cutting-edge technologies to ensure that all the products and materials they test, certify or inspect always have consistent quality and results, are compliant with all relevant industry standards and regulations and are fit for purpose.

Mechanical Testing Equipment

1. **Servo Hydraulic Universal Testing Machine**
MTS System (china) Co. Ltd.
SHT4106/3091104 | TCR/MEC/EQP/13 | 0-1000kN/ ±1% | Mfg. Date- Nov 2009

2. **Universal Testing Machine with Electronic extensometer**
GDR Sr. No-283/40 -1976 | Sr. No. 106/05/02 | Sr. No. 270 (Extn. Mtr) | TCR/MEC/EQP/01 | 0-1000 kN / ±1% | 0-25 mm

3. **Universal Testing Machine With Electronic extensometer**
MCS-MP/ 156-12/06 | Sr. No. 186-0207 | TCR/MEC/EQP/02
0-400 kN / ±1% | 0-50 mm

4. **Universal Testing Machine**
SFM30 | Make: United | Sr. No.: 293505 | TCR/MEC/EQP/03
0-130 KN

5. **Universal Testing Machine**
KIC-2-1000-C | Sr. No.: 110402
TCR/MEC/EQP/09
0-100 KN

6. **Charpy / Impact Testing Machine**
FIE/ IT/30 Sr. No-789 | 1975
TCR/MEC/EQP/04 | Izod-156J

7. **Charpy Impact Testing Machine**
IT 300 ASTM
Sr. No. 06/12-02 | TCR/MEC/EQP/05 300J

8. **Impact Testing Machine**
Model: ZBC2452-C/150 | Make: SANS, China
Sr. No.: 20910025 | TCR/MEC/10 0-450J (calibration valid upto 150J)

9. **Brinell / Vickers Hardness Tester**
HPO 250 F.Nr-308/92, 1979 | TCR/MEC/EQP/06 | HBW 80-400 | Hv5 40-1200, Hv10- 80-1000 | ±2%

10. **Rockwell Hardness tester**
RA/FIE | Sr. No-77/021 | 1976
TCR/MEC/EQP/07 | HRB 30-100 | HRC 20-70, ±1%

11. **Rockwell Superficial Hardness Tester**
RAS/FIE | Sr. No -S-7001 | 1976 | TCR/MEC/EQP/12 | HR 30T: 29-82 ±1%

12. **Wilson Wolpert Hardness Tester**
Sr. No.: 930/250 | TCR/MEC/EQP/11

13. **Cupping machine (Scale)**
FIE /1990 | TCR/CUPPING/SC/01
0.20 to 3 mm

14 **Brinell / Vickers Hardness Tester**
HPO 250 F.Nr-308/27, 1981 | TCR/MEC/EQP/08 | HBW 80-400 | Hv5 40-1200 | Hv10- 80-1000 | ±2%

15 **Micro Hardness Tester**
Make: LECO USA | M-400-HI | Sr No-170765,
1996 | TCR/MET/EQP/06
0-1000gms | ±3%

16 **V Notching Machine**
Fine Marketing | 1976 | TCR/MEC/EQP/15
2 mm V Notch

17 **Hydraulic Pipe Bending Machine**
Sr. No.: 965
TCR/MEC/EQP/15

18 **Hydraulic Test Pump & Compressor**
Horizon | TSO-05 | TCR/MEC/EQP/16
600kg/cm2

19 **Digital Thermometer with sensor (New)**
MARVEL SE, Sr. No. 090901
TCR/MEC/EQP/19
-199 to 50 | Deg C

20 **Digital Thermometer with sensor (New)**
MARVEL SE, Sr. No. 113/080603
TCR/MEC/EQP/19
-199 to 100 | Deg C

21 **Digital Weighing Balance**
CONTECH | Sr. No. 01/200766 (CT 15K)
TCR/MEC/EQP/17
0 to 15 Kg

22 **Digital Weighing Balance**
Pentral Electronics | Sr. No. 01/200766 r. No. 498 Model ILW 300 | TCR/MEC/EQP/21
0 to 30 Kg

23 **Temp controller with. Indicator & sensors**
SE/TCS1&TCS2
TCR/MEC/EQP/18
0-1000 Deg C

24 **Fatigue test system**
50 KN and 250 KN
Make BISS - Bangalore

Metallography Testing Equipment

1 **Olympus inverted microscope**
Olympus –GX51 inverted system
X50X- 1000X

2 **Metallurgical Microscope with image analyzer**
LECO 500
USA, 1989
Mag. 50X to 2000

3 **Shadowgraph checking Metzer Biomedicaf**
50X

4 **Insitu Metallography Kits**
BMI 101A Microscope
BMI 101A
Sr.No. – 200050065
100X-600X

Chemical Analysis – Instrumentation

1 **Automatic Carbon Sulphur Determinator**
LECO/CS244 USA 1990, Sr. NO. 2042 | TCR/INT/EQP/02
±0.005 C to ±0.005 S

2 **Automatic Carbon Sulphur Determinator**
LECO/CS400 USA 1997
Sr. No. 3153 | TCR/INT/EQP/03 |
±0.005 C to ±0.005 S

3 **Automatic Carbon Sulphur Determinator**
LECO/CS230, USA APR 2009
Sr. No. 4930 | Model No. 619-000-200 | TCR/INT/EQP/07
±0.005 C to ±0.005 S

4 **Automatic Oxygen, Nitrogen, Hydrogen Determinator**
LECO ONH 836 | Model No. 632-100-400 | Sr.NO. 3006

5 **Atomic Absorption Spectrometer (AAS)**
Perkin Elmer
Analyst 200 | Sr. No. 20056110104 | TCR/INT/EQP/05 | ±1% of conc.

6 **Optical emission Spectrometer (OES)**
ARL QUANTRIS/
Switzer. JUNE 2006
Sr. No. 15 | TCR/INT/EQP/01
±1% of concentration

7 **Optical emission Spectrometer (OES)**
Thermo fisher scientific
ARL 3460
Switzer. year 2012
Sr. No. 4948
TCR/INT/EQP/

8 **ICP Spectrometer**
Leeman Labs Inc, PRODIGY
SPEC JUNE 2005
Sr. No 5003 | TCR/INT/EQP/04
±1% of Concentration

9 **UV Spectrophotometer**
Make:Chemito, Model 2100

10 **XRF Spectrometer**
Rigaku Japan Model: Supermini
Sr. No. IR 16013-3 | TCR/INT/EQP/06| ±1% of Concentration

11 **Electronic Digital Balance Mettler,**
Model- AB 54-s | TCR/WAO/EQP/011 | 0-50 gm to ±0.1 mg

12 **Electronic Digital Balance Mettler,**
Model- AB 204
TCR/WAO/EQP/012
0-210 gm
±0.1 mg
Weight Box
-0.1 mg -100gm

13 **Rough Balance**
Make Penta model TLW Sr. No 4852 | 0.002 kg-500 gm ±0.1 gm

14 **Oven (Wet Analysis)**
TCR/WAO/EQP-014
Make EXPO | 0-300°C
Oven (Wet Analysis)
Lab Hosp Sr. No. 901115
0-300°C

15 **Electrolytic Analyzer With Analog Ammeter & Voltmeter**
TCR/AM/01, TCR/VM/01 | 10 A/15V to ± 1% FSD
TCR/AM/02, TCR/VM/02 | 10A/15 V to ± 1% FSD

16 **Glass Thermometer**
GRM INIDIA TCR/MECH/TM/02, -10 to 110 C
GRM INIDIA TCR/WAQ/EQP/22 -10 to360 C
GRM INIDIA TCR/WAQ/EQP/23, -10 to 360 C
GRM INIDIA TCR/WAQ/EQP/24, -10 to 360 C
GRM INIDIA TCR/WAQ/EQP/25, -10 to 360 C

17 **Temperature and humidity meters**
TCR/TEMP/02 -HTC-1 Spectro room
TCR/TEMP/03 -HTC-1 ICP Room
TCR/TEMP/04 -HTC-1 Wet Lab
TCR/TEMP/05 -HTC-1 Corrosion lab
TCR/ARB/TEMP/01 -HTC-1 SAUDI lab
TCR/ARB/TEMP/012- HTC-1 SAUDI lab

Inspection - Positive Material Identification (PMI), RoHS, Feritscope, Portable Hardness

1 **Niton XLT 898**
Sr. No. 18807 | USA | ±5%

2 **Innov-X Demo**
Sr. No. 6603 | USA | ±5%

3 **Innov-Alpha Demo**
Sr. No. 4444 | USA | ±5%

4 **Innov-X**
Sr. No. 10791 | USA | ±5%

5 **Innov-X system**
Sr.No 500625 | USA | ±5%

6 **Innov-X System DS-2000**
Sr. No 560099 | USA | ±5%

7 **Niton XL2**
Sr. No. 73308 | USA | ±5%

8 **Niton XL2**
Sr. No. 85754 | USA | ±5%

9 **Niton XLT 898**
USA | ±5%

10 **ARC-MET 8000 Mobile OES analyser**
Sr.No 800469 | USA | ±5%

11 **ARC-MET 8000 OES Analyzer**
Sr. No 800441 | pH meter

12 **TOSHNIWAL PH-01 & 022**
0-14 pH | pH meter

13 **Water Conductivity meter**
Make Hanna | Model HI 2300
Sr.NO. 08119182

14 **Electrical Conductivity Meter Technofour**

Wet Chemical Analysis

1 **Muffle Furnace**
TCR/WAO/EQP/09, 0-1000°C | TCR/WAO/EQP-010, 0-1000°C

2 **Oven**
Lab Hosar/ TCR/WAO/EQP-016, 0-300°C | EXPO/TCR/WAO/ EQP-014, 0-100°C | TEMPO/ Sr.no.4121O4, 0-300°C

3 **Glass Thermometer**
KWALITY/TCR/MEC/EQP/22, -100-+50°C, ± 2°C | JRM/TCR/ MEC/EQP/31, -50 - +50°C, ± 1°C | JRM/ TCR/MEC/ EQP/3129, -10 - 360°C, ± 1°C

4 **Analog DC Ammeter**
LCC/TCR/WAO/EQP/018
0-10 A, ± 1% FSD

5 **Analog DC Voltmeter**
LEE/TCR/WAO/EQP/DCV 018, 0-15 V, ± 1% FSD | Sr. No. 861015239, 0-15v

6 **Electronic Digital Balance**
Mettler, Model- AB 54-s
TCR/wao/eqp/011
0-51 gm, ±0.1 mg

7 **Electronic Digital Balance**
Mettler, Model- AB 204
0-200 gm, ±0.1 mg

Inspection and Quality Audit Equipment

1 **Metric Scale**
TCR/CUP/mach./01 | 0-20 mm
Technika, TCR/MS/02 | 0-1000 mm

2 **Dial Vernier Caliper**
Mitutoyo
Sr. No. 1096302
0-150 mm

3 **External Micrometer**
Mitutoyo
Sr.No.2031020 | 0-25 mm
Sr.No.099416 | 0-25 mm
Sr.No.7749020 | 25 mm

4 **Tube Micrometer**
Mitutoyo
Sr.No.56063638 | 25-50 mm
External Micrometer

5 **Pipe Micrometer**
Mitutoyo
Sr.No. 207759 | 0-15 mm

6 **Dial Vernier Caliper**
TESA | TCR/VC/TESA)/01
0-15 cm

7 **Vernier Caliper Aero space**
Sr.no. 050916033 | 0-20 mm
Sr.no. 209043 | 0-600 mm

8 **Digital Vernier Caliper**
TCR/DC/01 | 0-150 mm
Mitutoyo | Sr.No.07082256
0-200 mm

9 **Vernier Caliper Aero space**

Corrosion Testing Equipment

1 **Pressure Gauges**
Pioneer | TCR/PG/07 | 0-600 Kg/Cm2
Bourdon | TCR/PG/05 | 0-250 Kg/Cm2
Wika/ TCR/PG/08 | 0-40 Kg/Cm2
Hi Tech/ TCR/PG/09 | 0-70 Kg/Cm2
Fair / TCR/PG/09 | 0-70 Kg/Cm2
A LOT/ TCR/PG/10 | 0-42 Kg/Cm2
A LOT/ TCR/PG/14 | 0-70 Kg/Cm2
WIKA | 0-1000 Kg/cm2

2 **Pressure Gauges(Corrosion Lab)**
Hi-ech/1752/TCR/PG/COR/01
0-70 Kg/Cm2
Hi-ech/1762/TCR/PG/COR/02
0-70 Kg/Cm2
Hi-ech/1753/TCR/PG/COR/03
0-70 Kg/Cm2
AKVALA/TCR/PG/12 | Sr.No. 510130328
0-70 Kg/Cm2
AKVALA/TCR/PG/13 | Sr.No. 510130331
0-70 Kg/Cm2

3 **Thermocouple (Corrosion Lab)**
Marvel Electronics
Sr. No. 080220(D) | 0-800 deg. C
Sr. No. 080220(D) | 0-800 deg. C

4 **Digital Coating Thk. Gauge with Foils**
Defelsko corp. model-6000-FN2
0-1500 micron

5 **Digital Thermometer with Sensor for impact test**
Model-221P-RTD | Sr. No. 060601 | -196 To 200 Deg C
Model-Pt-100-RTD | Sr. No. 090901 | -196 To 50 Deg C

6 **Dial gauge**
Sr. No. 7532, 0-10 mm | Sr. No. J8037, 0-10 mm | Sr. No. 1386/1, 0-3 mm | Baker, SE/3534/3
Sr. No. G9490, 0- 10 mm | Sr. No. 1386/1, 0-3 mm | SE/3534/5, Sr. No. 2099, 0-10 mm

7 **Dial Gauge (Impact)**
Shock proof, Sr. No. J8037, 0-10 mm | Mitutoyo, Sr. No. 9813k7, 0-1 mm | Sr. No. 78018, 0-1”

8 **High Pressure vessel (Autoclave)**
2T2-6175-327-0606 & 328
Acrylic vessel
P H Meter
Make- Lab India

9 **HIC Vessel**
TIC With Sensor

10 **Temp. Indicator with sensor**
SE/TCS1&TCS2
0-1000

11 **Temperature Controller with Sensor (6 Channel)**
PID-8000
Libratham
TCR/CHEM/PID/01
0- 150

12 **Temperature controller with sensor**
SE/200 | SS/TC/02
Ambient

13 **Hydrogen Sulphide Cylinder**
Hydrogen Sulphide Controller
Hydrogen Sulphide Detector
MSA H2s ALTER
H2S Mask

14 **Temperature Sensors**
2K408THC1666 to 69 & Sensor 5
0-350
CR-AL SIMPLEX Thermocouple
2K7THC0001 | 2K7THC0223 | 2K7THC0222 | SENSOR 4

15 **Temperature Sensors**
Sensor 1 to 4

16 **Temperature Sensors (J Type)** OMEGA
P05D650JIHA2 | P05D650JIHA | P03C346JIHC2
0-250 Deg C

17 **Temperature Sensors (K Type)**
P03C346JIHC1 | 07070/71 | TC1 | TC2 | 0- 250 Deg C

18 **Constant temp.(Water)Bath**
INSU/TCR/CHE/EQP/WB-01 & 02
0-100

19 **Proving Rings**
Sr. No.02035, 12 kN | Sr. No.02034, 12 kN | Sr. No.02028, 12 kN | Sr. No.02026, 12 kN | Sr. No.02025, 12 kN | Sr. N. 02013, 12 KN | Sr. No.02014, 12 kN | Sr. No.02015, 0-1200 Kgs | Sr. No.97504, 0-2000 Kgs | Sr. No.97502, 0-2000 Kgs | Sr. No.97506, 0-2000 Kgs | Sr. No.97508, 20 kN | Sr. No.97505, 0-2000 Kgs | Sr. No.97507, 0-2000 Kgs | Sr. No. 3957, 20 kN | Sr. No. 3956, 20 kN | Sr. No.03001, 06 kN | Sr. No.03002, 06 kN | Sr. No.03003, 0-600 Kgs | Sr. No.03004, 0-600 Kgs | Sr. No. 02033, 12 kN | Sr. No. 97503, 0-2000Kgs

NDT - Industrial Safety and NDT Shutdown Project Management

1 *Ultrasonic Testing Equipment*
Ultrasonic Flaw Detector
Krautkramer / USK7 Sr. No- 27276-4561

V1 Block & V2 Block
Normal Probes
Ultratech / SN-16 | 2MHZ ⍰24 NP
Ultratech / SN-16 | 2MHZ ⍰10 NP
Ultratech | 4MHZ ⍰10 NP (2 No.)

2 **Angle Probes**
4A 8x 9-60, SN. 34 | 4A 8x 9-60, SN. 70

3 **TR Probes**
TR4 MHZ ⍰10, SN.111

4 **Ultrasonic Thickness Gauge**
Pulsecho system | Mp 1200-DL | Sr. No. 2151
Modsonic | EDISON-1/Sr. No 3536-0210

5 **Probes**
MPL 510-364 | MPL 510-365 | MPL 210-237

6 **Magnetic Particle Testing Eqpts. & Materials**
Yoke, Y7/13 | AC/DC | PT No 518601 | Dry Powder | Magnaflux –8A | Black Water Based Powder Automeg BW-245

7 **Magnetic Ink Black Oil Base**
Instacheak MSL 61 B
Fluorescent
Test

8 **Ultraviolet Light**
A M Trading UMV 001 | 12 V- 230 V

9 **Dry Powder Sprayer**
UPKAR

10 **D P Testing Eqpts. & Materials**
Developers: PD 31 B PMC
Penetrant: 15 B PMC
Cleaners
PMC

11 **Coating Thickness Gauges**
Positector 6000 NF-2
0- 650 Micron ± 3 Micron

12 **EPOCH LT PANAMRTRICS-NDT DIGITAL ULTRASONICDETECTOR EPOCH LT**
SR.NO 060124610
Einstein II DGS UT Machine
Modsonic Sr.No E 1502-0308
Feritscope (MP30E-S)
Sr. No. – 106-23060A
Fischer / USA

13 **Portable Hardness Tester**
TH-130/ HL- 200 | China | 5%

14 **Digital Coating thk. Machine**
Defelsko corp. model-6000-FN2
0-1500 micron

15 **Davinci Alpha UT machine**
Sr no. D 0152-4209
Modsonic

16 **Surface Roughness Tester**
TR 100
TIME
Sr. No. 10663000012

17 **Portable Magnetic permeability tester**
Model – Ferro master | Stefanmayer instruments,Germany Sr. NO 328 yr 2009

18 **Portable hardness Tester**
HL 200 | 783 H
Cu,Al conductivity meter (already mentioned above)
Technoflow | NA

19 **Fire Extinguisher**
Foam Inverted Type – B | Powder B&C | Dry Chemical Powder,
Type – B C (3 No.) | Dry Chemical Powder, Type – B C (Small)
9 KG

20 *Safety Equipments*
First Aid Kits: 3 Sets
Helmets: 2 Nos.
Boiler Suits: 10 Nos.
Hand Gloves: 50 Nos.
Safety Shoes: 10 Pairs
Safety goggles: 10 Pairs

AWARDS & APPRECIATION RECEIVED

TCR's expertise lies in enhancing business outcomes and this has been achieved through their deep technical knowledge, commitment to quality and unbiased reporting. This approach has helped their customers across industries to transform and gain significantly by leveraging TCR's services. Read through some of the appreciation letters received from their clients.


NACE INDIA SECTION

NACE International India Section

Presents

CORROSION AWARENESS AWARD - 2007

(Sponsored by NIIS)

To

TCR Engineering Services Pvt. Ltd.

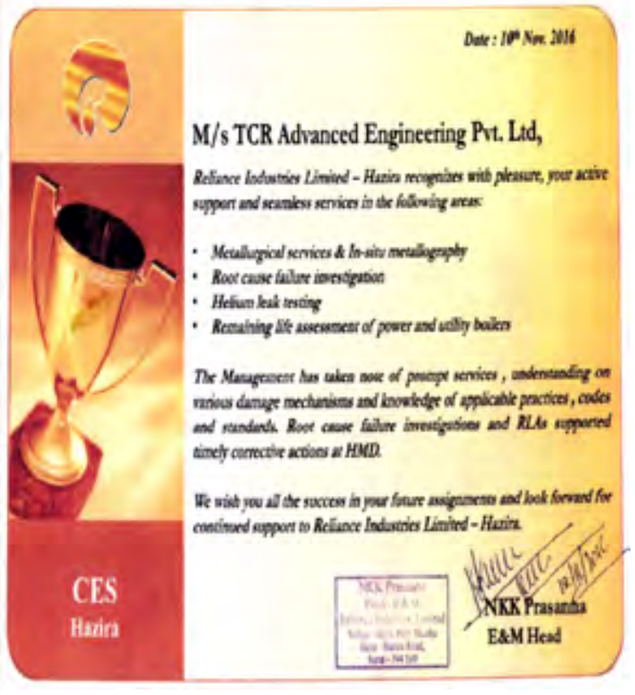
Award for excellent Laboratories in Private Sector

In recognition of their contributions in the field of Corrosion Sciences

Dr. Baldev Raj
Chairman Awards Committee

A M Upinchwar
Chairman India Section

NACE International, India chapter
TCR Engineering Services (Navi Mumbai) received prestigious NIIS Award for "Excellent Laboratory"


Date : 10th Nov. 2016

M/s TCR Advanced Engineering Pvt. Ltd,

Reliance Industries Limited – Hazira recognizes with pleasure, your active support and seamless services in the following areas:

- *Metallurgical services & In-situ metallography*
- *Root cause failure investigation*
- *Helium leak testing*
- *Remaining life assessment of power and utility boilers*

The Management has taken note of prompt services , understanding on various damage mechanisms and knowledge of applicable practices , codes and standards. Root cause failure investigations and RLAs supported timely corrective actions at HMD.

We wish you all the success in your future assignments and look forward for continued support to Reliance Industries Limited – Hazira.

CES
Hazira

NKK Prasantha
E&M Head

RELIANCE INDUSTRIES- HAZIRA for
Insitu Metallography, failure analysis, Helium Leak Test and remaining life assessment


MBH ANALYTICAL LTD

TCR Engineering Services Ltd
35 Pragati Ind Est
N M Joshi Marg
Mumbai 400 011
Attn V K Batra

11th February 2010

Dear Mr Batra

Customer Feedback

This letter is to confirm my complete satisfaction with the service and product quality I am receiving from the laboratory at TCR Engineering Services.

As you know, your results for all my samples are compared with those from ~12 other laboratories, mostly with 17025 accreditation, from countries including India, UK, USA and China.

In all the time we have been doing business, I have found your communication and product delivery to be as required, and the quality of your results can be compared favourably with the other commercial and industry laboratories. I am delighted with our relationship, and trust we can continue with the same arrangement in the future.

Yours sincerely

Chris Eveleigh, PhD

MBH Analytical for Chemical Analysis Testing Services


GE Energy

Subiya CCGT Project Kuwait

Date: 26 June 2012

TO WHOMSOEVER IT MAY CONCERN

General Electric appreciates TCR Engineering Services for their efforts, technical expertise and time spent on the On Line Helium Leak Inspection of Steam Turbine Condenser unit# 420 [270°/EZ3] to identify the Air ingress Points in the Condenser Neg.Pressure Parts at SUBIYA CCGT site, Kuwait.

Subiya Power Project is 2000 MW combined cycle plant consisted of 08 GE 9FA Gas Turbines-Generators, 08 Heat Recovery Steam Generators (HRSG) and 03 Steam Turbine-Generators. General Electric & WS are the main contractors and consortium partners.

The Management & Technical Team at site appreciate the valuable & prompt services provided by your technical team at site. We also expect the same from your company for our future projects.

Nabil Samaan
DA/QC Manager
General Electric
Subiya Power Project
Kuwait

GENERAL ELECTRIC (GE) for NDT Services


LARSEN & TOUBRO LIMITED

Date: 19 May 2010

TO WHOM SOEVER CONCERNED

Larsen & Toubro Limited, in association with Toyo Engineering Corporation Japan is executing the Naphtha Cracker Project (PNCP EPCC-1) on LSTK basis for Indian Oil Corporation Limited at their Panipat Refinery at Haryana.

Larsen & Toubro Limited have awarded the contract for Hot Test to M/s. TCR ENGINEERING SERVICES PVT. LTD., Navi Mumbai, Maharashtra vide P.O. Ref No. PETROCHEMICALS/64000-61449/CP dated 30/04/2009.

M/s. TCR ENGINEERING SERVICES PVT. LTD., have successfully completed the awarded job as per issued PO terms and conditions in time, fulfilling all the safety and technical requirements associated with the Hot Test job. Their approach to the project was very systematic and professional and their planning was meticulous.

They have got skilled and efficient manpower for each type of jobs and are equipped with all the required accessories equipment tools and tackles.

We wish them all the best in their future assignments.

This certificate is being issued as per their request.

Very Truly Yours,

L&T for Panipat Refinery Project of Indian Oil Corp


Reliance Industries Limited

TO WHOMSOEVER IT MAY CONCERN

TCR Advanced Engineering Baroda, was awarded the job of carrying out metallographic analysis by in-situ metallography technique of piping and piping components affected by fire in Oct 2006. M/s TCR deployed a team of engineers and technicians for taking replica's of components by in-situ metallographic technique. M/s TCR had mobilised the state of art of metallurgical microscope at site for immediate viewing of the microstructure and interpretation. The microscope had all the facilities for converting the replicas into computerised images for evaluation by experts in other parts of the world. A total of about 1200 replicas were taken in a period of about 15 days, working round the clock, which is considered a remarkable feat.

The knowledge of the crew deployed at site, the quality of the replica's and the zeal and enthusiasm with which the crew completed the work is commendable and highly satisfactory.

We wish TCR Advanced, all the very best in future assignments.

(U Anand)
Asst Vice President
Corrosion & Inspection Dept.

RELIANCE Industries for Metallography

GODREJ INDUSTRIES for Failure Analysis Project

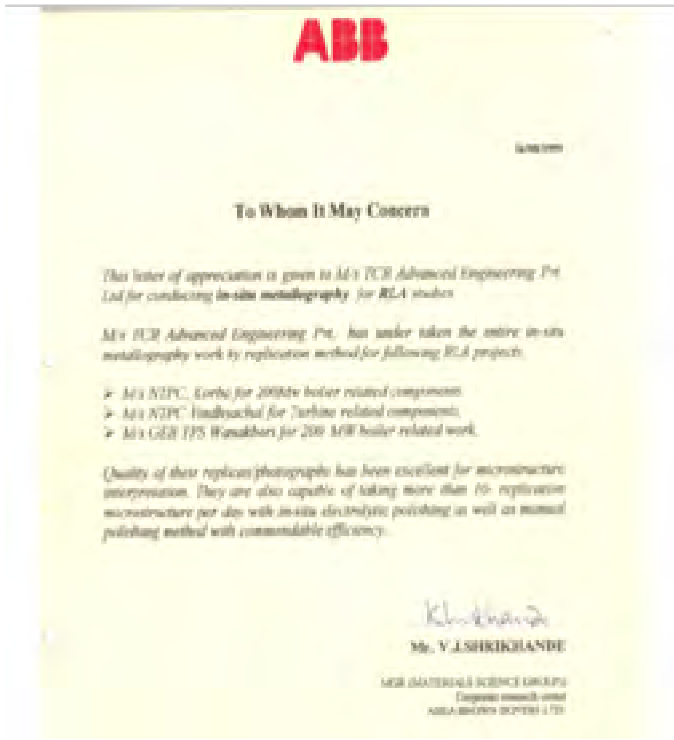
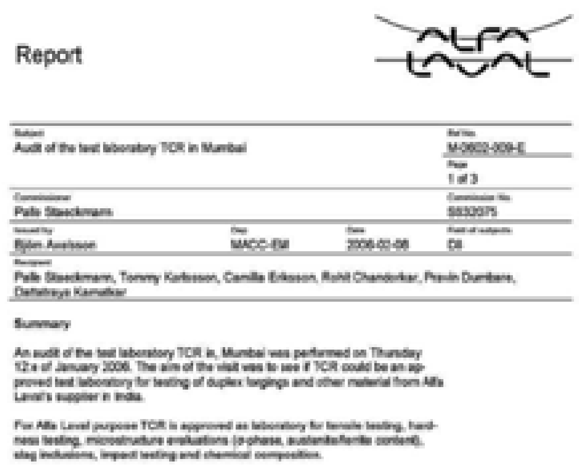


ABB for Metallography/Remaining Life Assessment Studies

Virgo Valves for on-going PMI Inspection

AL TOUKHI for Heat Treatment Services



ALFA LAVAL's preferred test lab in India

PETRO RABIGH for Advanced NDT and ToFD

HYUNDAI for Eddy Current Testing Services

NAVAL DOCKYARD for NDT & Inspection Services

INS Dara
C/o Fleet Mail Offic
Mumbai - 400 001

9 Jul 05

WORK COMPLETION CERTIFICATE

1. Refer to ASD(MB) letter DYT/FLS/05-06/SYS/DEL/W/252 dated 02 regarding NDT test on the weld joint of fireman system and cooling water sys M/S TCR Engineering Services Pvt Ltd, 35, Pragati Industrial Estate, Ground F Joshi Marg, Mumbai-400 011.

2. It is certified that the above mentioned work has been completed satisfa per schedule.

(Rakesh Grogate)
Lt. Cdr/Engineer
Senior Engineer Of
For Commanding O

INDIAN NAVY (INS) for Conventional NDT Services

IndianOil

INSPECTION DEPARTMENT
PANIPAT REFINERY

PRI/IP/106/2007 DATE: 01.06.2007

SUB : JOB COMPLETION CERTIFICATE.

To Whom It May Concern:

This is to certify that M/S TCR Engineering Services Pvt. Ltd. Has done PMI job in AVU-I of Panipat Refinery during June –2006 shutdown against Work Order No. 17350903. The job done was up to our satisfaction.

With Best Regards,

Chairman
Sr. Inspection Manager,
Panipat Refinery,
Panipat-132140.

Ph : 01802522596 ,
E-Mail : chairman@iocl.co.in
Fax:0180-2578713

INDIAN OIL (IOC) for Positive Material Identification (PMI)

EMERSON

23rd July 2015

SUBJECT: SPECIAL APPRECIATION TO M/S TCR ENGINEERING SERVICES PVT. LTD.

This letter is to confirm our complete satisfaction with the various testing services and product quality we are receiving from the laboratory at TCR Engineering Services Pvt. Ltd.

In all the time we have been doing business, we have found your communication and product delivery to be as required and the quality of your results can be compared favourably with the other commercial & industry laboratories.

We are delighted with our relationship and trust we can continue with the same arrangement in the future.

Thanking You,

Authorised Signatory

VWR

EMERSON for Laboratory Testing Services

MTAR

SPECIAL APPRECIATION TO TCR ENGINEERING SERVICES PVT. LTD.

We are delighted with our relationship and trust we can continue with the same arrangement in the future.

ADMINISTRATIVE MANAGER

Date : 01 July 2015

MTAR TECHNOLOGIES for various Testing Services

Ref. No.: Date: 11th Oct. 2008

NDT TRAINING COMPLETION CERTIFICATE

This is to certify that Mr. Nilesh Pathare (ASNT NDT LEVEL III) of TCR ARABIA COMPANY LTD, DAMMAM has visited PETRORabigh refinery from 15th Oct. To 19th Oct. 2008 and conducted the NDT LEVEL I course for employees of PETRORabigh - Engineering & Inspection Dept.

He has conducted NDT LEVEL I Training, Examination for certification as per ASNT –TC –1A of ASNT for PETRORabigh employees in following four methods:

1. ULTRASONIC TESTING (UT)
2. MAGNETIC PARTICLE TESTING (MT)
3. PENETRANT TESTING (PT)
4. VISUAL TESTING (VT)

This certificate is issued after successful completion of the NDT Level I training and Examination in above mentioned four NDT methods.

TCR ARABIA COMPANY LTD shall declare the results for the above NDT examinations and shall send the certificates for the passed candidates within two weeks after completion of this training as per contract.

Approved By: Mossaad Belmalas
Manager, Engineering

PETRO RABIGH for NDT Training & Certification

TATA

27th July, 2015

To,
Mr. Arjun Sail
General Manager
TCR Engineering Services Pvt. Ltd
Mhape, Mumbai

Subject: Metallurgical Services

The quality of services provided by your laboratory in various Metallurgical tests and Failure analysis is appreciable. In the last two years we have been doing business, we have found your services, prompt response to queries and interactions satisfactory and we are hopeful that the same would continue in future.

Rohit Shukla
Lead Engineer (Metallurgy) - Asset Management
Core Technology and Diagnostics

TATA POWER for Metallurgical Tests & Failure Analysis

VENDOR APPRECIATION LETTER

This letter is to confirm our complete satisfaction with the various testing services and product quality we are receiving from the laboratory at TCR Engineering Services Pvt. Ltd.

In all the time we have been doing business, we have found your communication and product delivery to be as required and the quality of your results can be compared favourably with the other commercial & industry laboratories.

We are delighted with our relationship and trust we can continue with the same arrangement in the future.

Lobhesh Gondane
Sr. Manager
Quality Assurance
Godrej Precision Engineering

Precision Engineering Systems

GODREJ PRECISION ENG for Testing and Quality Assurance Services

وزارة الكهرباء والماء
محطة الدوحة الشرقية لتوليد القوى الكهربائية وتقطير الماء
DOHA EAST POWER GENERATION AND WATER DESALINATION PLANT

Ref. Date

DOHA MINISTRY OF WATER for Metallography, UT, NDT & RLA

TCR ENGINEERING

OUR GLOBAL OFFICES

The TCR team operates globally across different regions and countries. Please reach out to them for any queries or assistance via email or phone

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Fax: +91-265- 2634375
baroda@tcreng.com
www.tcradvanced.com

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Fax: +966-14-3935181

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Fax: +965-23910340
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Fax: +603 6188 8311

TCR ENGINEERING

REDEFINING ON-TIME QUALITY
ISO 17025, NABL, BIS, IBR Accredited Lab

TCR Engineering Services Private Limited
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N.M.Joshi Marg, Mumbai - 400 011
Tel No: +91-22-23097921

Laboratory: VKB House, EL-182 MIDC-TTC,
Electronic Zone, Mahape, Navi Mumbai - 400 710
Tel No: +91-22-67380900
CIN No: U28920MH1973PTC016780

www.tcreng.com