TCR ENGINEERING

Redefining On-time Quality

Material Testing | NDT | Inspection & Consulting

Company Profile: 1973 - 2025 | www.tcreng.com

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

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Executive Summary

TCR Engineering: Precision, Integrity, Innovation Since 1973

India's oldest third-party inspection company, specializing in lab-based Materials Testing for Metals and Civil, NDT Services, Plant Asset Integrity Consulting on Failure Analysis and FFS

is a trusted partner for quality assurance, helping businesses enhance and certify their products, validate material quality, drive innovation, and gain a competitive edge in the marketplace.

At TCR Engineering, we don't just test materials; we build the foundation of trust and excellence in industries worldwide. Headquartered in Mumbai, TCR is an ISO 17025 and NABL accredited laboratory serving over 5000 clients across the globe. Since 1973, we have been a steadfast partner to businesses in India and beyond, with a presence stretching from Saudi Arabia to Malaysia, enabling companies to streamline plant operations, enhance safety, and drive performance.

For nearly half a century, TCR has been the epitome of reliability and transparency. When our clients need results, they know they'll get timely, unbiased insights that matter. From Mechanical and Civil Testing to NDT Services and Failure Analysis, every TCR report is backed by a legacy of expertise and innovation—created by a team that has spent decades mastering the art of precision. Our global reach means we can assemble expert teams with unmatched speed, tackling challenges wherever you are.

TCR's service is more than just data—it's a partnership for progress. We turn testing results into actionable insights that empower customers to anticipate challenges, maximize performance, and confidently take the next steps forward. With us, you get clarity and confidence, infused with the promise of accuracy.

TCR Engineering's story is written in the successes of its clients, both local and global, who have seen real, measurable impact from our partnerships. We are more than just a testing lab; we're a trusted ally in developing strategies and solutions that drive true business value. From Fortune 500 companies to dynamic mid-sized firms and innovative small businesses, clients of every scale rely on TCR to fuel their growth and ensure quality at every turn. Our marquee clients are a testament to the power of our commitment, precision, and unwavering focus on results.

TCR is the name behind honesty, reliability, and transparent results. Our team is composed of some of the finest minds in the field—engineers, scientists, inspectors, and innovators whose combined expertise crosses industries and borders. With a global reach, we can deploy the right talent wherever it's needed, working with industries as diverse as Automotive, Oil & Gas, Petrochemicals, Defence, Electronics, Nuclear, and Manufacturing. Whether it's unlocking material properties, boosting product performance, diagnosing failures, or exploring the frontier of material science, TCR's impact is as deep as it is wide.

Every project is delivered on time and to the highest standards, backed by a multi-disciplinary team certified to meet rigorous industry demands.

TCR started its journey as a pioneer for end-to-end inspection Material, Metallurgical & Corrosion Testing in India to becoming a global market leader for engineering and testing requirements

Advantage TCR

At TCR, we work with clients large and small, from Fortune 500 giants to small and medium-sized enterprises, with a commitment to quality that never wavers. We've earned accolades like NACE International's "Excellent Laboratory in the Private Sector" and a reputation as one of India's fastest-growing, most innovative companies—successes made possible by a legacy of ethics and excellence laid down by our founder, V.K. Bafna, a visionary metallurgist who shaped TCR's core values of precision, transparency, and integrity.

Today, TCR stands as a thought leader and pioneer in material testing, serving clients across the globe with the same respect and dedication that we bring to every interaction. From the first engagement to project completion, TCR is about empowering businesses to grow, building relationships on mutual respect, and setting the standard for integrity in the industry. Discover the difference that over five decades of innovation, trust, and results can make with TCR Engineering.

At TCR, we believe success means empowering clients to grow. For us, a report isn't just data on a page—it's a roadmap to insights, foresight, and solutions that maximize performance and sharpen strategic decision-making. Every TCR service is grounded in responsiveness, built on reliability and transparency, and rewarded by the repeat trust of our clients.

COLLABORATION: Collaboration is at the heart of everything we do. At TCR, we're not just service providers—we're partners. We align with our clients to build long-lasting partnerships, facing challenges head-on and delivering real, sustainable solutions that help our clients grow and thrive

HIGHLY COMPETENT TEAMS: People are our cornerstone. TCR invests deeply in talent—identifying, developing, and nurturing skills to build a team that's as dedicated to client needs as we are. This approach lets us field expert teams whose skill and insight make a genuine impact, no matter the challenge.

DEEP SECTORIAL EXPERTISE: With over five decades in materials testing, NDT inspection and quality assurance for plants, TCR brings unparalleled industry knowledge and unwavering commitment to ISO 17025 standards. Our technical experts have completed over 6000 failure analysis projects, making us the trusted partner for global leaders like SABIC, Tasnee, Schlumberger, and Reliance. Equipped with cutting-edge tools like Automated Robots, RT Crawlers, Civil Lab, Scanning Electron Microscopy and Optical Inverted Metallurgical Microscopes, our team sets the benchmark for quality and precision.

DIVERSIFIED PROBLEM SOLVING: We help clients tackle complex business issues through every stage of their project lifecycle—from assessment and research to testing, advisory services, solution design, deployment, and ongoing support. Our technical solutions don't just solve problems—they drive real business value.

Our approach is rooted in deep domain expertise, delivering insights that clients can act on. We assess, plan, and implement solutions tailored to each client's industry, helping streamline processes, accelerate delivery, and lower costs. Our solutions validate product quality, foster innovation, and provide a competitive edge for clients worldwide—helping them bring the right products to market, at the right time, and at the right cost.

MISSION

To deliver trusted, unbiased solutions that empower global organizations in managing plant operations with excellence. Through credible thought leadership and a relentless commitment

to integrity, TCR is shaping a future where material testing serves as a cornerstone for innovation and operational efficiency.

VISION

To become a globally impactful company, distinguished by our commitment to on-time, repeatable solutions, impeccable quality, and actionable insights. We strive to be the preferred partner in material testing, inspection, and consulting services, setting industry standards and driving progress across borders.

Accreditation to Global Quality Standards

TCR Engineering Services: Built on Standards, Driven by Precision

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.

For over five decades, TCR Engineering Services has set the benchmark for testing excellence in India, securing NABL and Bureau of Indian Standards accreditations—distinctions only granted to laboratories meeting the rigorous requirements of ISO 17025. Accredited by NABL, the National Accreditation Board for Testing and Calibration Laboratories under India's Department of Science and Technology, TCR demonstrates not only its technical competence but a dedication to delivering accurate, valid data and results, time after time.

What does this mean for our clients? TCR is one of a select group of labs recognized by titans of industry like RIL, NPCIL, Bharat Forge, Bharat Heavy Electrical Ltd., Mumbai Metro, High Speed Rail, Indian Oil, Gail, Mecon, L&T, ONGC, and BARC, among others. Our name appears on approved lists of industry giants across sectors, from energy and power to fertilizer and infrastructure—trusted by the Department of Defense, Indian Railways, and even Mumbai Municipal Corporation.

Our credentials extend beyond borders, with approvals from Halliburton, Schlumberger, NOV, Wartsila, Bureau Veritas, Lloyd's Register of Shipping, and the American Bureau of Shipping. This international trust positions TCR as India's gateway for reliable, internationally recognized material testing services.

Our ISO 17025 accreditation spans mechanical, Civil, NDT, PMI, RoHS, and chemical analysis, ensuring every specimen is expertly handled, precisely machined, and rigorously inspected. This quality commitment is anchored by our dedicated Quality Assurance Department, which conducts frequent audits to uphold TCR's exacting standards, giving clients confidence in every result.

Since 2014, we've held the title of a "Well-Known Material Testing Laboratory" by the Central Boilers Board, allowing us to assess and certify boiler components under Indian Boiler Regulations. This endorsement means TCR's assessment is the standard for reliability and safety, even for life-critical components.

At TCR Engineering Services, our name on a report or a certification is more than just an endorsement—it's a promise of quality, reliability, and technical excellence in every test and every result.

Salient Distinguishing Features

- QA to India Defence sector with long term contracts from NMRL and DMRL to undertake CTOD, Fracture Toughness, Fatigue (LCF & HCF) as well as S-N Curve including K1c, J1c. Approvals from CQAE, DRDO
- Strong Engineering Consulting division ensures plant profitability by RBI, IOW, FFS and RLA as per API and ASME. Complete Coverage in the Oil & Gas Sector serving and approved by RIL, BPCL, Shell, HPCL, ONGC, Halliburton, Schlumberger, Weatherford. Middle East based approvals from PDO, QChem, QGas, KNPC, Iraq Oil Ministry. TCR Arabia based in Saudi has approvals from Saudi Aramco and Sabic.
- Approvals and long term contracts from major plant owners from Tata, Siemens, NPCIL, Honda, Godrej, MDL, Deepak Fertilizer, and many more
- Support for insurance claims with detailed failure investigation services with over 8000 completed cases undertaken to date.
- Currently Working at cross country pipeline projects at IOCL and GAIL sites undertaking Radiography and Advanced NDT Services including the following real prestigious projects:
    - 36” Dia Dhamra to Angul (DAPL) pipeline of GAIL under Mecon
    - Kandla-Gorakhpur LPG pipeline of IOCL (KGPL)
    - Srikakulam (Andhra Pradesh) - Angul (Odisha) Pipeline of GAIL (SAPL)
    - Koyali-Ahmednagar-Solapur Pipeline
    - Paradip-Somnathpur-Haldia Pipeline line (PHPL)
    - Bathinda Sangrur Pipeline Project of HPCL under Tractebel
    - Station Works at NOC Terminal Amlekhganj (Nepal) under MAPL Ph-II project
    - CGD Project Nagapattinam-Karaikal GA of Torrent Gas
    - Digital X ray & RT for 36" Dia Mundra Panipat Pipeline Project of Indian Oil
    - CRS at Panipat-Jalandhar LPG Pipeline (PJPL) Project of Indian Oil
    - Destructive Testing for Welder Qualification for L&T at the Mumbai-Nagpur Pipeline under Mecon
- Preferred lab for National Infrastructure with approvals from Mumbai Metro, MMRDA, MSRDC, PDIL, L&T, RITES, BMC, NMMC, AFCON, HCC, Dextra, Leviat, Jaypee Group, Shapoorji Pallonji, Kalpataru, J Kumar Infra.
- Dedicated Low Cycle/High Cycle Fatigue, Slip Test, Static tensile test setup for Reinforcement bar couplers, mechanical splices and concrete reinforcement bars as per ASTM E1034, ISO 4449, EN 10138, ISO 15630, IS 16172 & IS 1786 ensuring that the structures built using these materials meet the highest safety and performance standards. This testing service is used by all major national highways, metro, real estate and infrastructure companies.
- Dedicated Boiler Services division with IBR approval undertaking RLA as well as ACRT and Creep Damage assessment
- Serving the Metal Trading Community with dedicated alliance and in-house setup with Bombay Metal Exchange serving over 2500 reputed traders at BME House
- Empanelled as the exclusive assayer to BSE and NSE commodity trade
- Largest number of chemical analysis spectrometers as well as full classical wet chemistry lab working on Colorimetry, Gravimetry and Titrimetric techniques. RoHS testing for export compliance is also available with XRF and ICP-OES spectrometers
- Experienced Team of TPI and Competent Persons for Factory - Quality Audit, Plant Inspection, Pre-Shipment Inspection of industrial raw materials and components.
- Undertaking Robotic and AI based inspection and structural audit of over 500 bridges in Maharashtra for PWD
- Approved test lab for Evaluation of Elastomeric Materials in Sour Gas Environments for Shell

- Dedicated Training Academy called “Evolve” in Vadodara where future plant operations experts are created imparting knowledge over and above what engineering and metallurgical institutions provide.
- Pan India presence with offices and sample collection in Mumbai, Chennai, Bhubaneswar, Gorakhpur, Pune and Nashik. TCR Engineering’s asset integrity company M/s TCR Advanced is based in Vadodara.

Core Services

For over half a century, TCR has been the name behind honesty, reliability, and transparent results. Our team is composed of some of the finest minds in the field—engineers, scientists, inspectors, and innovators whose combined expertise crosses industries and borders. With a global reach, we can deploy the right talent wherever it's needed, working with industries as diverse as Automotive, Oil & Gas, Petrochemicals, Defense, Electronics, Nuclear, and Manufacturing. Whether it's unlocking material properties, boosting product performance, diagnosing failures, or exploring the frontier of material science, TCR's impact is as deep as it is wide.

Material Testing	Inspection	Asset Integrity
• Mechanical Testing • Hot Tensile • NACE Corrosion Study • CTOD & Fracture Toughness • Coupler & TMT Rebar Fatigue Test • Railtrack butt joint Fatigue • Metallurgy Evaluation • Composite Testing • Civil Testing Lab • Chemical Analysis Spectro • Wet Chemical • RoHS Compliance • Creep & Stress Rupture • Welder Certification & Qualification	• Advanced NDT • ToFD and PaUT • Helium Leak Detection • High Temperature Inspection • Boiler Audit Inspection • Reformer Tube Inspection • ARTiS • Tube Inspection • Eddy Current Test for Tubes • IRIS, RFET and MFL • Pipeline Weld Inspection • Cross Country Pipeline RT • Digitalization of RT Films • Robotic Storage Tank Inspection • PWHT Heat Treatment • Conventional NDT Services • Metallographic Replica • PMI-Positive Material Id • Gamma Radiography • Civil NDT for Concrete • Inspection of Road & Bridges • Third Party Inspection • Turnaround Manpower	• AiOM - Asset Integrity Management • Failure and Root Cause Analysis • Pipeline Integrity • Engineering Critical Analysis • Fitness for Service • Remaining Life Assessment • Boiler Audit • CAD/CAM & Stress Analysis • Research and Development • Plant Relocation Advisory • Insurance & Litigation Referee • Plant Reliability Training

Material Testing

Mechanical and Physical Testing

TCR has a comprehensive range of Mechanical Testing services with a dedicated in-house 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 Elevated Temperature Tensile Test is a special service offered by TCR. Tests are conducted as per ASTM, BS, IS, DIN, 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 80 °C to 1000 °C and beyond, for particularly high-temperature applications. The Mechanical Testing department at TCR performs a range of Impact tests, including Izod and Charpy, Charpy impact testing at temperatures from 100°C to -101 °C & -196°C. Highly specialized pressure test facilities are also frequently done at TCR's Mumbai Laboratory.

TCR Engineering has state-of-the-art equipment's available across different mechanical testing capabilities:

Universal Testing Machines

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

Test Equipment

1. Erichsen Cupping Machine
2. Shadowgraph
3. Hydraulic Test Pump

Hardness Testers

1. Model MH 400 Micro Hardness Tester (USA)
2. Model HPO 250 Brinell / Vickers Hardness Tester (Germany)
3. Rockwell & Rockwell Superficial Hardness Testers

Impact Testers

1. Model IT 40 Charpy Impact Tester as per ASTM & ISO standard (400 Joule)
2. Model IT 30 Charpy / Izod Impact Tester (300 Joule)
3. SANS -ZBC245C Charpy Impact Tester (750 Joule)

Laboratory Facility

1. 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
2. Complete set of measuring and inspection instruments including Vernier Calipers, Micrometers, and Dial Gauges
3. Number of fixtures and attachments for various tests

TCR Engineering provides a diverse range of physical testing services that include:

- Tensile / Transverse/Compression test
- Tensile test with 0.2% proof stress, stress/strain diagram with electronic extensometer inclusive of sample machining charges
- Tensile test at an elevated temperature of up to 1100 °C with Extensometer and without Extensometer upto elevated Temperature of 400 °C
- Tensile (n.k.r. value) / composite / plastic / fabric
- Tensile test for fine wires/foils
- Full section Tensile test for steel bar up to 40 mm diameter
- 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 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 above and below 60°C
- Rockwell Hardness tester (scale A, B, C)
- Vickers Hardness tester (Micro/Macro indentation)
- Brinell Hardness tester
- Jominy End Quench Test (with normalizing heat treatment) as per ASTM A255
- Sectional Weight of CTD/TMT/Reinforcement bars
- Surface characteristics of CTD/TMT/Reinforcement 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 800 kN
- Peel Test
- Residual Stress Measurement

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 (IS 1608 Part 3), Elevated Temperature (ASTM E21, ISO 6892-2), Shear strength, Temperature and Humidity, Combined Tension and Compression, Through Thickness Tensile, Notched Tensile and Strain-Hardening exponent 'n' (ASTM E646, IS 15756) & Plastic-Strain Ratio 'r' (ASTM E517 & IS 11999) values.

All tests at TCR Engineering Services are performed in line with the ASTM E8, ASTM A370, ASTM B557 and IS/BS/ISO Standards. TCR has the expertise to determine the mechanical properties of materials and resolve a wide variety of technical problems for the industry:

Bend Test

This procedure that determines the relative ductility of metal that is to be formed (usually sheet, strip, plate, bar & 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, semi-guided bend & wrap-around bend. as per ASTM E290, E190, A370 and other IS, BS, ISO standards)

Compression Test (ASTM E9)

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

Pipe/Tube Flaring Test, (ASTM A370, ASTM A513, ASTM B153, IS 2335, IS 2501)

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

Pipe/Tube Flattening Test (ASTM A370, ASTM A513, ASTM B111, IS 2328, IS 2501)

A seamless Pipe/Tube sample, 4" - 6" in length is flattened between parallel plates & welded Pipe/Tube with the weld at 90° to 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

Impact Testing

The impact test (ASTM E23, BS EN 10045, ISO 148-1 and IS 1757, IS 1598) is a method for evaluating the toughness and notch sensitivity of engineering materials. It is usually used to understand the energy required by material to deformation before fracture i.e. 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.

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

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.

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.

Hardness Testing

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

Brinell, ASTM E10, IS 1500-1, ISO 6506-1 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

Vickers (Macro indentation) & Knoop hardness ASTM E92, ISO 6507-1 and IS 1501-1 Standard

The Knoop indenter has a polished rhombohedral 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 hardness testing of hard and brittle materials

Rockwell, ASTM E18, ISO 6508-1 & IS 1586-1 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. The difference between the two is in the 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

Rockwell, ASTM E18 and IS/ BS Standard

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Vickers (Micro indentation) hardness, ASTM E384, BS EN 1043-2, ISO 6507-1 & IS 1501-1 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 of the test specimen

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 In-situ, where cutting the sample is not possible

Nick Break and Weldability

Nick break testing is another simple process that lends itself to learning welding (API 1104 specification), 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

Weld Bead Bend Test (WBBT) as per SEP 1390 standard

In the weld Bead Bend Test, the crack arrest behaviour of a material shall be checked. For this purpose, welding bead shall be laid on grooved test plate. Then test plate shall be subjected to bending stress. in doing this, it shall be checked if an incipient crack occurring in the weld metal is arrested by heat affected zone (HAZ) or the base metal when bending without interruption

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.

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

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

Wedge Tensile

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

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

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. Proof load testing of Bolt/Stud is measure in terms of permanent extension in length after application of specified proof load

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 handheld torque wrenches

Evaluation of TMT Rebars and Reinforcement Couplers

TCR Engineering Services, based in Mumbai, specializes in the testing and evaluation of TMT (Thermo-Mechanically Treated) rebars and reinforcement couplers. As the construction industry shifts towards modern methodologies, mechanical splicing of reinforcement bars using couplers has emerged as a reliable technique.

Importance of Mechanical Splicing
Mechanical splicing involves the end-to-end joining of two reinforcement bars using couplers. This technique is particularly advantageous in structures subjected to cyclic loading and where inelastic yielding may occur, such as multi-story buildings and bridges. The use of couplers reduces congestion during concreting, accelerates construction timelines, and ensures a more efficient load transfer between bars. To ensure safety and reliability, the quality of both the couplers and the TMT rebars must be rigorously assessed, considering factors such as material compatibility and construction standards.

TCR Engineering conducts testing in accordance with several established standards, including:

- IS 16172: 2023: This standard outlines the requirements for mechanical splices of reinforcement bars.
- IS 1786: This specifies the requirements for TMT rebars, including their mechanical properties.
- IS 16651:2017: Standards for TMT made of SS material.
- ASTM A1034: This standard specifies the requirements for mechanical splicing of bars.
- ISO 15835-2: This standard covers the testing procedures for mechanical couplers.
- BS 4999: This standard includes guidelines for testing the mechanical properties of reinforcement couplers.

TCR Engineering utilizes a variety of testing methods to ensure the integrity and performance of TMT rebars and their couplers:

TMT Testing - IS 1786:2008

- Static Tensile Test: Determine the tensile strength and elongation of TMT rebars (Grades Fe 500 D, Fe 415 D/S, up to 45 mm diameter) per IS 1786.
- Bend and Re-Bend Tests: Evaluates ductility and flexibility by bending specimens to specified angles and then straightening to inspect for cracks or failure.
- Spectro/Wet Chemical Analysis: Confirms chemical composition of TMT rebars as per IS 1786 and IS 16651 (for SS materials).

Rebar Coupler Testing - IS 16172:2023

- Static Tensile Test: Evaluates tensile strength on static machines.
- Slip Test: Measures permanent extension post-loading (performed before cyclic testing).
- Cyclic Tensile Test: Evaluates splice behavior under cyclic loads, typically 100 cycles at stress levels from 5% to 90% of yield stress, according to relevant standards, without loss of static tensile strength.
- Low Cycle Fatigue (LCF) Test (10,000 Cycles): Tests endurance under alternating loads of the splice in such a way that they should withstand 10,000 cycles of alternating tension and compression without failure.
- High Cycle Fatigue (HCF) Test (2 million Cycles): Measures durability under extensive cyclic loads with parameters including:
    - Minimum Stress: 30 MPa
    - Maximum Stress: 130-350 MPa
    - Frequency: 3-10 Hz
- Reporting: S-N curve documentation.

Common Material Grades: EN8D and 45C8 for rebar couplers.
Equipment: Tests are conducted on advanced machines, static tensile and slip test performed on a static machine and fatigue tests (cyclic, LCF, HCF) on a dynamic machine.

Closed-loop servo-hydraulic dynamic UTM machines enable testing frequencies from 0.035 to 30 Hz, ensuring precision and reliability.

Coupler Sizes and Standards
TCR conducts rebar coupler testing across diameters from 12 mm to 40 mm, ensuring compatibility with rebar grades like Fe415, Fe500, and Fe550, in compliance with standards such as IS 16172. All tests align with TCR's NABL accreditation (ISO/IEC 17025:2017), emphasizing the company's dedication to quality and accuracy.

TCR Engineering stands at the forefront of material testing for TMT rebars and couplers, ensuring that the structures built using these materials meet the highest safety and performance standards. With over five decades of experience, TCR continues to support the construction industry with rigorous testing protocols, advanced technologies, and adherence to stringent quality standards, solidifying its role as a trusted partner in the field of materials testing.

Chemical Analysis Lab

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, XRF spectrometer, and more.

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 including state-of-the-art Spectrometers and Wet Chemistry laboratory facilities. TCR caters to all 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, right form trace chemical analysis to very low detection levels.

TCR Engineering Material Testing Laboratory provides both analytical and interpretive expertise, including method development, method validation and identification of unknown materials. The lab can successfully meet all challenges, whether it is for PPB or PPM level analysis or in percentage. TCR has the capability to provide results with both, standard specifications and client supplied specifications. It has the expertise to develop customized analytical procedures for analysis of materials and substances for which no protocol is available.

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 up to 8 elements
- Impurities in PPM Level using AAS or ICP

Chemical Analysis by LECO

- Oxygen by LECO
- Nitrogen by LECO
- Hydrogen by LECO

Steel and Cast Iron

1. Determination Of Any One Element (%C)
2. Determination Of Any One Element (Mn, Si)
3. Determination Of Any One Element (Ni, Cr, S,
4. Determination Of C, Mn, Si, S, P
5. Complete Analysis Of Low Alloy Steel Up To 8 Elements Including C, S, P, Si, Mn, Ni, Cr, Mo
6. Determination Of Any One Element in Stainless Steel
7. Complete Analysis Of Stainless Steel up to 8 Elements
8. Determination Of High Alloy Element (Cr, Ni, Mn)
9. Determination Of Some Special Element (Cu, Ti, Co, V, W, Al) Per Element
10. Complete Analysis Of High-Speed Steel (8 Elements) Per Element
11. Determination Of Mo%
12. Determination Of V%
13. 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, Aluminium, 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

EQUIPMENTS

Wet Chemistry

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

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

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.

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 making them the most flexible instruments that are available today with parts per billion detection limits.

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.

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.

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.

Oil Analysis Ferrography

Ferrography for 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 provides them with the opportunity to be prepared for investing in maintenance programs for breakdowns.

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.

- 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

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. 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.

RoHS Compliance Testing

The RoHS Directive states that certain non-exempt products, as well as electrical and electronic products available in 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

compliance testing 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 they ensure that the products meet all the requirements while retaining full product functionality.

1. 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

2. 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.

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 like in the field of 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
- Corrosion test in nitric acid medium by measurement of loss in mass (Huey test) per ISO 3651-1

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 3651-2 Method A, B, C

Metallic Materials

- Potentiostatic & Potentiodynamic Anodic Polarization Measurement per ASTM G5
- Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel, or Cobalt-Based Alloys per ASTM G61
- Electrochemical Impedance Spectroscopy (EIS) tests to find out Rp (polarization resistance), Cdl (double layer capacitance) & Corrosion rate measurement.
- 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 ASTM 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 Substrate

- 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
- Mechanical Hydrogen Embrittlement Evaluation as per ASTM F519

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 unrivalled 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.

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).

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 24º and 90º Celsius. Stressed samples are exposed to sour environment for a predetermined time, after which they are removed and analysed for crack detection. NACE TM0177 specifies test duration of 30 days (720 hours) for Method A or B test.

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.

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- 160 long pieces irrespective of dia, cut strip of 16mm width

Bar- 160mm long piece irrespective of diameter

INTERGRANULAR CORROSION 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. 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. his procedure measures the susceptibility of stainless steel 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 percent 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 if 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.

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.

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 non-metallic protective coatings. Several samples can be tested simultaneously depending on their size.

Corrosion Test in artificial atmospheres – Salt Spray Test, ISO 9227

This procedure is employed to assessment of corrosion resistance of metallic material with or without permanent temporary corrosion protection. The selection of test methods that can be used in the identification and examination of rusting as well as the evaluation of pitting corrosion to determine the extent of its effect in various atmospheres with respective to Method NSS, AASS & CASS.

Welder Certification & Procedure Qualification

TCR Engineering Services provides a comprehensive welder certification and welding procedure program that includes:

1. Welder Qualification Testing for performance qualification and certification of welders (a welder / welding operator performances qualification - WQT) to ASME Sec. IX, ASME Sec. VIII, ANSI, AWS D 1.1, AWS D 1.2, API 1104 etc.
2. Preparation for Weld Procedure Qualification (WPS) that is relevant for either the project or any client requirements
3. Coupon Testing as per Welding Procedure Qualification including visual examination, mechanical testing, metallographic examination, and non-destructive testing
4. Documentation of the Procedure Qualification Record (PQR) as per ASME Sec. IX, ASME Sec. VIII, ANSI, AWS D1.1, AWS D1.2, API 1104 etc.
5. Detailed weld inspection including review of the qualification e.g. weld procedure specification, welder performance qualification, validity for process materials and consumable items, equipment, setup and other factors including certificates of calibration and/or conformity governing the task
6. Ascertain safety of operations for self, welder and other workers in the vicinity, particularly ultraviolet radiation from arc during welding

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, and Mechanical Test Etc.
- 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 equipment's 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 an Ammeter, Voltmeter etc.
- Temperature Measuring Instruments (Thermometer)/Aids (Thermo Chalk)

TCR brings over 50 years of experience in QA /QC inspection in the Oil and Gas industry, Petrochemicals and refineries, and has experience in pressure vessel fabrication (static equipment), inspection and Third-Party Inspection of materials like plates, pipes, forgings, and castings at the vendor's location. TCR has extensive hands-on experience in NDT (UT, MT, PT) and Radiographic Film Interpretation and Destructive testing of various materials.

Civil Testing and Road Inspection

TCR Engineering in India is NABL ISO 17025 accredited and provides superior end-to-end solutions for civil testing across all the elements of building structures and has an extensive Road Inspections program as per requirements of IRC.

TCR is trusted by contractors, construction companies, and infrastructure developers for delivering accurate and reliable testing services across various sector ranging from residential, commercial, and industrial infrastructure.

Advantage TCR:

- Decades of Experience: With 50 years of industry expertise, we understand the intricacies and challenges of construction projects.
- NABL Accredited: Our ISO 17025 accreditation ensures that all testing is performed to the highest India IS and International standards.
- Advanced Technologies: We utilize cutting-edge robotic NDT solutions for underwater inspections, ensuring the safety of critical infrastructure like bridges.
- Unmatched Expertise: Our team of experts is committed to delivering precise and reliable results for all your construction material testing needs.

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

Prominent Civil Testing Projects by TCR Include:

- NDT work at prestigious sites such as Antillia and Wankhede Stadium in Mumbai.
- Structural audits at Vikas Complex in Thane West, KC College in Thane, and Essential Power Transmission in Andheri, Mumbai.
- Structural audits conducted at STT Global Data Centre, a building by Larsen & Toubro Limited, Construction
- Performed structural analysis for a building project of Petro India Private Limited in Tehsil – Sanganer, Jaipur
- Conducted structural analysis for the Synergia Life Sciences Pvt. Ltd. factory in Wada, Maharashtra.
- Structural Inspection of over 400 bridges across Maharashtra, utilizing advanced underwater robotic NDT solutions, ensuring safety and integrity.

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 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, Mumbai. 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

TESTS CONDUCTED:

Part A – Visual Inspection

1. Visual inspections of individual building / structures from inside and outside and to study present status of different structural members
2. Study of Architectural / RCC / Structural drawings (If available)
3. Photographic Survey
4. Capturing multiple details including:
    - Load transfer system,

- Structural framing system,
- Structural deficiencies,
- Settlement if any,
- Cracks in RCC members,
- Cracks in masonry / plaster
- Leakages,
- Loads on structure,
- 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

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

Part C – Repair & Rehabilitation Consultancy

1. For preparation of detailed report for range of visual inspection & ND tests
2. For Interpretation of ND test results
3. For Diagnosis & Root cause analysis of the problems / observations
4. For preparation of Repair & Rehabilitation scheme to make structure durable, healthy and to stand for a long life
5. For preparation of technical specifications & draft tender document for repair and rehabilitation
6. For preparation of cost estimates for the same
7. For scrutinizing the tender documents
8. For periodic inspection of work
9. For issuing Structural Stability Certification after completion of entire job

New Construction Civil Testing

Cement

Chemical Test as per IS 269: 2015, IS 1489-1: 2015 and IS 4032:1985

- Magnesia (% by mass)
- Sulphuric Anhydride (% by mass)
- Loss on Ignition (% by mass)
- Insoluble Residue (% by mass)
- Chloride content (% by mass)
- Ratio of percentage of Lime to percentages of silica, alumina and iron oxide
- Ratio of percentage of alumina to that of Iron oxide

Physical Testing as per IS 4031

- Fineness
- Normal Consistency
- Setting Time (Minutes)
- Soundness by Le Chatelier method and Autoclave test method
- Compressive Strength
- Drying shrinkage

Inspection at Site as per IS 269: 2015, IS 1489-1: 2015 and IS 4031(Part 1):1996

- Fineness (by Sieve)
- Age
- Visual Inspection
- Weight

Ground Granulated Blast Furnace Slag (GGBS)

Chemical Testing as per IS 16714: 2018 and IS 4032

- Manganese oxide, MnO
- Magnesium oxide, MgO
- Sulphide sulphur, S
- Sulphate as (SO3)
- Insoluble residue
- Chloride content
- Loss on Ignition
- Molar Ratio of CaO, MgO, Al_2O_3, and SiO_2
- Moisture content % by mass
- Glass content % by mass

Physical Testing as per IS 16714:2018, IS 4031 (part 2)

- Fineness (Specific Surface)
- Slag activity Index 7/28 Days

Inspection at Site as per IS 16714:2018

- Moisture Content
- Visual Inspection for lumps

Micro Silica

Chemical Testing as per IS 15388: 2003, IS 1727, IS 4032

- Silicon dioxide (SiO2), in % by mass
- Loss on Ignition, in % by mass
- Alkalies as Na2O, in %
- Moisture Content, in % by mass
- Total chlorides in percent by mass

Physical Testing as per IS 15388: 2003 and IS 1727

- Oversize percent retained on 45 micron IS sieve
- Compressive Strength at 7 Days as percentage of control sample

Inspection at Site as per IS 15388: 2003

- Moisture Content
- Oversize Particles retained

Flyash

Chemical Testing as per IS 3812 - P1 (2013), IS 1727

- Silicon Dioxide (Si02) plus Aluminium Oxide (Al2O3) plus Iron Oxide (Fe2O3) % by mass
- Silicon dioxide (SiO2) in percent by mass
- Reactive silica in % by mass
- Total sulphur trioxide (S03) in percent by mass

- Total chlorides in percent by mass
- Available alkalis as equivalent sodium oxide (Na2O) in percent by mass
- Loss on Ignition in % by mass
- Magnesium oxide (MgO) in % by mass

Physical Testing as per IS 1727

- Particles retained on 45 Micron IS sieve (Wet Sieving)
- Fineness (Specific Surface)
- Lime Reactivity compressive strength
- Soundness by autoclave test
- Specific gravity
- Compressive Strength

Inspection at Site as per IS 3812:2013 and IS 4031/4032

- Particles retained on 45 Micron IS sieve (Wet Sieving)
- Moisture Content
- Visual Inspection for lumps

Admixture

Physical and Chemical Test as per IS 9103: 1999

- Dry material content for liquid and solid admixture
- Relative density
- Chloride ion content
- pH
- Ash Content

Field Test as per IS 9103: 1999

- Material shelflife and storage check
- Packing of material
- Relative Density of chemical

Water

Chemical Testing as per IS 456:2000 and IS 3025

- pH Value
- Organic
- Inorganic
- Sulphatea (as SO3)
- Chlorides
- Suspended Matter
- Total acidity
- Total alkalinity

Field Test as per IS 456:2000

- Visual Inspection for clean water
- pH

Readymix (RM) Plaster

Field Test as per BS 998 and EN 1015

- Age of batch
- Visual Inspection
- Workable life (minutes)

Fine Aggregate

Chemical Testing as per IS 383: 2016 and IS 2386

- Deleterious Material
- Soundness of aggregates
- Alkali aggregate reaction
- Petrography

Physical Testing as per IS 383: 2016 and IS 2386

- Size & Grading
- Specific Gravity
- Water absorption Value
- Material finer than 75 micron IS sieve

Field Test as per IS 383: 2016 and IS 2386

- Grading
- Silt content in case of river sand
- Material finer than 75 micron in case of crushed sand
- Specific Gravity
- Bulkage Test
- Water absorption Value

Coarse Aggregate

Chemical Testing as per IS 383: 2016 and IS 2386

- Deleterious material
- Soundness of aggregates
- Alkali aggregate reaction
- Petrography

Physical Testing as per IS 383: 2016 and IS 2386

- Size & Grading
- Aggregate impact Value
- Sp. Gravity
- Water absorption Value
- Combined Flakiness and elongation index
- Aggregate abrasion Value

Field Test as per IS 383: 2016 and IS 2386

- Shape
- Size & Grading
- Aggregate impact Value
- Sp.Gravity
- Water absorption Value

Reinforcement

Physical and Chemical Testing per IS 1786: 2008

- Tensile Test with 0.2% Proof / Yield Stress
- Bend & Rebend test
- Carbon
- Sulphur
- Phosphorus

Field Test as per IS 1786: 2008

- Identification Mark & grade of steel check
- Visual Inspection for Rust
- Bend test as per internal procedure at site
- Weight per meter

Coupler

Chemical Testing all elements as per ASTM E415

Physical Testing as per IS 16172

- Static Tensile test
- Slip test
- Cyclic tensile test
- Low Cycle Fatigue (LCF) test
- High Cycle Fatigue (HCF) test

Autoclaved Aerated Concrete (AAC) Blocks

Physical Testing per IS 2185, IS 6441 and IS 3346

- Dimensional Tolerances
- Compressive Strength
- Drying Shrinkage
- Density
- Thermal Conductivity

Field Test of dimensional tolerance as per IS 2185

Gypsum Plaster

Chemical Testing as per IS 1288 and IS 2547

- SO3, percent by mass
- CaO, percent by mass
- Soluble magnesium salts
- Soluble sodium salts
- Loss of ignition, percent by mass
- Free lime %

Physical Testing as per IS 2547 and IS 2542

- Setting time minutes
- Soundness
- Mechanical resistance of set neat plaster
- Residue on 150 µm IS sieve in percentage
- Adhesion strength

Field Test as per IS 2542

- Residue on sieve
- Shelf life
- Weight of Bag

Bricks (Clay and Flyash)

Physical Testing as per IS 1077, IS 12894, IS 3495 and IS 4139

- Dimensional Tolerances checks of Modular and Non-Modular brick sizes
- Water absorption (% by weight)
- Compressive Strength
- Drying shrinkage
- Efflorescence Test

Field Test as per IS 1077, IS 12894, IS 3495 and IS 4139

- Dimension analysis
- Water absorption
- Visual observation
- Edges
- Resistance under a free fall of 1 meter on the flat surface on strong concrete surface

Concrete

Concrete Mix Design Test as per IS 10262, EN 12390, IS 16700, ASTM C1202, DIN 1048, IS 3085, BS 1881

- Proportion of constituent of concrete
- Concrete Mix Design revalidation for Slump, cohesiveness, retention, setting
- Modulus of Elasticity of Concrete
- RCPT
- Water permeability / Water penetration test
- Water absorption
- Initial Surface Absorption Test (ISAT)

Fresh Concrete Test as per IS 1199

- Workability
- Plastic Density/ Yield
- Concrete temperature

Field Test of Compressive Strength as per IS 1199 and IS 516

Building Finishing Works Testing

Tiles

Physical Testing as per IS 15622: 2017 and IS 13630

- Dimensional Analysis including Length & Width, Thickness, Straightness of sides, Rectangularity
- Surface Flatness - Centre, edge, warpage curvature
- Surface quality
- Physical Properties

- Water Absorption
- Scratch Resistance (Mohs Scale)
- Resistance to Surface Abrasion of glazed tiles
- Breaking strength
- Modulus of rupture
- Coefficient of Linear thermal expansion
- Moisture expansion
- Thermal Shock resistance (external grade tiles)
- Impact resistance: Coefficient of restitution
- Coefficient of Friction - Tiles intended for use on floors
- Crazing resistance

Chemical Testing as per IS 15622: 2017

- Resistance to household chemicals
- Resistance to staining of glazed tiles
- Resistance to acids and alkalies

Granite

Physical Testing as per IS 14223, IS 1124, IS 13630, IS 1706 and ISO 10545

- Specific gravity
- Water absorption
- Porosity
- Hardness (Mohs)
- Resistance to wear (for floor application)
- Stain Test

Marble

Physical Testing per IS 1124, Mohs Scale and IS 1122

- Water absorption after 24 hours immersion
- Hardness
- Specific gravity

Wooden Flooring

Physical Testing as per Manufacturer Spec

- Moisture, Grade, Length, Width, Thickness, Joints, Surface effects
- Dimension check

Precast Concrete Pipes

Physical Testing as per IS 3597

- Dimensional Analysis
- Hydrostatic Test

Fiber Cement Board

Physical Testing as per IS 14862

- Length and width
- Thickness
- Modulus of rupture
- Apparent density

- Bending strength

Wooden Door Frame

Physical Testing as per IS 287: 1993, IS 11215: 1991 and Moisture Meter

- Moisture content (%)
- Density

Laminated Veneer Lumber (LVL Door Frame)

Physical Testing as per IS 14616, IS 1734, IS 1708, IS 2380

- Dimensions
- Moisture content
- Adhesion of plies
- Strength Tests

Door Panels

Physical Testing as per IS 4020

- Dimensions and squareness
- Planeness Test
- Flatness test
- Impact indentation test
- Edge loading test
- Shock resistance test
- Buckling resistance test
- Slamming test - Misuse, End Imersion, Knife
- Glue adhesion test
- Screw withdrawal resistance test
- Flexure test
- Varying humidity test

Aluminium Sections

Chemical Testing as per BS 573

- Mg, Si, Mn, Fe, Cu, Zn, Ti, Cr, Al

Physical Testing per BS 573, IS 13871 and IS 101

- Tensile
- Hardness
- Weight per Meter
- Thickness of Powder coating
- Finish
- Scratch hardness at 3000 g
- Cross cut adhesion

Glass

Toughened glass Physical Test as per IS 2553 and IS 17004

- Thickness of glass
- Dimensions and Squareness
- Surface compression

Laminated glass Physical Test - IS 2553, IS 17004

- Thickness of glass
- Dimensions, squareness and Edge displacement

Float glass Physical Test as per IS 14900

- Visual light transmission
- Dimensions (Length, Width and squareness)
- Thickness of glass
- Visual faults

Ensuring Quality Excellence in Road Construction as per IRC

TCR takes pride in upholding the highest standards in road and bridge construction through rigorous quality control measures.

We adhere to the guidelines set forth by the Indian Roads Congress (IRC), exemplified by three essential publications:

IRC:SP:11-1984 - Handbook for Quality Control for Construction of Roads and Runways:

This foundational publication outlines comprehensive quality control measures for road and runway construction. It serves as our guiding manual, ensuring that every aspect of the construction process aligns with the stipulated standards.

IRC:SP:57-2000 - Guidelines for Quality Systems for Road Construction:

In an era where systematic quality management is paramount, this publication serves as our benchmark. We meticulously implement the guidelines to establish and maintain robust quality systems throughout the road construction process.

IRC:SP:47-1998 - Guidelines for Quality Systems for Road & Bridges:

Acknowledging the intricate relationship between roads and bridges, we follow the guidelines outlined in this publication. Our commitment to quality extends to both components, ensuring the seamless integration and durability of road and bridge structures.

TCR's Approach to Road Inspection:

Our road inspection services in India encompass a thorough examination of construction projects, focusing on adherence to design specifications and quality benchmarks.

Adherence to IRC Guidelines:

We strictly adhere to the IRC publications, ensuring that our road and bridge construction projects align with the recommended quality control measures.

At TCR, our commitment to quality control in road and bridge construction is unwavering. By aligning with the IRC guidelines, we guarantee that our projects not only meet but exceed industry standards, providing durable and safe infrastructure for communities to thrive. Choose us for road construction that stands the test of time.

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 with 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 the 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 equivalency 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.

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

- Fatigue Crack Propagation [da/dN vs ΔK Studies]
- Fracture Mechanics [K1c, J1c, CTOD] Testing
- 3 – Point Bend Testing of Materials
- Spring Fatigue Testing
- Room Temperature and High Temperature Tests [up to 1000 °C]
- Tension/Compression
- Low/High Cycle Fatigue (LCF/HCF) Testing
- High Temperature Tensile Tests [up to 1000 °C]
- High Strain Rate Testing [300mm/sec on 50KN and 100mm/sec on 250KN UTM]
- Slow Strain Rate Testing [10-7 mm/sec on 100kN UTM]

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

- 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)
- ASTM E647: Standard Test Method for Measurement of Fatigue Crack Growth Rates
- 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 (ASTM A1034, IS 16172)
- Cyclic Tensile Test (ASTM A1034, IS 16172)
- Slip Test (ASTM A1034, IS 16172) High
- Cycle Fatigue Test (ASTM A1034, IS 16172)

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 representative of in-service conditions. TCR has capability to conduct the CTOD testing at temperature from Ambient to -25 °C

Fatigue Test

- ASTM E466: Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials
- ASTM E606: Standard Practice for Strain-Controlled Fatigue Testing
- ASTM E 2714 – Standard Test Method for Creep-Fatigue Testing
- ISO 12106: Metallic materials — Fatigue testing —Axial-strain-controlled 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
- Uniaxial Fatigue Test as per BS EN 14587-2, IRS-T19, ISO 14587

Fatigue testing of butt-welded track rail

Fatigue testing of weld joints in rail tracks, as per IRS-T19, ISO 14587 & other National/International standards, is a crucial aspect of ensuring the safety and longevity of railway infrastructure. By following standardized testing procedures, rail industry professionals can gain valuable insights into the fatigue performance of weld joints, leading to improved design practices and enhanced reliability of rail tracks worldwide.

Fatigue testing involves subjecting the welded rail joint to repeated loading cycles that simulate the dynamic forces experienced during normal train operations. The purpose of this testing is to evaluate the performance of the welded joint under repeated stress and determine its ability to withstand the anticipated service conditions without failure or degradation over time.

TEST SET-UP

A representative length of welded rail joint, usually several meters long (span length 1.5 meter), is selected for testing. The rail is typically mounted on a test fixture or a specialized fatigue testing machine that applies cyclic loading (4-point bend) to the joint. The loading can be

applied in the form of vertical, forces, depending on the specific requirements as per relevant national/International standards.

CYCLE LOADING

The rail joint is subjected to repeated loading cycles that simulate the stress patterns encountered during train operations. The loading can vary in magnitude, frequency, and direction to simulate different operating conditions. The number of cycles applied during testing depends on the desired fatigue life assessment.

MONITORING & MEASUREMENTS

During the fatigue test, various parameters are monitored and measured to assess the performance of the welded joint. These may include strain, displacement, crack propagation, and other relevant factors. Advanced measurement techniques such as strain gauges or non-destructive testing methods may be employed to gather accurate data.

FAILURE CRITERIA

The test is typically continued until a predefined failure criterion is reached. This criterion can be defined based on the appearance of cracks, changes in strain or displacement values, or other factors indicating potential failure or significant degradation of the welded joint.

EVALUATION & ANALYSIS

After the test, the collected data is analysed to determine the fatigue life and performance characteristics of the welded rail joint. This analysis helps in understanding the joint's ability to withstand cyclic loading and predict its service life in real-world operating conditions.

STANDARDS & REGULATIONS

Fatigue testing of butt-welded track rail is often conducted in accordance with specific industry standards and regulations. These standards provide guidelines for test procedures, acceptance criteria, and performance evaluation methodologies.

By performing fatigue testing on butt welded track rail, railway authorities and manufacturers can ensure that the rail joints are robust, reliable, and capable of withstanding the anticipated stresses and strains during the operational lifespan of the railway track. This testing helps enhance safety, reduce maintenance costs, and optimize the performance of rail systems.

Spectrum of Services

At our fatigue testing division, we are equipped with a state-of-the-art Dynamic Universal Testing Machine (UTM) that offers unparalleled capabilities for conducting various fatigue tests. Our Dynamic UTM is designed to handle a wide range of testing requirements and can accommodate specimens of different sizes and strengths.

Here's a detailed overview of our testing machine and the comprehensive capabilities it offers:

Dynamic UTM Specifications:

- Capacity: Our Dynamic UTM boasts impressive load capacities, allowing us to conduct fatigue testing on a diverse range of materials and components. With load capacities of 50kN, 250kN, and 1000kN, we can effectively evaluate the fatigue behaviour of various specimens.
- Frequency Range: Our Dynamic UTM operates within a frequency range of 0.01Hz to 40Hz, enabling us to simulate real-world loading conditions and accurately assess the fatigue performance of materials under dynamic loading.

In our fatigue testing division, we specialize in a range of fatigue testing methodologies, including:

Fracture Toughness (KIC) Test

- Specimen Size: We can test specimens ranging from 8mm to 32mm in thickness on Test temperature range: at subzero up to -20 °C & at elevated temperature up to 1100 °C. We can test specimens ranging from 8mm to 50mm (CT/SENB specimen) at Room Temperature & over 50 mm to 100mm (SENB specimen only, depends on the strength of material)
- Test Method: Our testing procedures adhere to recognized industry standards such as ASTM E399, ASTM E1820, ASTM B645, BS7448 (Part 1-4), ISO12135, ISO 12737 and ISO15653, ensuring accurate and reliable results.
- Test temperature range: -20°C to 1100°C

Fatigue Crack Growth Rate (FCGR) Test

- Specimen Size: We can test specimens ranging from 8mm to 32mm in thickness on Test temperature range: at subzero up to -20 °C & at elevated temperature up to 1100 °C. We can test specimens ranging from 8mm to 50mm (CT/SENB specimen) at Room Temperature & over 50 mm to 100mm (SENB specimen only, depends on the strength of material)
- Test Method: Our testing protocols strictly follow ASTM E647, ISO 12108 guidelines, allowing us to assess the crack growth behaviour under fatigue loading accurately.
- Test temperature range: -20°C to 1100°C

CTOD Test (Crack Tip Opening Displacement)

- Specimen Size: We can test specimens ranging from 8mm to 32mm in thickness on Test temperature range: at subzero up to -20 °C & at elevated temperature up to 1100 °C. We can test specimens ranging from 8mm to 50mm (CT/SENB specimen) at Room Temperature & over 50 mm to 100mm (SENB specimen only, depends on the strength of material)
- Span Length: Our testing equipment accommodates span lengths between 55mm and 1,600mm.
- Test Method: We adhere to industry standards such as ASTM E1290, ASTM E1820, BS7448 (Part 1-4), ISO12135, and ISO15653, ensuring precise CTOD measurements.
- Test temperature range: -20°C to 1100°C

J-Integral (JIC) Test

- Specimen Size: We can test specimens ranging from 8mm to 32mm in thickness on Test temperature range: at subzero up to -20 °C & at elevated temperature up to 1100 °C. We can test specimens ranging from 8mm to 50mm (CT/SENB specimen) at Room Temperature & over 50 mm to 100mm (SENB specimen only, depends on the strength of material)
- Test Method: We follow standardized test methods, including ASTM E1820, ASTM B645, BS7448 (Part 1-4), ISO12135, and ISO15653, to accurately determine the J-Integral values.
- Test temperature range: -20°C to 1100°C

Uni-axial Fatigue Test

- Test Method: Our fatigue testing procedures align with ASTM E466, ASTM E606, and IS 5074, IS 16172 guidelines, ensuring comprehensive assessment of uni-axial fatigue behavior.

- Test temperature range: ambient to 1100°C

Fatigue test of flash butt joint welding of track rail

- Test Method: Our fatigue testing procedures align with BS EN 14587 (Part1 & Part2), BS EN 13674-1, guidelines, ensuring comprehensive assessment of fatigue behaviour.

Helical Spring Test. (As per RDSO / National / International Standards)

- Static Load Test.
- Load v/s Displacement (Spring Constant/ Spring Rate)
- Fatigue Test

Additionally, our capabilities extend beyond traditional fatigue testing, as we offer specialized testing for Reinforcement Couplers and Grouter for Mechanical Splices of Bars in Concrete. Our testing services in this area include:

- Static Tensile Test
- Slip Test
- Cyclic Tensile Test
- Fatigue Test
- Low Cycle Fatigue Test
- High Cycle Fatigue Test

We can accommodate reinforced bars with nominal diameters ranging from 8mm to 40mm, adhering to relevant industry standards such as IS16172, ASTM A1034, IS16651, ISO15630, and ISO15835-2. With our Dynamic UTM and comprehensive range of testing capabilities, we are well-equipped to meet your fatigue testing needs, providing accurate and reliable results for a wide range of materials.

Fatigue Testing of Gully and Manhole tops made of composite materials

Test as per BS EN BS EN 124-1 and BS EN 124-5

At TCR, we understand the critical importance of ensuring the durability, reliability, and safety of infrastructure components like gully and manhole tops, especially when constructed from advanced composite materials. Fatigue testing simulates real-world conditions and repetitive stresses that gully and manhole tops may experience over their operational lifetimes. By subjecting these components to fatigue testing, manufacturers and users can assess how well the materials and structures withstand cyclic loading without developing cracks or failures. This ensures the products' long-term reliability and helps in predicting their lifespan.

Gully and manhole tops are critical components of infrastructure, often subjected to heavy loads, traffic, and environmental stresses. Fatigue testing helps identify potential weaknesses or fatigue-related failure modes that could compromise structural integrity and safety over time. Addressing these issues early through testing minimizes the risk of sudden failures, ensuring safer operation and maintenance of infrastructure.

Gully and manhole tops are fatigue tested as complete units in their intended position of use where cover/grating is suitably positioned within the frame and the frame is supported in a manner to replicate intended installation support structure. TCR’s facilities and expertise thoroughly evaluates against the rigorous requirements outlined in BS EN 124-1 (for gully tops) and BS EN 124-5 (for manhole tops) with rectangular / circular / triangular as well as double or multiple triangular covers and/or gratings.

TCR's testing protocols cover a comprehensive range of performance factors, including load-bearing capacity, impact resistance, chemical resistance, and fatigue durability. TCR's fracture mechanics department has specialized testing machine (complying to EN ISO 7500-1:2004) which includes a Servo Hydraulic Dynamic UTM machine which is capable of applying a load as recommended (at least 25 % greater) than the respective test load (FT) for classes A 15 to D 400 and (at least 10 % greater than) the respective test load (FT)for classes E 600 and F 900.

Conducting fatigue testing as part of quality control processes ensures that manufactured gully and manhole tops meet design specifications and performance expectations. It helps manufacturers identify potential design flaws, material weaknesses, or manufacturing defects that could lead to premature failures in the field, thereby improving overall product quality and customer satisfaction.

TCR also specializes in conducting both the Permanent Set Test and Load Bearing Capacity Test to evaluate material performance. The Permanent Set Test is undertaken to evaluate a material's resilience by measuring its ability to recover its original shape after being subjected to a specified load over a defined period. Additionally, TCR conducts the Load Bearing Capacity Test to determine the maximum load a material or structure can endure before failure. This test provides crucial insights into the strength and durability of metals, polymers, composites, and other materials, supporting informed engineering and design decisions with precise data.

Whether you're a manufacturer seeking compliance validation or Kitemark certification, or a specifier ensuring product suitability, our dedicated team of experts is here to support you every step of the way. By partnering with us, you can be confident that your composite gully and manhole tops will undergo detailed testing processes.

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 3 different SEM/EDAX, 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.

TCR undertakes metallurgical evaluation using SEM, EDAX, XRD and TEM technologies

The ambit of frequently tested services in TCR metallography lab include:

- Microstructure Examination (Routine) with two photographs
- NDT microstructure with two photographs
- Microstructure with Comment on Heat Treatment
- Microstructure examination for failure related study
- Grain size distribution chart on Image Analysis (With print out)
- Prior austenite grain size measurement (including heat treatment charges)
- Prior austenite grain size measurement by Mc Quid Ehn method (including carburizing)

- Oxide-scale/Nitriding/Carburizing/Decarburizing/ Coating – Measurements. (Avg. of 3 readings), over and above microstructure examination charge
- Grain size Measurement as per ASTM E112 with photograph
- Linear measurement, up to 3 measurements, over and above macrostructure/microstructure examination charge
- Each Additional linear measurement
- Inclusion Rating as per ASTM E45 Method A with photograph
- Inclusion rating as per ASTM E45 with photograph
- Color Metallography (With two Photos)
- Delta ferrite from SS weld microstructure, Sigma phase, volume fraction by microstructure examination (Avg. 3 frames)
- % Nodularity, Nodule Count as per ASTM A247 and IS 1865
- Porosity Analysis as per ASTM A 276
- Decarburization Level as per IS 6396 And ASTM E 1077
- Phase Distribution as per ASTM E 562 / 1245
- Powder Particle Size Measurement (Avg. 5 Frames)
- Coating Thickness Measurement as per ASTM B 487
- Retained Austenite Measurement with Electro Polish and Copper Deposition Method, And Calculation On Image Analysis Software from Microstructure Examination. (Avg. 3 Frames)
- Micro-Hardness Testing
- Micro Hardness Profile For Case Depth Measurement (Max. 10 Readings)
- Macro Etch Test Up To 100 Mm (Including Photo & Comments)
- Macro Etch Test Between 100 To 200 Mm (Including Photo & Comments)
- Macro Etch Test Over 200 Mm (Including Photo & Comments)
- Fractography by Stereo Microscope
- Fractography by SEM
- Coating Thickness by SEM
- 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
- Hydrogen Embrittlement on Copper
- Ferrite As Per ASTM E562 per Phase per Sample
- Intermetallic Phase (Chi, Sigma, Laves Nitrate Carbide) per phase per Sample
- Intermetallic Phases In Weld, Parent Material (PM), Heat Affected Zone (HAZ) per phase per Sample
- Microstructure Test with Photograph (For Sigma Phase)
- icrostructure Test With Photograph (For Ferrite Content)
- 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.
- Cost To Prepare the Sample for Placement In SEM Sample Chamber
- SEM Analysis with Single Image
- Delta Ferrite Measurement by Ferritscope
- Pit Dimension Measurement
- EDAX / EDS Analysis
- XRD Analysis
- In-Situ Replica Interpretation only On a Client Supplied Replica. (Please Note: TCR will not be held responsible for accurate data interpretation in areas where a TCR technician has not taken the replicas
- Structural Examination Charges (As Per 6.1)

- Structural Examination (Each Additional Measurement)
- Inclusion Rating as ASTM E45 – Method D (Set Of Six Specimen)
- Volume Fraction Measurement (30 Frames) as per ASTM E 562
- Microstructure as per A 923 Method A
- Microstructure Carbide Network as per SEP 52100 Chart (Heat Treatment Charges Are Extra)
- In-Situ Metallography
- Step Macro without Photograph – Each Step
- Step Macro with Photograph – Each Step
- Macro Measurement (MLP/Penetration) -Each
- Depth Of Attack
- Banding Index
- Intermetallic Phases – Charges On Request
- Coating/ Plating Thickness/Mesh Size
- Austenitic Grain Size with Photographs (Up To 3 Samples)

Metallography Tests at TCR

Macro-Examinations

In Macro-etching 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.

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.

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.

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.

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

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.

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 millimetres.

Grain Size Determination (ASTM E112, ISO 643, IS 4748)

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 ASTM NO. 00 (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.

TECHNOLOGY @ TCR

SCANNING ELECTRON MICROSCOPE WITH EDS ANALYSER

TCR has three Scanning Electron Microscopes (SEM) attached to an Energy Dispersive Spectrometer (EDS) system. This is the highest number of SEM in any commercial lab in India.

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

Composite: Plastic & Rubber Testing Lab

At our state-of-the-art materials testing lab in India, we offer comprehensive testing services for composites, plastics, and rubber to ensure the quality, durability, and performance of your materials.

Our services include:

- Tensile Testing (Average of % Specimen): Measures the strength and elongation properties of materials under tension.
- Shore Hardness Testing (Shore A & Shore D): Determines material hardness levels for both soft and rigid plastics.
- Differential Scanning Calorimetry (DSC): Analyzes thermal properties and stability.
- Thermogravimetric Analysis (TGA): Measures changes in material weight as it is heated.
- Fourier Transform Infrared Spectroscopy (FTIR): Identifies chemical bonds in a material.
- Filler Content & Identification: Determines the percentage and type of filler in materials.
- Density Testing: Measures material density.
- Water Absorption Testing: Evaluates material's resistance to water.
- Compression Set & Compressive Strength Testing: Assesses rubber deformation and compressive strength.

These tests ensure compliance with industry standards and provide insights into material performance for demanding applications.

Creep and Stress Rupture Testing

TCR Engineering provides advanced testing solutions for evaluating high-temperature material behavior through Creep, ACRT and Stress Rupture Testing, essential for industries where equipment operates under extreme heat and stress. These tests deliver critical insights into

material durability, making them invaluable for applications in boilers, gas turbines, jet engines, ovens, and other high-temperature environments.

Understanding Creep and Stress Rupture

- Creep Testing measures the progressive deformation (creep) of materials under constant stress at elevated temperatures. The term “elevated temperature” is relative and depends on the specific material under testing. Creep testing is fundamental for understanding long-term material stability, especially in applications where continuous stress is applied at high temperatures. During a Creep Test, a tensile specimen is subjected to a constant load and temperature, and strain is recorded over time to determine the material's creep rate.
- Stress Rupture Testing builds on the principles of creep testing, with an increased stress level that brings the material to failure within a shorter timeframe. This test evaluates the time-to-failure for a material under high stress and temperature. Stress rupture testing continues until material failure, allowing for the direct determination of time-to-failure and elongation values. Data from these tests are plotted, often resulting in a linear or best-fit curve, providing essential material strength parameters for engineers.

TCR's Testing Capabilities

TCR Engineering is equipped to conduct the following tests in strict adherence to international standards, such as ASTM E139, E292, IS 340, and ISO 204:

1. Creep Rupture / Creep Testing – Provides strain data over time for materials under constant load and temperature.
2. Stress Rupture Testing – Establishes time-to-failure for materials at high stress and temperature, helping engineers predict failure risks in high-stress environments.
3. Accelerated Creep Rupture Test (ACRT) – A faster alternative to traditional creep testing, allowing rapid assessment of material behaviour for Remaining Life Assessment (RLA) and Fitness-for-Service (FFS) evaluations.

Accelerated Creep Rupture Testing (ACRT): A Fast and Efficient Solution

ACRT is increasingly popular in industries for its time-saving benefits. Using the Larson-Miller equation to derive initial test parameters, ACRT enables a faster, efficient way to estimate material life. Results from ACRT are particularly valuable for Remaining Life Assessments (RLA) and Fitness-for-Service (FFS) analyses of boilers, conducted in line with API 530 and API 579 standards.

Key Benefits of TCR’s Creep and Stress Rupture Testing

- Reliable Data for Material Selection: Understanding how materials perform at elevated temperatures helps engineers design safer, more resilient systems.
- Enhanced Failure Prediction: Creep and stress rupture data provide insight into potential failure points, enabling proactive maintenance planning.
- Comprehensive Standards Compliance: TCR’s adherence to ASTM, IS, and ISO standards ensures that test results are dependable and applicable across global industrial standards.

By leveraging TCR Engineering’s expertise in Creep, Stress Rupture, and ACRT testing, clients gain vital data for high-temperature component design and risk mitigation.

Inspection Services

TCR offers advanced NDT services led by NDT Level 3 experts, with our team operating in full compliance with ASNT CP-189 guidelines to ensure accurate material evaluation and adherence to the highest quality and safety standards.

Phased Array (PaUT)

TCR Engineering specializes in advanced Phased Array Ultrasonic Testing (PAUT) using Olympus OmniScan machines, providing high-resolution inspections for welds, components, pipelines, and pressure vessels. Our certified experts conduct thorough assessments of material integrity with precise defect detection and characterization, ensuring superior safety and reliability.

In compliance with industry standards, TCR performs PAUT inspections in accordance with ASME Boiler and Pressure Vessel Code, ASME B31.3 for Pressure Piping, and API 650 for Welded Tanks. These inspections are critical for pipelines and pressure vessels, ensuring structural integrity and adherence to the highest safety requirements. Our expertise enables us to deliver accurate, code-compliant results for industries such as oil & gas, power generation, and manufacturing, where operational efficiency and safety are paramount.

Time-of-Flight Diffraction (ToFD)

TCR Engineering specializes in the Time-of-Flight Diffraction (ToFD) technique, an advanced ultrasonic non-destructive testing (NDT) method that relies on the diffraction of ultrasonic energy from the corners and ends of internal structures, primarily defects, within the components being tested. Our expert NDT team provides amplitude-independent, accurate flaw sizing across a wide coverage area, ensuring that even the most subtle defects are detected and evaluated.

ToFD is particularly valuable for conducting Fitness for Service (FFS) inspections, making it an essential tool in maintaining the integrity of critical assets. This fast and effective method allows for the rapid scanning of extensive weld areas in a limited timeframe, which is crucial for minimizing downtime in industrial operations.

In addition to providing top-tier ToFD inspections, TCR offers services for creating customized ToFD scan plans and procedures tailored to specific client needs in India. The advantages of ToFD include its ability to deliver precise and reliable defect sizing, comprehensive coverage, and the facilitation of effective decision-making for asset management, all of which are critical for industries such as oil & gas, petrochemical, and power generation.

High-Temperature Online Inspection

TCR Engineering provides cutting-edge online inspection solutions designed to minimize plant downtime and reduce costs for operators. With capabilities to perform inspections at temperatures up to 350°C, TCR's innovations in high-temperature PAUT (HT), ToFD (HT), and corrosion mapping deliver essential data without halting operations. This technique is vital for in-service piping, vessels, and tanks.

Key Benefits of TCR's High-Temperature Inspection Services:

- Minimized plant downtime and reduced production losses by conducting inspections online
- Accurate detection of corrosion, wall thinning, and defect growth for engineering evaluations
- Real-time corrosion rate monitoring and defect growth tracking for better maintenance planning

- Supports RBI (Risk-Based Inspection) by delivering critical data for shutdown scheduling
- Online inspection of repairs, including welds and critical areas, up to 350°C
- Immediate feedback with digitized inspection records for future reference
- Enhanced health, safety, and environment (HSE) compliance

By offering in-service inspections, TCR Engineering helps clients avoid costly shutdowns, improve maintenance efficiency, and ensure the safety and reliability of their equipment. Our high-temperature inspection solutions are designed for critical applications, enabling precise and real-time defect detection in the harshest conditions.

High-Temp Phased Array UT

TCR Engineering's high-temperature PAUT inspections are designed to inspect surfaces up to 350°C, minimizing plant downtime. This advanced technique employs sectorial scans that cover the complete weld volume using a range of angles, ensuring comprehensive inspection in even the most challenging environments.

- Suitable for equipment/piping with thicknesses from 3 mm to 300 mm
- Handles temperatures from 10°C to 350°C
- Inspects pipelines with diameters of ¾” and above
- Detects, sizes, and monitors weld defects, corrosion, HTHA, HIC-SWC damage, and stress corrosion cracks
- Effective for one-sided weld inspections and dissimilar weld joints (CS/SS)
- Accurate damage/weld defect sizing with high Probability of Detection (POD)
- Encoded, recordable data/images for detailed analysis
- Compatible with Inconel and other high-performance materials
- Enhanced inspection range and cooling capacity via optimized water jacket design

Applicable Standards:

- ASME Section V (Nondestructive Examination)
- ASME Section VIII (Pressure Vessels)
- API 579 (Fitness-for-Service)
- AWS D1.1 (Structural Welding Code – Steel)

TCR Engineering—leading the way in high-temperature phased array inspections, ensuring the safety and integrity of critical infrastructure.

High-Temp Corrosion Mapping

TCR Engineering delivers state-of-the-art automated high-temperature corrosion mapping inspections using the straight beam pulse-echo technique with dual element transducers. Our custom-designed high-temperature probes, crafted from heat-resistant plastics and equipped with advanced cooling systems, ensure reliable performance in extreme environments.

- Suitable for equipment and pipelines with thicknesses from 5 mm to 125 mm
- Handles temperatures ranging from 10°C to 350°C
- Effective for pipelines with diameters of 6” and above
- Accurately detects, sizes, and monitors corrosion, erosion, and HIC-SWC damage
- Offers precise damage sizing with 0.1 mm accuracy
- High Probability of Detection (POD) for comprehensive inspection
- Provides recordable corrosion mapping images for detailed analysis
- Enhanced inspection angle range and sizing accuracy

Our cutting-edge technology ensures accurate, reliable inspections, minimizing downtime and optimizing asset integrity. With advanced probe cooling designs, we deliver highly effective results, even in the harshest environments.

Detecting High-Temperature Hydrogen Attack (HTHA)

TCR Engineering specializes in Advanced NDT services to detect High-Temperature Hydrogen Attack (HTHA), a critical phenomenon in petrochemical and refinery industries. HTHA occurs when steel, exposed to temperatures above 200°C, reacts with hydrogen, creating methane bubbles at the grain boundary. These bubbles lead to microcracks, weakening the steel and potentially causing catastrophic failures.

Even equipment designed under stringent safety codes may suffer from HTHA damage. Early detection through expert NDT inspections by TCR Engineering ensures safe, long-term operation, minimizing risks of equipment failure or accidents.

Industries and Equipment at Risk:

- Catalytic Reformers (CCR & Cyclic)
- Hydrotreating Units (Hydrocracking and Desulfurization)
- Ammonia and Hydrogen Reformers
- Highly stressed locations like flanges, reducers, and pipe fittings

Key Advantages of TCR's NDT Expertise:

- Comprehensive assessment of long-term HTHA damage
- Inspection over large, complex areas with external-only access
- Estimation of damage depth without the need for equipment shutdown

While early-stage micro-degradation is difficult to detect, our team's deep expertise ensures precise interpretation of HTHA in its critical stages. TCR Engineering—leading the way in safeguarding your assets from hydrogen-related risks.

Heat Exchanger Tube Inspection

TCR Engineering provides comprehensive inspection services for tubular products using advanced non-destructive testing (NDT) methods, including Eddy Current Testing (ECT), Remote Field Eddy Current (RFEC), Magnetic Flux Leakage (MFL), and Internal Rotary Inspection System (IRIS). These techniques utilize internal diameter probe coils, such as bobbin coils, for testing both non-ferrous and ferrous materials (the latter with magnetic saturation).

Our expertise in the inspection of heat exchangers, condensers, and steam generators—commonly found in power plants—ensures the detection of critical issues like corrosion, erosion, cracking, and other material degradations. These tubular structures, which contain thousands of tubes, must be regularly monitored to prevent leaks and ensure operational integrity. The high-speed testing provided by these methods ensures accurate identification of anomalies and minimizes downtime.

The testing is conducted in accordance with relevant international standards, such as ASTM E243 for eddy current testing and ASME Boiler and Pressure Vessel Code, Section V for ultrasonic and eddy current examination of tubing. TCR Engineering's NDT solutions ensure compliance, safety, and efficiency for critical infrastructure assets in power generation and industrial sectors.

Eddy Current Testing

TCR Engineering offers Eddy Current Testing (ECT), a fast and highly accurate technique for detecting discontinuities in tubing, heat exchangers, condensers, steam generators, air coolers, and feedwater heaters. By leveraging electromagnetic induction, TCR identifies flaws in conductive materials with precision, including detecting even the smallest cracks near the surface. This method requires minimal surface preparation and can easily accommodate complex geometries, making it ideal for a wide range of industrial applications.

In addition to flaw detection, ECT is effective for alloy separation, determining heat treatment conditions, measuring electrical conductivity, and assessing coating thickness. It can also pinpoint the location of repair welds, girth welds, and seam welds on ground-machined surfaces.

TCR Engineering's in-house team of certified Eddy Current Testing professionals brings deep expertise in inspecting tubing in heat exchangers and other critical equipment. Our advanced testing devices are portable, contactless, and provide instant feedback, ensuring minimal downtime and maximum efficiency. Our equipment is capable of operating at frequencies up to 8 kHz, with an impressive inspection speed of 2 meters per second, ensuring rapid and reliable results.

Key Benefits of TCR Engineering's Eddy Current Testing Services:

- High-Speed and Precise Detection: Rapid flaw identification with minimal surface preparation.
- Complex Geometries: ECT can investigate intricate shapes and sizes.
- Non-Destructive: Ensures the integrity of the material without physical damage.
- Versatility: Can detect flaws, measure conductivity, and identify different alloys.
- Immediate Feedback: Portable, real-time inspection results to facilitate quick decision-making.

Applicable Standards:

- ASTM E243: Standard Practice for Electromagnetic (Eddy-Current) Testing of Tubular Products
- ASME Section V: Non-Destructive Examination (NDE), covering Eddy Current Testing for heat exchanger tubes
- ISO 15548: NDT equipment and techniques for eddy current testing

TCR Engineering ensures that all tubes are properly cleaned prior to testing, with hydro jetting at pressures ranging from 280 to 560 kg/cm^2. The adequacy of cleaning is verified by inserting a dummy probe or rod to guarantee smooth inspections.

Our Eddy Current Technicians expertly evaluate flaw signals generated during testing, comparing them against calibration standards to ensure the highest accuracy in flaw detection and assessment. By utilizing industry-leading equipment and adhering to stringent international standards, TCR Engineering delivers unparalleled inspection services for tubular products, ensuring your operations remain safe and reliable.

Remote Field Eddy Current Testing (RFET)

TCR Engineering offers Remote Field Testing (RFT), a cutting-edge electromagnetic non-destructive testing (NDT) method as per ASTM E2096 and ASME Section V, ideal for detecting and sizing wall thinning due to corrosion, erosion, wear, pitting, and baffle cuts in ferromagnetic tubes.

Our RFT services are widely utilized in critical industrial equipment such as boilers, feedwater heaters, air coolers, and carbon steel heat exchangers, providing accurate assessments of tube integrity without the need for invasive procedures.

We combine Remote Field Eddy Current Testing (RFET) and Near Field Testing (NFT), deploying them individually or together, depending on the specific capabilities of the testing equipment and the condition of the asset. These methods allow us to achieve comprehensive coverage, ensuring reliable detection of both surface and subsurface defects.

Magnetic Flux Leakage Testing (MFL)

TCR Engineering offers Magnetic Flux Leakage (MFL), a highly reliable electromagnetic non-destructive testing (NDT) technique used to detect corrosion, pitting, and other forms of material loss in steel structures and ferromagnetic tubing. MFL is widely employed in critical industrial applications, including pipelines, storage tanks, and heat exchangers.The MFL method involves using a powerful magnet to magnetize the steel or conductive material under test. When defects like corrosion or material thinning are present, the magnetic field "leaks" from the surface, allowing our expert technicians to precisely detect and measure the extent of wall loss.

Key Benefits of TCR Engineering's MFL Services:

- Accurate Detection of Defects: MFL is ideal for identifying sharp defects such as pitting, grooving, and circumferential cracks.
- Effective for Ferromagnetic Tubing: This method is suitable for detecting defects in steel and other ferromagnetic materials.
- Aluminum-Finned Carbon Steel Tubing: MFL is highly effective even in aluminum-finned carbon steel tubes, as the magnetic field remains largely unaffected by the fins.
- Complementary to Remote Field Testing (RFT): MFL provides a valuable back-up inspection to RFT, ensuring a comprehensive evaluation of tube integrity.

By using TCR Engineering's advanced MFL services, industries can detect and mitigate corrosion and material loss early, enhancing asset longevity and reducing operational risks.:

Internal Rotary Inspection System (IRIS)

TCR Engineering provides Internal Rotary Inspection System (IRIS), a highly accurate ultrasonic method for the non-destructive inspection of tubes, particularly in heat exchangers, boilers, and condensers. The IRIS technique uses an ultrasonic beam to measure and detect metal loss on both the inner and outer walls of the tube. The IRIS probe is inserted into a water-filled tube, and as it is pulled out, real-time data is displayed and recorded, allowing precise wall thickness measurement and defect detection.

Key Benefits of TCR Engineering's IRIS Services:

- Precise Defect Detection: IRIS can accurately detect and measure metal loss along both the length and circumference of the tube, providing a comprehensive evaluation of tube integrity.
- High Accuracy for Ferrous Materials: IRIS offers superior accuracy for measuring wall thickness in ferrous materials, with a resolution as low as 0.15mm, making it more accurate than Remote Field Eddy Current Testing (RFET) for ferrous tubes.
- Comprehensive Analysis: This method is highly effective at detecting both internal and external corrosion, erosion, and other forms of degradation, making it ideal for asset integrity management.

Limitations:

- Slower Testing Speed: While IRIS offers high accuracy, it is slower compared to other techniques, with a scanning speed of approximately 1 inch per second, making it less efficient for large-scale inspections.
- Surface Cleaning Requirement: IRIS requires thorough cleaning of the tube surface, often more rigorous than what's required for Eddy Current Testing (ECT).
- Despite its slower speed, IRIS provides unparalleled accuracy in wall thickness measurement, making it a critical method for industries focused on the longevity and reliability of their tubular assets. TCR Engineering's experienced team ensures precise inspections that help prevent unexpected failures and extend the life of your equipment.

Fully Saturated Eddy Current Testing

TCR Engineering offers Saturation Eddy Current (SET), a specialized non-destructive testing technique used for inspecting thin ferromagnetic materials such as carbon steel (CS), duplex stainless steel, and slightly magnetic materials like Monel Nickel-Copper alloys. This advanced method is highly effective for detecting and quantifying both internal and external cracks, as well as local defects and overall wall loss in ferromagnetic tubes used in boilers, feedwater heaters, air coolers, and carbon steel heat exchangers.

This technique, done in accordance with ASTM E709. ISO 15548-1 and ASME Section V, excels at identifying both internal and external cracks, pitting, and wall thinning in challenging materials, providing detailed insights into the condition of tubes.

SET is particularly beneficial in industries like power generation and petrochemical processing, where the reliable operation of critical heat exchangers and boilers depends on early detection of material degradation.

TCR Engineering's use of Saturation Eddy Current ensures precise inspections, enabling operators to avoid costly downtime and prevent unexpected failures.

By choosing TCR Engineering's Saturation Eddy Current services, clients can expect high-speed, accurate inspections that extend the lifespan of their critical components, ensuring operational reliability and safety.

Long Range Guided Wave Ultrasonic Testing (LRUT)

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

This technique involves inducing torsional or longitudinal guided waves into the pipe, allowing them to propagate throughout the entire segment under examination. When these guided waves encounter an anomaly or a feature within the pipe, they convert into laminar waves and reflect back to the original location of the tool. These signals are digitally captured using a laptop, and the time-of-flight for each signal is calculated to determine its distance from the tool. The cross-sectional area is assessed based on amplitude, while the circumferential extent is estimated through focused beams, which are broken down into octants to evaluate the significance of any detected defects.

TCR conducts LRUT in collaboration with its international partner, which adheres to and exceeds the PHMSA's 18-point requirements for examining casings and crossings. LRGUT is primarily utilized in industries such as oil and gas refining, petrochemicals, storage, offshore operations, and pipeline transportation.

Specifically, these tests play a critical role in External Corrosion Direct Assessment (ECDA) and Internal Corrosion Direct Assessment (ICDA) methodologies, particularly in situations where access to piping systems is challenging, such as:

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

Helium Leak Testing

TCR provides vacuum leak testing for all types of vacuum vessels and pressure probe testing for systems operating at or above ambient pressure. Any system requiring leak tightness or suspected of leakage issues can be tested using these helium leak testing methods with high reliability.

The Helium Leak Testing unit at TCR employs advanced mechanical vacuum pump technology specifically designed for heavy-duty use in challenging industrial environments. The rotary vane pump's helium stability ensures exceptional consistency of the helium signal, while the Molecular Drag Pump (M.D.P.), operating at a low rotational speed of 27,000 RPM, provides full insulation against accidental air influxes. This design also allows for the leak detector to be relocated during operation. The high compression ratio of the M.D.P. enables efficient gross leak testing at elevated pressures (7.5 Torr / 10 mbar), significantly accelerating the leak testing process for outgassing components. The internal configuration of the unit allows for easy access to all components, enhancing usability. TCR's Helium Leak Testing instrument boasts a roughing capacity of 10 m^3/h (7 CFM) with usable helium sensitivity in the 10^-11 atm.cc/s range. Additionally, it features a dedicated sniffing unit based on a reliable leak-testing concept, suitable for outboard leak testing applications.

TCR has conducted numerous leak tests on-site across various industries, including nuclear carriers, polymer plants, oil refineries, and gas and steam turbine power plants in Kuwait, the Kingdom of Saudi Arabia, and India.

Our technicians are highly mobile and perform helium leak testing on a wide range of systems and components, including heat exchangers, steam turbines, condensers, distillation towers, and buried pipelines.

Thermography

TCR employs thermography testing to detect temperature anomalies in equipment during operation using remote, non-contact methods. This technique, now also performed via helicopters for large areas, captures heat radiation from hot objects using infrared sensors to create thermal images. By analyzing the hot and cold regions, the condition of the equipment can be assessed.

Thermography is valuable in detecting blockages or deposits in pipelines carrying hot or cold fluids, as well as insulation or refractory damage in furnaces, boilers, and heaters. It is also widely used for monitoring electrical substations, transformers, control panels, and rotary equipment like motors, generators, and turbines for signs of overloading, overheating, and faulty contacts.

Alternating Current Field Measurement (ACFM)

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
- Cooling Tower Welds
- Compressor Fin Surfaces and Threads
- Drill Collar Threads
- Pipeline Girth Welds and Supports
- Pressure Vessel System Welds

ASNT Level III Consultancy in India

TCR Engineering boasts a highly skilled advanced NDT inspection team, with 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), and Visual and Dimensional Evaluation (VT). The team is also equipped to execute projects using Automated Ultrasonic Testing with Time of Flight Diffraction (ToFD) techniques, and its experts are certified in AWS/CSWIP 3.1 and 3.2 as well as CSWIP Painting inspection.

TCR's ASNT Level III professionals possess the expertise to develop techniques, interpret codes, standards, and specifications, and prepare or approve procedures and instructions. All NDT inspectors at TCR are qualified under the American Society for Nondestructive Testing Practice SNT-TC-1A and adhere to CP-189 guidelines. Each non-destructive examination is conducted in accordance with major codes such as the ASME Boiler and Pressure Vessel Codes, ASME/ANSI Pressure Piping Codes, American Petroleum Institute Codes, American Welding Society Standards, and Aviation/Military specifications.

TCR's combined strengths in metallurgy and advanced NDT services have enabled global leaders like Reliance, Saudi Aramco, QAFCO, IOCL, GAIL, and BPCL to increase plant availability, reduce costs, minimize shutdown times, and improve safety compliance. The TCR team excels in assessing and calculating the risk profiles of plant equipment based on "active" and "potential" damage mechanisms, ensuring that inspection intervals are reliably optimized in a safe and cost-effective manner.

Conventional NDT

RADIOGRAPHY TESTING

TCR Engineering offers Automated Radiographic Testing (ART) for circumferential butt welds in cross-country and City Gas Distribution (CGD) internal pipelines using advanced crawler systems. This technology enables efficient, high-precision detection of both surface and subsurface defects in welds through external X-ray or Gamma ray radiation. Our crawler-based ART solution ensures reliable and comprehensive weld inspections, helping to maintain pipeline integrity and compliance with industry standards, while minimizing operational downtime.

TCR Engineering also specializes in Gamma Ray Radiographic Testing, which uses gamma radiation to inspect welds and detect internal defects in pipelines. Gamma rays, emitted from a radioactive isotope source such as Iridium-192 or Cobalt-60, have the ability to penetrate thick materials, making them highly effective for inspecting dense pipeline welds. This method is ideal for locations where access to electrical power for X-ray equipment is limited, as gamma ray testing does not require an external power source. Gamma radiation provides high-resolution imaging of both surface and subsurface flaws, ensuring precise identification of any anomalies that could compromise the integrity of the pipeline. Combining gamma ray technology with our crawler systems allows for comprehensive and efficient inspection of welds in cross-country and CGD station piping works.

ULTRASONIC TESTING

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.

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

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

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.

TCR provides microstructure survey for critical components viz., Boilers, Pipelines, Reactors and Vessels for monitoring and health assessments. TCR has developed a databank 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.

Metallography Replica Interpretation

TCR, at their material testing laboratories in Mumbai and Baroda, has a state-of-the-art Inverted Metallurgical Microscope, GX5, 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 microstructures.

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.

At TCR, the 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

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.

MAGNETIC PARTICLE INSPECTION

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.

At TCR, dry magnetic particle examinations and wet fluorescent magnetic particle examinations are performed on ferromagnetic materials to detect surface and slightly subsurface discontinuities.

Specialized wet fluorescent magnetic particle techniques are available for black light internal examinations of equipment through borescopes.

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 has 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 using 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.

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

- Carbon and Low Alloy Steels
- Copper Alloys
- Stainless and High Alloy Steels
- Aluminum Alloys
- Nickel Alloys
- Austenitics Duplex and Super
- Titanium Alloys
- Zirconium Alloys

TCR Engineering's PMI equipment includes

- Portable X-Ray Florescence (XRF) Spectro
- Portable Optical Emission Spectrometer (OES)

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, Kuwait, Kingdom of Saudi Arabia and other parts of Middle East.

Some PMI projects were undertaken in conjunction with the third-party inspection of EIL, Lloyds, KTI, TUV, DNV & BARC.

PAINT & 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:

- The Blasting and Coating Materials
- The Blasting and Coating Equipment
- The Temperature and Humidity
- The Surface Condition
- The Application Procedure

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

Thickness Measurement

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:

- Each corrosion loop (for on-site piping) have a combined isometric where Thickness Management Locations (TML) are serially marked
- If any base readings are taken before commissioning, it is done with random values measured on the components
- 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
- 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.
- 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

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.

Thickness Locations 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

Heat Treatment

TCR Engineering has expanded its services range with a dedicated division that offers both gas and electric post weld heat treatment services including:

1. Electric resistance localized PWHT of butt welds for piping projects
2. Temporary / permanent furnace heat treatment and normalizing.
3. Internal high velocity gas firings of spherical and bullet tanks and other large storage tanks / vessels.
4. Localized PWHT of vessel closing weld seams.

TCR Engineering undertook PWHT services for Essar Construction at the BF Shell Project at Jindal Steel in Angul, Odisha and at the HURL site as well. Having our base Pan-India helps has mobilize faster as well as provide the necessary repair and maintenance of our machines in a rapid manner. Our team members are dedicated and are backed with our supervisory skills gained over the past 50 years of TCR's services towards quality assurance to the Indian Industry.

Preheating Services

TCR undertakes preheating of weldment to eliminate weld defects and improve weld quality by avoiding cracking in the heat affected zone (HAZ) or at the weldment.

Furnace Heat Treatment (Static / Temporary / Gas / Electrical)

Within the TCR's lab environment, we have high velocity gas fired burners which create a 'scrubbing action' of hot gases against the walls of the component eliminating any cold spots.

Electric Resistance Localized Post Weld Heat Treatment

Carefully controlled localized post weld heat treatment by electric resistance, by TCR's expert heat treaters, tempers the metal and reduces tensile stresses, minimizing the risk of brittle fracture, stress and corrosion cracking and metal fatigue.

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 equipment's 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.

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.

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 connected by an armored flexible hosing to Combustion Air Fan (s), with a maximum output of 2800/Nm^3 per hour via a 150mm diameter outlet, at a pressure of 700mm W.G. The burner is fitted with a (25/20) stainless steel outlet nozzle designed to clear the furnace wall adjacent to the intended opening(s), in such a way that it eliminates the possibility of any direct impingement on components.

Cross Country & CGD Pipeline Radiography

At TCR Engineering, we offer a complete range of pipeline-related services for cross-country and city gas distribution (CGD) pipelines, focusing on inspection, material verification, and asset integrity management. Our services include Automated Radiographic Testing (ART), Ultrasonic Testing (UT) with advanced methods like Phased Array (PaUT) and Long-Range Ultrasonic Testing (LRUT). We specialize in the digitalization of RT films as per IOCL and GAIL standards and provide destructive testing for PQR/Welder qualification and material confirmation. Our O&M services utilize cutting-edge technology for pipeline asset integrity management (AIM), including Engineering Critical Analysis (ECA), failure analysis, corrosion assessments, robotic inspections, and leak detection using smart pigs. We also monitor cathodic protection (CP) systems to ensure long-term pipeline integrity.

With a focus on safety, efficiency, and data-driven decision-making, TCR Engineering is your trusted partner for maintaining the health of critical pipeline infrastructure.

Pipeline Weld Inspection

TCR Engineering's Pipeline Inspection for Anomalies services are designed to detect defects and discontinuities in pipelines using advanced radiographic and ultrasonic testing methods. By employing tools like internal crawler robots, external X-ray/gamma radiation, and automated ultrasonic testing, we can inspect pipelines with precision, ensuring their integrity and safe operation. Our comprehensive approach adheres to relevant industry standards like API 1104, guaranteeing reliable results that help our clients mitigate risks and maintain pipeline health.

Automated Radiographic Testing (ART) of Circumferential Butt Welds from Internal Pipelines Using Crawlers

Automated Radiographic Testing (ART) involves the use of high-resolution imaging technology to inspect circumferential butt welds inside pipelines. We deploy specially designed crawler robots that travel inside the pipeline to scan welds with precision. This method allows for internal inspections where external access may be limited or challenging. ART is particularly useful for large-diameter pipelines and provides a comprehensive evaluation of weld integrity, enabling the detection of both surface and subsurface defects.

External X-Ray or Gamma Ray Radiation for Detection of Surface and Subsurface Defects in Welds

For pipelines where internal access is restricted, External Radiographic Testing using X-ray or gamma-ray technology is applied. This method enables the detection of both surface and subsurface anomalies in pipeline welds. The process works by emitting radiation through the weld area, capturing images of any defects that may compromise the structural integrity of the pipeline. This non-invasive testing technique is ideal for pipelines that must remain operational during inspection and complies with API 1104 standards for welding inspections.

Computed Radiography

TCR Engineering has strong expertise in Computed Radiography (CR) as per ASTM E 2033 and ISO 17636-2 which is an advanced form of radiographic inspection that uses imaging plates (IP) instead of traditional X-ray films to capture images of pipeline welds. These plates, coated with phosphor, store the radiographic image when exposed to X-rays or gamma rays. The stored image is then read by a laser scanner and converted into a digital image, which can be viewed, analyzed, and archived electronically. The adoption of Computed Radiography (CR) in the inspection of cross-country pipelines offers numerous advantages over conventional radiography testing, from improved image quality and faster turnaround times to enhanced environmental safety and cost-effectiveness.

UT Shear-Wave Anomaly Evaluation, Phased Array (PaUT) and ToFD for Seam-Weld Scanning

Ultrasonic Testing (UT) is used to detect anomalies like cracks, lack of fusion, and other discontinuities in seam welds. The shear-wave UT technique is particularly effective for identifying these anomalies by introducing ultrasonic waves at an angle to the weld seam.

Phased Array Ultrasonic Testing (PaUT): PaUT provides a more detailed and dynamic evaluation of welds by using multiple ultrasonic beams, which can be steered, focused, and scanned electronically. This allows for greater coverage and sensitivity to defects, making it ideal for inspecting complex geometries.

Time-of-Flight Diffraction (ToFD): ToFD complements PaUT by detecting and sizing defects using the diffraction of ultrasonic waves. It is highly accurate for locating crack tips and providing a quantitative assessment of defect size. The combination of PaUT and ToFD ensures a thorough evaluation of seam welds, with high sensitivity to both small and large anomalies.

Automated Ultrasonic Testing and LRUT/Guided Wave Including A/B/C-Scans as per API 1104

Automated Ultrasonic Testing (AUT) and Long-Range Ultrasonic Testing (LRUT), also known as Guided Wave Testing, are powerful tools for pipeline inspection, particularly in situations where accessing the entire pipeline is impractical. LRUT allows for the inspection of long sections of pipeline from a single access point, making it cost-effective for detecting corrosion, cracks, and other anomalies over large distances. A/B/C-scans provide detailed cross-sectional images of the pipe's wall thickness and defect locations, ensuring comprehensive evaluation as per API 1104 standards for pipeline welding.

- A-Scan: Displays the amplitude of received ultrasonic signals, helping identify the depth of defects.
- B-Scan: Provides a side-view image of the pipeline, showing the thickness of the walls and the presence of defects.
- C-Scan: Gives a plan-view image of the pipeline, mapping the location and extent of anomalies across the pipeline's surface.

Weld Assessment of Difficult-to-Access, Small Diameter Pipes (1.5" to 3.5") Using Palm Scanner

For pipelines with smaller diameters (1.5" to 3.5"), weld inspection becomes more challenging due to space constraints. TCR Engineering employs specialized palm scanners that are designed for these hard-to-reach areas. These handheld scanners use high-frequency ultrasonic waves to inspect welds in small-diameter pipes, ensuring comprehensive coverage even in difficult-to-access locations. This method allows for the detection of anomalies like

incomplete fusion, porosity, and cracking that can compromise the integrity of small-diameter pipelines.

Digitalization of RT Films

TCR Engineering's Bengaluru-based central operations team, comprised of IT and Google-certified experts, remotely coordinates with sites across India to ensure compliance with stringent film density and resolution standards all conducted in full accordance with ASME Section V - Article 2, and ASTM E 1936.

Key Benefits of NDT Film Digitization:

- Prevents film degradation while maintaining image quality
- Eliminates physical storage costs for films
- Allows secure storage on custom developed Google Cloud platform
- Enables archiving of inspection RT reports including UT and MPI data
- Utilizes Artificial Intelligence (AI) for easy retrieval and comparison of scans

Lab Tests & AWS/CWI Inspectors

TCR Engineering dedicated materials testing laboratory in Mumbai and Bhubaneshwar undertakes mechanical testing and chemical analysis as recommended in ASME Section IX, ASME Section VIII Division-1, AWS Division 1.1, API 1104 & Customer Specifications. Testing for Electrode qualification as per ASME Section II Part C, IS 814 can also be done in our Laboratories. These tests are done for Welding Procedure Specification (WPS)/ Procedure Qualification Record (PQR), Welder Performance Qualification (WPQ) & Production Weld Coupons.

The laboratory is fully compliant to NABL and ISO 17025.Tests done for WPS as per ASME Section IX & API 1104 include All Weld Tensile Test, Transverse Tensile Test (as per API/ISO), Nick Break Test, Bend Test, Macro, Micro, Hardness, Chemical Analysis, Charpy V Notch Impact, and Radiography of weld coupon.

TCR requires coupon of the following sizes:

- 12” NB = 1 coupon
- 2” NB = 4 coupon for API 1104
- 2” NB = 4 coupon for ASME Sec IX

TCR Engineering has expert CWI and AWS inspectors who provide consultancy as IIW-IWS (RWC-External) for welders Training & Certification which includes training programs for staff & welders, guidance for preparation of Quality Manual, Procedures, Work Instructions and Witness/Review of WPS/PQR/WPQ tests.

Asset Integrity

AiOM: Asset Integrity Optimization and Management

TCR Advanced introduces AiOM (Asset Integrity Optimization Management), a comprehensive digital solution designed to maximize plant asset performance, enhance plant life extension, and ensure optimal reliability of process equipment. Leveraging TCR's extensive expertise and a robust database built from decades of hands-on industrial problem-solving, AiOM integrates advanced technology with an in-depth understanding of plant challenges, delivering a next-generation approach to asset management.

Why AiOM? Addressing Complex Challenges in Asset Integrity Management

As plant facilities age and process complexities grow, maintaining asset integrity requires more than periodic inspections. Despite advancements in reliability, certain assets remain challenging to access and inspect effectively. AiOM addresses these limitations by focusing on damage mechanisms, risk-based inspection (RBI) strategies, and optimized resource allocation. This software's insights enable operators to extend inspection intervals and improve safety and performance, supporting the critical objective of plant life extension.

AiOM is built around a suite of robust modules that enhance decision-making and accountability across the asset lifecycle:

1. Centralized Asset Database

- A single-source asset database structures and standardizes data, enabling quick and easy configuration. The platform includes a comprehensive asset classification system, making it simple to add and update equipment data.

2. Integrated Maintenance, Materials, and Spares Management

- AiOM's maintenance management module offers a holistic view of asset maintenance, including cost analysis and risk assessment for high-failure-rate equipment.
- Integration with spares and materials management ensures quick decision-making, facilitating timely interventions.

3. Enhanced Maintenance Strategies

- The software incorporates predefined maintenance strategies to improve safety, asset availability, and reliability while optimizing costs. Each strategy aligns with regulatory standards and best practices to minimize risks and streamline plant operations.

4. Asset Optimization Tools

- AiOM's Fitness-for-Service (FFS) tools support the continuous assessment of critical assets, monitoring efficiency, and health to detect potential failures early. Real-time insights enable proactive, rather than reactive, asset management.

5. Advanced Analytics and Dashboard Visualization

- Customizable dashboards provide at-a-glance data visualizations for reliability trends, downtime analysis, and cost tracking. This empowers asset managers with actionable insights to spot problem areas, facilitating data-driven decisions to enhance reliability and efficiency.

6. Risk-Based Methodologies for Optimized Resource Allocation

- AiOM utilizes API 580/581 RBI methodologies for asset risk management, allowing for a strategic approach to inspection scheduling. This helps balance inspection intervals

and maintenance priorities, minimizing plant shutdowns and ensuring compliance with safety standards.

7. Material Search and Root Cause Analysis (RCA) Tools

- AiOM includes a material search engine that helps engineers access critical material information quickly. The RCA tool provides a structured method for analyzing failures, identifying root causes, and implementing effective mitigation to reduce repeat failures.

8. Turnaround and Shutdown Planning

- The platform facilitates turnaround planning by flagging maintenance notifications tied to shutdowns, enabling strategic planning for maintenance events. This functionality aids in efficient resource allocation and minimizes unplanned outages.

9. Quality Assurance and Inspection Plans

- AiOM's quality assurance module supports the creation and maintenance of standard QA plans and inspection schedules. This ensures that all equipment meets rigorous standards and helps maintain a consistent level of asset quality across the plant.

10. Accelerated Learning and Troubleshooting Tools

- Asset engineers gain access to a vast database of failure case studies and a troubleshooting guide powered by AI. This unique feature offers rapid access to problem-solving resources, allowing engineers to address equipment issues quickly and effectively.

11. Engineer's Toolbox for Design Calculations

- The Engineer's Toolbox provides essential tools for on-the-fly engineering and design calculations. With tools for corrosion loops and Integrity Operating Windows (IOW) based on API-584, engineers can monitor the health of piping circuits and other critical equipment.

12. Work Order Management and Action Tracking

- AiOM includes a work order management system for structured issue tracking, prioritization, and resource planning. Asset histories, recommendations, and action statuses are documented and easily traceable, ensuring accountability and seamless problem resolution.

Transforming Asset Integrity for the Future

By implementing AiOM, TCR enables its clients to proactively manage asset integrity with precision and efficiency, enhancing safety, compliance, and profitability. With real-time monitoring, predictive insights, and a powerful array of tools, AiOM is a vital asset for any plant aiming to extend equipment life while ensuring consistent operational reliability.Align with TCR's commitment to innovation and sustainability by adopting AiOM for a smarter, data-driven approach to asset integrity management, transforming how assets are maintained and optimized for years to come.

Root Cause Failure Analysis, FFS and RLA

TCR's dedicated engineering and metallurgical consulting team in India is the perfect partner for solving plant 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.

Failure and Root Cause Analysis

TCR prides itself for its deep knowledge and has garnered best practices from success stories compiled from over 8000 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 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

1. Collection of Background Data and Selection of Samples
2. Preliminary Examination of the Failed Part
3. Complete Metallurgical Analysis of Failed Material
4. A thorough examination of the Failed Part including Macroscopic and Microscopic Examination and Analysis (Electron Microscopy, If Needed) Tests, If necessary may also include Weld Examination, Case Depth, Decarburization Measurement, Coating/Plating Evaluation, Surface Evaluation and/or Grain Size Determination
5. 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
6. Analysis Of Fracture Mechanics
7. Selection and Testing of Alternative Products and/or Procedures That Will Significantly Improve Performance
8. 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:

1. Description of the Failed Component

2. Service Condition at the Time of Failure
3. Prior Service History
4. Manufacturing and Processing History of Component
5. Mechanical and Metallurgical Study of Failure
6. Metallurgical Evaluation of Quality
7. Summary of Failure Causing Mechanism
8. Recommendations for Prevention of Similar Failures
9. Latest Inspection Solutions

Fitness for Service

TCR undertakes Fitness For Service (FFS) Assessment based on Level 2 and 3 of BS 7910 standards and 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

- Decision to Run, Alter, Repair, Monitor, or Replace the Equipment
- Guidance on Inspection Interval for the Equipment

Fitness for Service Assessment uses 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

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

Asset Integrity Consulting Assistance

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 and 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 Modelling

Pipeline Asset Integrity for O&M

TCR Engineering specializes in Pipeline Fitness for Service (FFS) assessments, a crucial process that evaluates the operational capability of pipelines. By analyzing factors such as material properties, loading conditions, and identified anomalies, we determine whether a pipeline can continue to operate safely without the risk of failure.

TCR Engineering also undertakes Engineering Critical Analysis (ECA) for pipelines as per Saudi Aramco requirement, utilizing methodologies outlined in standards such as ASME B31G and API

579. ECA involves assessing the integrity of pipeline structures by evaluating defects, material properties, and loading conditions to ensure compliance with safety and regulatory requirements.

Our services include Internal Corrosion and External Corrosion Direct Assessment (DCA), adhering to NACE SP 0206 and NACE SP 0502 standards. This comprehensive evaluation identifies potential corrosion areas, analyzes corrosion mechanisms, and recommends necessary remedial actions to maintain pipeline integrity.

To enhance inspection efficiency, TCR Engineering employs Robotic Crawlers for Visual Inspection of underground pipelines. These advanced robotic systems facilitate remote monitoring, allowing for detailed visual assessments in challenging and confined spaces. This significantly reduces risk to personnel while increasing inspection accuracy.

Additionally, we conduct Corrosion Loop Identification for Risk-Based Inspection (RBI) studies, following API 580/581 standards. This process categorizes pipelines based on the likelihood and consequences of failure, enabling us to prioritize inspection and maintenance efforts effectively.

Through these comprehensive analyses and assessments, TCR Engineering ensures the integrity, reliability, and safety of pipeline systems, empowering our clients to make informed decisions for asset management and maintenance strategies.

Cathodic Protection (CP)

TCR Engineering offers comprehensive Cathodic Protection (CP) monitoring services as per GAIL to assess the effectiveness of installed permanent CP units at feeding points. This essential service helps prevent corrosion in pipelines and other metallic structures by ensuring that the CP systems function optimally.

Through our CP monitoring, we utilize advanced techniques to evaluate the performance of CP units, measuring key parameters such as voltage and current levels. This proactive approach enables us to identify any potential issues that may compromise the integrity of the CP system and allows for timely interventions to enhance corrosion protection.

Our dedicated team of experts employs state-of-the-art equipment and methodologies to conduct thorough inspections, providing clients with detailed reports and actionable insights. By ensuring the effective operation of CP units, TCR Engineering supports the longevity and reliability of critical infrastructure, safeguarding against corrosion-related failures.

Reformer Tube Inspection with FFS

At TCR we have developed ARTiS – Automated Reformer Tubes Inspection System, a cutting-edge solution for the comprehensive assessment of reformer tubes. Having completed over 100 projects for clients in India and internationally, TCR is the leader in reformer tube integrity assessments. Our multidisciplinary approach incorporates Fitness for Service (FFS) analysis as per API579/ASME FFS1 and features a unique ability to determine "when to retire tubes." Over the years, TCR has developed an extensive database of reformer tube failure mechanisms, allowing our research wing to identify early warnings of tube failures with unparalleled accuracy.

TCR's deep understanding of the operational and metallurgical interactions of reformer tubes, combined with our innovative ARTiS technology, enables us to deliver superior insights into the condition of your tubes. With automated crawlers that accommodate tube outer diameters from 105 mm to 190 mm, ARTiS provides precise data for Level III FFS assessments, ensuring the accurate prediction of remaining tube life.

Key Features of TCR's Reformer Inspection using ARTiS:

- Multi-technique approach for detailed condition assessment of reformer tubes
- Level III FFS Assessment as per API579/ASME FFS1 for remaining life calculations
- Proprietary standard samples with known damage scenarios, offering superior accuracy
- Ultrasonic attenuation measurement for fissure detection via automated crawler
- In-situ metallography for microstructural analysis to assess microstructural degradation
- Visual Inspection for bulging, baldness, sagging, and bowing by an expert
- Automated Outer Diameter Measurement with electronic devices on ARTiS at intervals of 0.1M using infrared light sensors
- Automated Bowing Measurement with on-board electronic devices
- Hardness Testing at metallography locations
- Manual Ultrasonic Wall Thickness Measurement at platform (bottom) level
- Magnetic Permeability Measurement at platform level

TCR provides a detailed Level III FFS Assessment in accordance with API579/ASME FFS1 Inspection results summarizing accumulated creep damage including calculation of effective tube metal temperature and projected creep damage up to the next shutdown. Retirement date prediction based on accumulated creep damage (0.8 life fraction) and Remaining life assessment for each tube.

RLA and Condition Assessment of Boilers

TCR Engineering offers expert services in Remaining Life Assessment (RLA) and comprehensive condition assessment of boilers, ensuring optimal performance and extended service life. With extensive experience in both Level II and Level III assessments, TCR utilizes a systematic approach, combining technical data collection and expert consultations to evaluate the current condition and predict the remaining life of boiler components.

At TCR, we adopt two proven methodologies to determine boiler life:

1. Calculation-Based Approach: We analyze temperature and operational cycling data using advanced calculation procedures to estimate the extended life of components under creep, fatigue, and creep-fatigue conditions. By leveraging plant records and standard material properties, we accurately estimate the fractional life consumed up to a given point in time.
2. Design-Based Approach: Our experts evaluate components that operate in high-stress environments, accounting for factors like yield strength, tensile strength, and fatigue resistance. Even when components are designed for long-term durability, unforeseen factors can reduce their life. We ensure that these risks are accounted for in our assessments.

TCR's Expertise in Remaining Life Assessment includes:

- Comprehensive Analysis of Degradation Mechanisms: We identify key issues such as fatigue, thermal aging, creep, embrittlement, and corrosion.
- Advanced NDT Techniques: Our assessments include visual examination, in-situ metallography, ultrasonic testing, magnetic particle inspection, DP testing, and ferrite measurement to ensure a deep understanding of component integrity.
- Stress Analysis: We evaluate the material's strength and its resistance to rupture under various conditions.
- Laboratory Testing: We provide critical insights into material soundness through precise laboratory testing.
- Fitness Judgments & Repair Recommendations: Based on our findings, we recommend repairs or preventative maintenance measures to extend the life of your equipment.

Comprehensive Boiler Life Assessment:

- History-Based: Evaluating failure statistics, repair frequency, and life-exhaustion calculations to estimate when equipment may fail.
- Performance-Based: Monitoring efficiency loss, leakages, or malfunctions to identify severe degradation.
- Inspection-Based: Detecting dimensional changes, crack initiation, or microscopic damage through regular inspections.
- Destructive Evaluation: When necessary, we utilize metallography and mechanical testing to pinpoint potential life exhaustion.

By partnering with TCR Engineering, plant owners can make informed decisions on maintenance, repair, and equipment upgrades, minimizing risks and maximizing operational efficiency. Our proven expertise in boiler RLA ensures that your critical assets are evaluated and maintained with the highest standards of safety and performance.

TCR Engineering—ensuring your boilers operate safely, efficiently, and reliably for years to come.

Boiler RLA Audit and Creep Test

TCR Engineering's dedicated team serves customers in the power industry by conducting comprehensive Remaining Life Assessments (RLA) for critical boiler components. Our expertise covers a wide range of issues, including but not limited to boiler tube leaks (BTL), metallurgical degradation, creep damage, erosion, pitting, general corrosion, high-temperature hydrogen attack, and fatigue-related damage mechanisms.

Our Managing Director, Mr. Paresh Haribhakti, has co-authored the acclaimed book "Boiler Tube Failures", which is published by ASM International offering valuable insights into boiler tube failure mechanisms and prevention strategies.

With TCR’s advanced assessment services and industry-leading expertise, we help ensure the reliability, safety, and extended operational life of your boilers.

Internal Oxide Scale Boiler Measurement

TCR Engineering offers specialized Internal Oxide Scale Measurement services for steam boilers, ensuring optimal performance, extended lifespan, and operational safety. High-temperature boiler operations, especially those exceeding 1000°F (500°C), lead to the formation of brittle iron oxide, known as magnetite, on the inner surfaces of tubing. This magnetite layer reduces heat transfer, increases the operating temperature of tube walls, and significantly shortens the tube's creep life. Early detection and accurate measurement of this oxide scale can guide critical maintenance decisions such as descaling, which can enhance efficiency and prolong the service life of your boiler.

- Oxide Scale Detection: We measure the thickness of the internal oxide scale (magnetite) formed on the inner surfaces of boiler tubes, providing a precise assessment of the level of oxidation.
- Remaining Life Estimation: Based on oxide scale measurements, we help you determine the remaining life of your boiler tubes, enabling proactive maintenance and descaling decisions.
- Thermal Efficiency Improvement: Our service helps identify excessive oxide scale formation, which hinders heat transfer and increases operational costs, allowing you to take corrective action to improve boiler efficiency.

Benefits of TCR Engineering's Oxide Scale Measurement:

- Early Detection of Tube Degradation: Detecting internal oxide scale formation early allows for timely descaling, preventing premature tube failure and ensuring optimal boiler performance.
- Enhanced Heat Transfer Efficiency: By measuring and controlling oxide scale formation, we help maintain better heat transfer, reducing fuel consumption and operating costs.
- Extended Boiler Life: Timely descaling and proper maintenance based on accurate measurements can significantly extend the service life of your boiler tubes, reducing the frequency of costly replacements.
- Safety Assurance: Prevent overheating of boiler tubes caused by thick oxide layers, which can lead to catastrophic failure under high pressure and temperature conditions.

Omega Creep Testing for Fired Heater and Boiler Tubes

TCR Engineering offers comprehensive Omega Creep Testing and Creep Remaining Life Assessment services to help you ensure the safety and longevity of your fired heater and boiler tubes. With over 5 years of experience and expertise in Omega testing, we provide clients with critical insights into the current condition of their materials, detecting service-induced material degradation, creep damage, and remaining operational life.

- Material Degradation Analysis: We determine the current metallurgical condition of the tube samples, assessing the impact of service-induced degradation and creep damage.
- Omega Creep Testing: Our specialized Omega creep testing method accurately evaluates the creep properties of the supplied samples, providing a clear understanding of their condition.
- Creep Remaining Life Assessment: We calculate the remaining life of your fired heater/boiler tubes, leveraging:
    - Results from Omega creep testing.
    - Mechanical & Metallurgical Testing including Tensile testing, Hardness testing, Microstructure analysis (Optical & SEM)XRD analysis for deposit identification

TCR's detailed report will cover calculating the consumed life fraction, covering key factors such as accumulated strain, current creep rate, remaining life, total damage, and damage rate. Comprehensive evaluation of future operational scenarios, providing tables and curves to guide decision-making.

Applicable Technical Standards:

- API 579/ASME FFS: Fitness-for-Service assessment to ensure your equipment meets industry safety standards.
- API 530: Calculation of heater-tube thickness, ensuring the integrity of petroleum refinery components.
- API 573: Inspection of fired boilers and heaters to assess degradation and ensure safe operation.

By choosing TCR Engineering, clients receive world-class Omega Creep Testing services, backed by extensive expertise, advanced equipment, and a commitment to providing reliable assessments. We help ensure your critical assets operate safely and efficiently for years to come.

Accelerated Creep Rupture Testing (ACRT) for Boiler Tubes

TCR Engineering offers Accelerated Creep Rupture Testing (ACRT) services to assess the long-term durability and remaining life of boiler tubes operating under high temperature and pressure conditions. Our ACRT tests are designed to simulate real-world operational stresses and

provide critical insights into the material's behavior over time, ensuring safety and optimal performance for your equipment.

- Comprehensive Material Assessment: We accurately determine the time to rupture under elevated temperatures, helping to predict failures and prevent costly downtime.
- Accurate Life Predictions: Our tests provide data essential for predicting the remaining life of critical components, enabling proactive maintenance.
- Compliance with International Standards: All our ACRT procedures adhere to globally recognized standards such as ASTM E139 and BS EN 10291, ensuring reliable and repeatable results.

TCR Engineering's expertise in boiler tube testing helps plant operators avoid unexpected failures, enhance safety, and extend the life of their critical assets.

Electro-Magnetic Acoustic Transmission (EMAT) Thickness Measurement

TCR Engineering utilizes Electro-Magnetic Acoustic Transmission (EMAT) technology to provide highly accurate surface thickness measurements in high-temperature environments, ensuring safe and efficient operations of industrial equipment. With the ability to perform non-contact ultrasonic testing, EMAT offers a reliable solution for inspecting metallic surfaces without the need for couplants, making it ideal for extreme temperature conditions.

High-Temperature Thickness Measurement: Using EMAT with Panametric probes, TCR can accurately measure surface thicknesses up to 325°C. Beyond this temperature, readings may become unstable and non-repeatable, and alternative testing methods may be recommended.

Painted Surfaces: Thickness measurements can be conducted on painted surfaces, provided there are no blisters or peeling paint. For critical corrosion rate calculations or remaining life assessments, paint removal is recommended before performing the thickness survey.

Benefits of EMAT Testing by TCR Engineering:

- Non-Contact Testing: EMAT is ideal for surfaces where couplants cannot be used, allowing for efficient testing in high-temperature environments.
- High-Temperature Capability: EMAT technology provides reliable results at temperatures up to 325°C, ensuring safety in extreme operational conditions.
- Accurate Corrosion Rate Calculations: By measuring surface thickness with precision, TCR can help you accurately calculate corrosion rates, assess the remaining life of equipment, and make informed maintenance decisions.
- Minimal Surface Preparation: EMAT requires only minimal surface cleaning, reducing preparation time and enabling quicker, more efficient inspections.

Applications:

- Boilers and pressure vessels
- Piping and tubing in refineries and chemical plants
- Heat exchangers and steam generators
- High-temperature industrial equipment

Engineering Critical Analysis (ECA)

Engineering Critical Analysis (ECA) is a sophisticated approach employed to determine alternative acceptance criteria for weld defect lengths versus depths. As per the guidelines outlined in API 1104 – Option 2, ECA provides a framework to assess the structural integrity of pipeline girth welds by considering critical parameters such as fracture toughness, residual stresses, and combined axial stresses. TCR has undertaken this work as a vendor for prestigious

client in KSA with Saudi Aramco being the end client in connection with the Jafurah Gas Compression Plants and PWIS (Package-1) project.

TCR's expertise in performing advanced ECA ensures comprehensive evaluation of pipeline girth welds. With capabilities extending to CTOD assessments, FEA, and real-world damage analysis, we deliver actionable insights to ensure the structural integrity and safety of critical pipeline systems. Whether you require API 1104-compliant evaluations or customized solutions, TCR in India as well TCR Arabia in Saudi Arabia are your partner in achieving excellence in engineering assessments.

Robotic Inspection of Storage Tanks

The total cost of conventional inspections often far exceeds that of cleaning and inspection, with significant expenses tied to material transfer, product downgrades, and extended tank downtime. Additionally, the hidden costs of premature repairs can be substantial. When tanks are emptied for conventional inspections, it disrupts operations, leading to the need for rapid inspections, which often carry a premium price and result in unnecessary repairs that may not be required for another five to ten years.

With TCR Engineering's In-Tank Robotic Inspection service (deployed with our service partner company), you can drastically reduce these costs by performing API 653-compliant inspections of Above-Ground Storage Tanks (ASTs), including those filled with hydrocarbons or firewater, as well as Sumps, intake pipeline and Basins without needing to take them out of service for manual cleaning and inspection. This innovative approach minimizes operational disruptions while ensuring thorough and accurate inspections.

These robots have been engineered to operate in hazardous environments, including hydrocarbon-filled tanks, with full compliance to ATEX certification by a European Notified Body and PESO approval from the Government of India. Our robotic inspection services deliver 5X cost efficiency, 10X faster results, and capture 1000X more inspection data, all while eliminating confined space entry and working-at-height hazards, which are major causes of industrial accidents.

The Robot is designed for in-service ultrasonic and visual inspection of storage tanks, significantly reducing the need for confined space entry. Our robotic crawlers perform high-density Ultrasonic Thickness (UT) scanning of storage tank floors, even while the tank is full, capturing up to 200,000 UT scans for comprehensive analysis. These inspections provide precise, real-time data on the tank's condition, pinpointing areas of corrosion and quantifying remaining plate thickness without requiring the tank to be taken out of service or cleaned.

Its results provide valuable data, such as minimum remaining thickness, via extreme value analysis, and online in-depth analysis with color mapping for easy interpretation. In tandem with API 653 and RP 575 standards, TCR's robotic solutions are transforming the market, ensuring more efficient and safer inspections of critical assets.

Our robotic systems have been successfully deployed at various reputable oil refineries and industrial sites. The ITIS Rover has completed internal inspections for over 14 in-service tanks at LNG terminals and other refineries. TCR has executed external shell inspections for 34 assets at a major petrochemical complex, demonstrating the versatility and capability of our MagRover technology. Our passionate team can also develop custom robotic solutions tailored to specific inspection needs for pressure vessels, dome roof tanks, cross-country pipelines, jetty pile casing, pipe racks, and offshore riser pipes.

Key Benefits of TCR's In-Tank Robotic Inspection Services:

- No downtime: Conduct API 653 inspections while tanks remain in service.
- Faster inspections: Complete inspections in days rather than weeks or months.
- Cost-efficient: Avoid costly tank downtimes and unnecessary repairs.
- Safety and environmental advantages: Reduce safety risks and avoid cleaning-related waste disposal.
- Data-driven insights: Receive comprehensive data for informed decision-making, enabling repairs only when needed.

By utilizing TCR Engineering's robotic solutions, industries can ensure the integrity of their assets while minimizing operational disruptions, environmental impact, and overall costs.

Acoustic Emission Testing

At TCR Engineering, we provide cutting-edge Acoustic Emission Testing (AET) services for Above Ground Storage Tanks (AST) and other critical infrastructure, following industry standards such as API 650 and API 653. AET is a powerful Non-Destructive Testing (NDT) method used to detect and analyze sound waves emitted from structural defects or discontinuities. This technique is highly versatile, with applications in assessing structural integrity, detecting flaws, corrosion monitoring, leak detection, and ensuring weld quality. TCR Engineering's extensive expertise allows us to offer precise and reliable AET solutions that help industries maintain safety and operational efficiency.

Our AET process monitors tanks for active leaks, corrosion, and structural weaknesses by attaching highly sensitive acoustic sensors to the tank walls. These sensors detect stress waves generated by defects or discontinuities when the tank is subjected to pressure changes, temperature fluctuations, or external loads. After conditioning the tank (turning off heaters and agitators), we triangulate the location of potential flaws, particularly those in the tank floor, and provide a detailed assessment of the tank's overall condition, graded from "A" to "E" for maintenance management purposes.

TCR Engineering applies AET in a wide range of industrial applications, from storage tanks and pressure vessels to pipelines and aerospace structures. Our experts utilize multi-channel acoustic systems to inspect pressurized tanks, detect leaks in real-time, and monitor for damage mechanisms like fatigue cracking, metal thinning, and corrosion. This technique is especially effective for monitoring hard-to-reach areas, providing actionable data to ensure asset integrity and compliance with safety regulations.

By leveraging Acoustic Emission Testing, TCR helps clients in the oil and gas, petrochemical, and storage industries detect critical issues early, reducing downtime and maintenance costs, while ensuring adherence to API standards and safeguarding operational safety.

Tank Floor Inspection by Magnetic Flux Leakage Testing

At TCR Engineering, we utilize Magnetic Flux Leakage (MFL) testing as a highly effective Non-Destructive Testing (NDT) method to detect discontinuities such as corrosion, erosion, pitting, and circumferential cracks in finned ferromagnetic and carbon steel heat exchanger tubes, air coolers, and other large steel structures. MFL is particularly well-suited for the inspection of Above Ground Storage Tanks (ASTs), especially the tank floor, due to its ability to quickly cover large surface areas. The method is recognized for its precision in identifying and sizing material loss with millimeter-level accuracy, providing valuable insights into the structural integrity of ferromagnetic assets.

Magnetic Flux Leakage (MFL) Testing is widely used in industries that require large-scale inspection, such as oil and gas, petrochemical, and storage sectors, and complies with

standards like API 650 for ASTs. The method enables rapid scanning of tank floors, where a scanner equipped with an array of magnetic sensors can map material loss efficiently. This makes MFL an ideal technique for detecting corrosion and erosion in vast areas, often covering hundreds of square meters, and for ensuring compliance with relevant industry standards.

TCR's Magnetic Flux Leakage (MFL) services are particularly useful in industries that prioritize safety and efficiency. We adhere to industry standards such as API 653 for tank inspections, ensuring that our clients meet regulatory compliance and maintain the highest levels of structural integrity. MFL is applied to a variety of use cases, including storage tanks, pressure vessels, and pipelines, providing quick and accurate results to guide maintenance and repair decisions.

By leveraging MFL technology, TCR Engineering provides clients with actionable data to identify and manage structural weaknesses, reduce downtime, and ensure the continued safe operation of critical assets.

Contract 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.

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 research assistance include:

1. Determining the Right Material for a Product
2. Undertaking Corrosion Engineering, Corrosion Testing and Corrosion Investigations
3. Conducting Metallurgical Failure Analysis and Welding Evaluations
4. Investigating The Effects on Environmental Conditions
5. Preparing Material and Process Specifications for In-House Quality Control
6. Comparing Vendor or Competitor Products
7. Identifying Equivalents Between Local and Foreign Specifications
8. Assisting In Solving Product Quality Problems
9. Assisting In Cost-Benefit Analysis Post Failure Analysis
10. Reverse Engineering and Rapid Prototyping

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

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.

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.

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, nitrided components reformers and many other such issues.

1. 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.

2. 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.

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

Engineering Design and 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.

TThe 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.

COMPUTER AIDED DESIGNING (CAD)

DESIGNING
Initial Concept
3D Modeling
3D Surfacing
Concept Layout
Product Definition

LEGACY DATA CONVERSION
Drafting Conversion from 2D to 3D
Data Extraction
Data Validation
Parametric Models
Castings
Plastic Parts
Sheet Metal Parts

DETAILING
Part Drawings
Assembly Layouts
Manufacturing Drawing
GD & T
Process Sheets
Tool Drawings
Product Drawing
Part Lists

PLANT & PROCESS LAYOUT
Structural
Mechanical
Hydraulics
Pneumatic

COMPUTER AIDED ENGINEERING (CAE)

FINITE ELEMENT MODELING
2D Mesh
Hybrid Mesh
Hexa Mesh
Tetra Mesh

STRUCTURAL ANALYSIS
Linear & Non-linear
Static & Dynamic
Contact Stress
Moldflow Analysis
Fatigue Analysis
Failure Analysis
Impact and Crash Analysis
Steady State & Transient
Thermal Analysis

NOISE, VIBRATION, HARSHNESS (NVH)
Sound Transmission
Sound Radiation
Sound Quality Study
Vibration
Structure Borne Noise
Air Borne Noise

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

Turnaround Inspection Manpower

TCR Engineering is proud to offer highly qualified and experienced inspectors for short-term turnaround projects at plant sites globally. Our expert inspectors, based in India, are fully certified in API, ASNDT, and BGAS qualifications, and are equipped to handle the most rigorous inspection demands in various industries, including oil & gas, petrochemicals, refineries, and power generation.

With extensive experience in international standards and compliance, TCR's inspectors bring advanced skills in non-destructive testing (NDT), asset integrity, corrosion monitoring, and high-temperature inspections. Our team is dedicated to supporting safe and efficient operations through thorough inspections, providing clients with fast, reliable insights to ensure minimal downtime and maximum safety during critical turnaround periods.

TCR Engineering's commitment to quality and reliability has earned us trusted partnerships with industry leaders worldwide. We are ready to deploy our inspectors at your site, bringing in-depth expertise and the highest standards in inspection and evaluation, ensuring that your assets meet safety, regulatory, and operational excellence benchmarks.

PLANT SHUTDOWN MANAGEMENT

TCR has the capability to rapidly source, engage and deploy talented NDT manpower across Petrochemical, Fertilizer 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 GCC area including Qatar, Bahrain, Oman and Saudi Arabia. In the past TCR's inspectors have done turnaround projects in South Africa, Nigeria and Kazakhstan as well.

TCR works with industry-specific organizations, research and development facilities, and clients to develop new inspection equipment, applications, and procedures.

TECHNICAL CAPABILITIES

TCR Engineering supports plant shutdown projects with a diverse range of NDT skill-sets for its NDT Personnel 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

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 equipment's 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

Third Party Audit & Quality Inspection

The inspectors at TCR Engineering bring an unmatched level of precision, expertise, and commitment to every inspection, making them invaluable partners in ensuring your products meet the highest global standards.

With extensive backgrounds in engineering and quality control, TCR's inspectors are adept at identifying even the most subtle inconsistencies, potential flaws, or deviations from standards early in the production process. They work closely with vendors to ensure that issues are resolved immediately, preventing costly reworks and delays.

By meticulously managing every detail—from material sourcing and production processes to final packaging and loading—TCR inspectors protect your interests at every stage. This dedication allows you to focus on your business growth while resting assured that every item from India meets the quality, durability, and compliance standards your reputation demands.

Let TCR handle the details, so you receive only the best from India, with the confidence of knowing your products are in expert hands.

Assuring Quality for International Clients

TCR Engineering is your ultimate partner for independent, top-tier Third-Party Technical Inspection and Quality Assurance services in India. From Factory Audits to Loading Supervision, TCR covers every critical phase to ensure that your vendors deliver products that meet the highest standards, saving you time, resources, and risk.

As a globally trusted provider, TCR Engineering combines over five decades of industry expertise with ISO 17025 certification, offering Factory Audits, OEM Development, Raw Material Inspection, Initial Production Check, In-Production Check, Random Inspection, and Loading Supervision. Our field inspectors visit supplier sites across India to rigorously assess and report on quality at each phase, so you can have total confidence in the items you procure from Indian manufacturers.

FACTORY AUDIT

Tailored to verify a supplier's ability to meet your contract's quality, quantity, and delivery standards. With TCR managing this, you're assured that every aspect of production is under expert supervision, minimizing the need for on-site visits.

RAW MATERIAL INSPECTION

Our teams conduct on-site evaluations, assessing everything from fabrication to assembly and quality control. Continuous monitoring, on-site photography, and logging mean you're kept informed and assured every step of the way.

SAMPLE PICK-UP FOR TESTING

During production, we collect and label samples on-site and send them to TCR's advanced labs. Here, we conduct Mechanical Testing, Chemical Analysis, PMI, Non-Destructive Testing, Metallography, Corrosion Testing, Dimensional Measurement and Product Evaluation to ensure material quality and durability.

INITIAL PRODUCTION CHECK

TCR's inspection teams monitor and document production from day one, addressing any concerns early to ensure smooth progress and timely delivery.

IN-PRODUCTION CHECK

This inspection includes visual assessments and random material testing to minimize risks before final inspection. For an even more rigorous approach, combine it with Initial Production and Random Inspections.

FINAL INSPECTION

At the end of production, TCR conducts stringent quality and quantity checks on-site, ensuring that each shipment meets your specifications for packaging, labeling, and quality.

LOADING SUPERVISION

Our inspectors oversee the loading process, checking container conditions, verifying packing units, and sealing containers to ensure secure and accurate shipments.

LOGISTICS MANAGEMENT

With TCR, shipment logistics are handled with precision. Our logistics management services streamline all export documentation, customs, and regulatory requirements, ensuring timely and cost-effective delivery to you.

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:

- Name, Address, Telephone & Fax No of Vendor
- Details of the materials ordered along with specification (IS/BS/ASTM etc), the quantity testing requirements and other special needs
- 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 its 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

Major Projects

At TCR, we work with clients large and small, from Fortune 500 giants to small and medium-sized enterprises, with a commitment to quality that never wavers. We've earned accolades like NACE International's "Excellent Laboratory in the Private Sector" and a reputation as one of India's fastest-growing, most innovative companies—successes made possible by a legacy of ethics and excellence laid down by our founder, V.K. Bafna, a visionary metallurgist who shaped TCR's core values of precision, transparency, and integrity.

Today, TCR stands as a thought leader and pioneer in material testing, serving clients across the globe with the same respect and dedication that we bring to every interaction. From the first engagement to project completion, TCR is about empowering businesses to grow, building relationships on mutual respect, and setting the standard for integrity in the industry. Discover the difference that over five decades of innovation, trust, and results can make with TCR Engineering.

At TCR Engineering Services, we don't just serve clients; we build lasting partnerships grounded in trust, precision, and shared goals. Unlike short-term, transactional engagements, TCR is committed to creating strategic, long-term alliances that drive lasting value. Our journey has taken us across a broad landscape of industries—from oil and gas, chemicals, and power generation to construction, fertilizer, automotive, defense, aerospace, mining, and general trading. With each partnership, TCR has earned a reputation as a trusted advisor to some of the world's most respected refineries, manufacturers, and public sector entities, delivering quality assurance services that set the benchmark for excellence across sectors.

TCR Engineering Services partners with industries of every kind, from automotive to aerospace, oil refineries to chemical processing, always beginning with a simple but powerful approach—asking the right questions to uncover the best solutions. We don't believe in one-size-fits-all; our recommendations are tailored to meet the unique needs of each client, creating value that transforms businesses. Our mission is to help management teams unlock unprecedented economic value, reshaping their enterprises along the way.

Over the years, TCR has had the privilege of working with industry giants like Reliance Industries, Indian Oil Corporation, GAIL, L&T, NPCIL, Saudi Aramco, QAFCO, Qchem, Siemens, Schlumberger, Hyundai, Likhitha Infrastructure, Dextra, Leviat, Essar, Bharat Petroleum, NOV USA, ONGC, Kalpataru, PowerMech, Megha Engineering and Unilever. Whether it's Oil and Gas, Petrochemicals, Defense, Automotive, Nuclear Power, or Manufacturing, our impact is woven into the success stories of leading organizations across the globe.

Each one of the listed jobs below 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

METALLOGRAPHY ASSIGNMENT PROJECTS

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

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

NDT-CCS
Evaluation of Metallographic Replicas

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

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

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

Zamil Group
Micro Hardness Testing

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

Alsom
SEM and EDAX Analysis

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

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

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

IPCL
Insitu metalloography 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 condenser 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 PROJECTS

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 nuts (Belts) as per client Requirement

NON-DESTRUCTIVE TESTING PROJECTS

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 a 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

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
4 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

REMAINING LIFE ASSESSMENTS PROJECTS

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

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

Hindustan Unilever
RLA study of critical components of MP Boiler No.- 1 (G-122) at Kundain 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.- MR 6495 at Sewri

Gujarat Fluoro-Chemicals Ltd.
- Metallurgical Assessment of CFC Reactor R-501 and Column C-513 at Formosa Plastics ompany Taiwan Roc ondition Assessment work (V.E, letallography, U.T, MPI, Hardness & Thickness Survey) on AHF Bullet: V-31B
- Health assessment work on R-201 Main Reactor CFC plant [Metallography& hardness] at Alfa-laval; Pune

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 landle furnac

Aarti Industries
RLA of turbine

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

THIRD PARTY INSPECTION SERVICES PROJECTS

Saudi Chemanol
Third party inspection at various locations (Kolkatta, 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 Audco 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

TMT REBARS AND REINFORCEMENT COUPLERS FOR END-PROJECT CLIENTS:

END-PROJECT CLIENTS: NHSRCL, NHAI, L&T, AFCONS INFRASTRUCTURE, NCC, TATA PROJECTS, DINESHCHANDRA R. AGRAWAL INFRACON, K. RAHEJA CORP, MAHARAIL, CEIL, GPT INFRAPROJECTS LIMITED, DILIP BUILDCON, ASHOKA BUILDCON, MEGHA ENGINEERING & INFRASTRUCTURES LTD (MEIL), OBEROI REALTY, KEC INTERNATIONAL, S J CONTRACTS, SHAPOORJI PALLONJI ENGINEERING & CONSTRUCTION, AHLUWALIA CONTRACTS, LODHA

CIVIL TESTING AND ROAD INSPECTION PROJECTS

- NDT work at prestigious sites such as **Antillia** and **Wankhede Stadium** in Mumbai.
- Structural audits at **Vikas Complex** in Thane West, **KC College** in Thane, and **Essential Power Transmission** in Andheri, Mumbai.
- Structural audits conducted at **STT Global Data Centre**, a building by **Larsen & Toubro Limited**, Construction
- Performed **structural analysis** for a building project of **Petro India Private Limited** in Tehsil – Sanganer, Jaipur
- Conducted **structural analysis** for the **Synergia Life Sciences Pvt. Ltd.** factory in Wada, Maharashtra.
- **Structural Inspection of over 400 bridges across Maharashtra**, utilizing advanced underwater robotic NDT solutions, ensuring safety and integrity.

CROSS COUNTRY & CGD PIPELINE RADIOGRAPHY PROJECTS

Trusted by Maharatna/Navratna Public Sector Undertakings and Large Private Corporations in the Oil and Gas Sector. TCR Engineering has conducted works at the following sites:

RT Crawler and Gamma Ray

- 36" Dia Dhamra to Angul (DAPL) pipeline of GAIL under Mecon
- Kandla-Gorakhpur LPG pipeline of IOCL (KGPL)
- Srikakulam (Andhra Pradesh) - Angul (Odisha) Pipeline of GAIL (SAPL)
- Koyali-Ahmednagar-Solapur Pipeline
- Paradip-Somnathpur-Haldia Pipeline line (PHPL)
- Bathinda Sangrur Pipeline Project of HPCL under Tractebel
- Station Works at NOC Terminal Amlekhganj (Nepal) under MAPL Ph-II project

- CGD Project Nagapattinam-Karaikal GA of Torrent Gas

Computed RT Crawler with CR Scanner and Image Plates

- Digital X ray & RT for 36" Dia Mundra Panipat Pipeline Project of Indian Oil at Rajasthan
- CRS at Panipat-Jalandhar LPG Pipeline (PJPL) Project of Indian Oil

Welder Qualification Tests

- Destructive Testing for Welder Qualification for L&T at the Mumbai-Nagpur Pipeline under Mecon

Engineering Critical Analysis (ECA)

- Onshore construction works of Saudi Aramco

MAJOR PROJECTS - BOILER RLA CLIENTS:

- Tata power
- Adani Power
- Torrent Power
- Wanakbori Thermal Power Station
- Sasan Power
- GE Power
- Shreeyam Power
- Essar Power

MAJOR PROJECTS - BOILER FAILURE ANALYSIS CLIENTS:

- Powermech Projects
- Torrent Power
- Jhajjar power
- Sasan Power
- Odisha Power
- SMC Power
- GE Power
- Jindal India Thermal Power
- Renew Power
- Jhabua Power
- Nabha Power

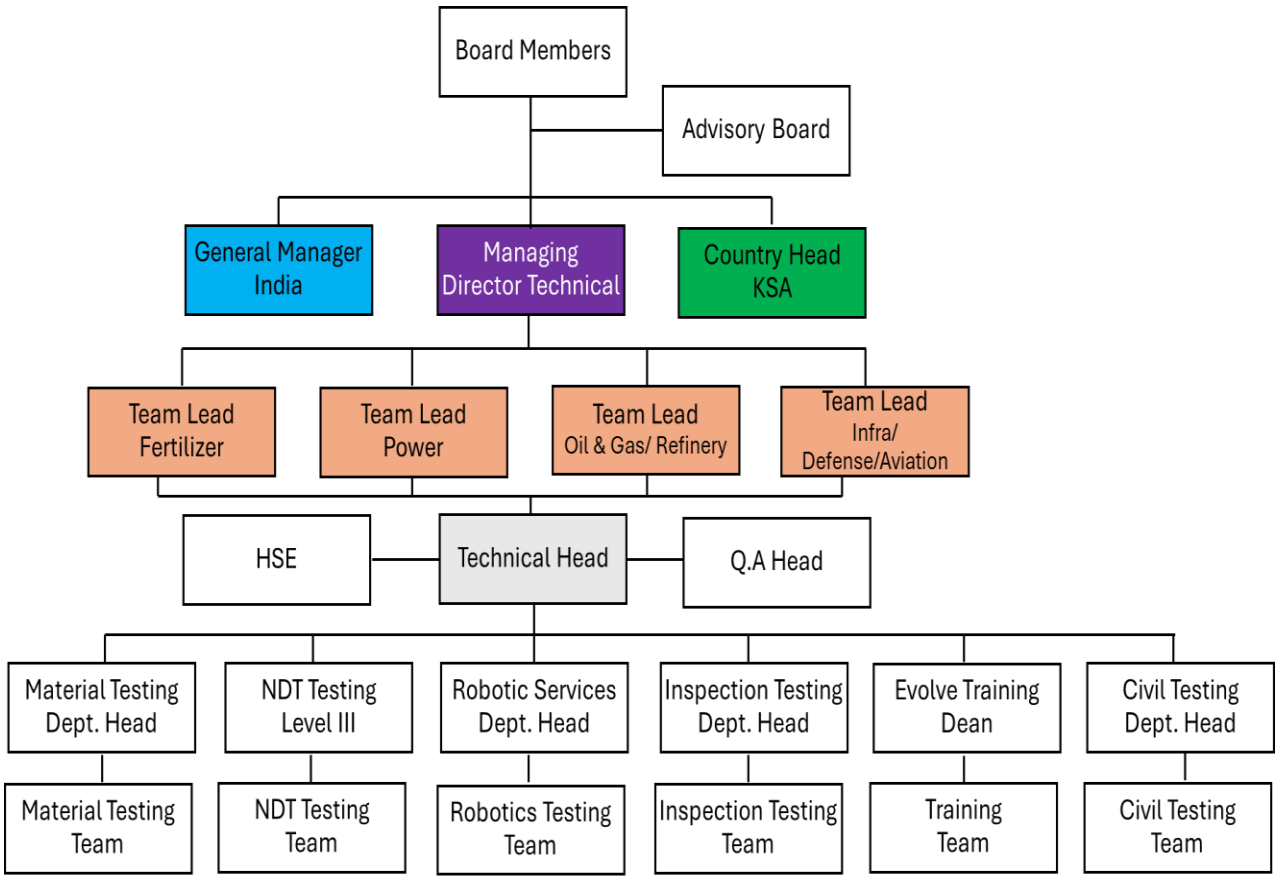
REFORMER TUBE INSPECTION WITH FFS – MAJOR CLIENTS

TCR has delivered reformer tube inspection and FFS assessments for a variety of prestigious clients, including:

- PEMEX Refinery Salamanca, Mexico
- Notore Chemicals, Nigeria
- PT Musim Mas, Indonesia
- Indian Oil Corporation Ltd. (Vadodara, Panipat, Digboi, Guwahati, Bongaigaon, Mathura, Haldia, Barauni)
- Hindustan Petroleum Corporation Ltd. (Mumbai, Visakh)
- Bharat Petroleum Corporation Ltd., Mumbai ...and many others across the refining and petrochemical industries.

Our integrated, multi-technique approach ensures accurate insights and reliable predictions, positioning TCR as a globally recognized leader in reformer tube integrity assessments.

Organization Chart



Leadership and Key Team Members

Virendra K. Bafna, Chairman Emeritus

Late Shri Virendra K. Bafna was more than just the founder of TCR Engineering Services—he was a pioneer, a visionary, and a guiding force in the field of materials science and engineering. With an unwavering commitment to excellence and a passion for innovation, he laid the foundation for what would become a globally recognized leader in materials testing, asset integrity, and non-destructive testing (NDT).

A gold medallist from the University of Indore, Mr. Bafna's thirst for knowledge took him across the world. He earned two distinguished master's degrees—one in Engineering from the University of Toronto, Canada, and another in Industrial Management from Clarkson College of Technology, New York. His deep expertise, coupled with an indomitable entrepreneurial spirit, led to groundbreaking advancements in materials characterization, corrosion studies, and mechanical testing.

With over 35 years of hands-on experience, Mr. Bafna redefined industry standards. His pioneering work in X-ray fluorescence (XRF)-based Positive Material Identification (PMI) set new benchmarks for precision, while his contributions to corrosion detection, chemical analysis, and failure analysis cemented his reputation as a thought leader. Under his stewardship, TCR Engineering expanded its reach, and TCR Arabia became a center of excellence in the Middle East, serving major industries across the globe.

Beyond his technical expertise, Mr. Bafna was an active member of leading global organizations, including ASTM International, ASM International, NACE, the Indian Institute of Metals, and the Non-Destructive Testing Society of India. His invaluable contributions were recognized at the highest levels, including an appreciation award from ISRO for TCR's pivotal role in Project ASLV (Augmented Satellite Launch Vehicle)—a testament to his impact on India's scientific and industrial advancements.

His vision and leadership transformed TCR into a name synonymous with integrity, innovation, and technical excellence. Though he passed away in 2013, his legacy continues to inspire generations of engineers, scientists, and professionals. Today, every achievement of TCR Engineering is a tribute to his pioneering spirit, and his guiding principles remain embedded in the DNA of the company.

Late Shri V.K. Bafna was not just the chairman of TCR Engineering—he was its heart and soul. His unwavering dedication, wisdom, and foresight will forever be remembered, as TCR continues to build on the strong foundation he created.

His journey may have ended, but his legacy endures—etched in the very fabric of TCR Engineering.

Neelam Bafna, Chairperson and MD

It's rare to find a company in India so firmly led by a woman of Mrs. Bafna's vision and tenacity. Under her guidance, TCR has not only thrived in India but expanded internationally, with trusted partnerships and joint ventures around the globe. Mrs. Neelam Bafna is more than a leader; she is the heart of TCR Engineering Services, embodying a legacy of quality, respect, and enduring impact.

Mrs. Neelam Bafna, the powerhouse behind TCR Engineering Services, has been steering the company forward since she co-founded it in 1973 alongside her late husband, Mr. V.K. Bafna. Together, they built TCR from a visionary idea into a global leader in material testing, one renowned for its integrity, precision, and consistent excellence. Mrs. Bafna has not only kept

this legacy alive but propelled it to new heights, meticulously overseeing daily operations, finance, and administration with an unyielding dedication that has kept TCR firmly anchored and always reaching.

Her leadership style is as authentic as it is inspiring. Mrs. Bafna leads by example, believing deeply that a company's true strength lies in its people. Her energy and commitment are infectious, fostering an environment where every team member is encouraged to excel. She has an innate gift for building relationships, seamlessly blending intuition with a genuine warmth that transforms colleagues, clients, and partners alike into an extended family. By welcoming diverse perspectives and focusing on collaborative solutions, she has become the glue that binds the TCR family together, setting a standard for leadership that is as empathetic as it is effective.

Her passion for entrepreneurship doesn't stop at TCR. A natural innovator, Mrs. Bafna has founded ventures that champion India's rich handicrafts, luxury textiles, and even groundbreaking medical products. She is always buzzing with new ideas, exploring synergies, and thinking up solutions to enhance both business and social impact. Although her contributions to various charitable causes are quiet and private, her community commitment speaks volumes. Beyond the office, she's known for her love of yoga, her passion for travel, and her culinary skills, which are as vibrant as her personality.

Paresh Haribhakti - Asset Integrity

Mr. Paresh Haribhakti is MD of TCR Advanced Engineering Services in Baroda, India (a TCR Engineering Services partner company) and the Global Technical Consultant to TCR group of companies. With over two decades of experience in the field of metallography and microstructure examination Mr Haribhakti has solved more than 5000 industrial problems. He is pioneer in promoting in situ-metallography as an acceptable and reliable technique for process plant monitoring and components in the industries.

He has experience of failure investigation, reaming life assessment and FFS of power plants, fertilizers, chemicals and petrochemicals industries, Mr Haribhakti has intensive work experience to his credentials. 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.

Having expertise in corrosion Mr Haribhakti was a principal team member in conducting the study on high temperature electrochemistry study to select the boroted stainless steel for thermo nuclear reactors, a project led by France along with 8 countries consortium. He has solved many critical corrosion problems pertaining to chemical and petrochemical industries. The expertise lies in identifying the root cause including MIC, selective leaching, SSCC, hydrogen embrittlement, PASCC.

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

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 colour metallography to increase the capabilities of interpretation of microstructure. He has also developed custom electrolytic polishing for carbon and alloy steel material.

Mr. Haribhakti 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, aluminium, 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. Haribhakti is the co-author of the book titled “Failure Investigation Of Boiler Tubes: A Comprehensive Approach” which has been published by American Society of Metals (ASM)

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.

PUBLICATION'S

- Book on “Failure Investigation of Boiler Tube - A comprehensive approach” 2019 | American Society of Metals
- Article on “Optimizing Tube Life” 2019 | World Fertilizer Magazine
- Published article on “Knowledge Based Life Management of Boilers” 2018 | SteamTech-2018
- Paper given on “Preventive Approach for Failure Free Boilers” 2016 | SteamTech-2016
- Presentation and Paper on “An Integrated Approach for RLA of Reformer Tubes by NDT (ARTis)” 2014 | APCNDT 2013 Session: NDT for Life Assessment
- Paper on “Boiler Tube Failure, Root Cause Investigation & Mitigation: Case Studies” 2014 | SteamTech-2014
- Paper on “Corrosion Failures in Water-Wall Tubes” 2014 | Corcon-2014
- Paper on “Material Testing and Characterization” 2014 | American Society of Metals
- Paper on “Fitness For Service: Using NDT & Inspection” 2013 | 14th Asia Pacific Conference on NDT
- Paper on “In-situ Metallography for the Plant Health Assessment study and Failure Investigation” 2008 | MENDT-2007

- Technical Paper titled “Fitness for Service: Using NDT and Inspection” by Paresh Haribhakti, Katan Upadhyaya, Jaidev Patel & V.K. Bafna presented at the 14th Asia Pacific conference on NDT (2013)

APPRECIATION & AWARDS

- Indian Institute of Metals (Baroda Chapter) confers the IIM-KK Award in recognition of outstanding, selfless & meritorious contribution towards Professional field in particular and Metallurgical society in general, in the state of Gujarat. (2016)
- Recognition of Active Participation as an invited speaker at 4th Middle East Conference by Saudi Arabian Section of ASNT (2007)
- Recognition of Active Participation at Inspection Technical Exchange Meeting & Exhibition by Saudi Aramco, Inspection Department (2008)
- Appreciation from 5th Middle East NDT Conference by Saudi Arabian Section of ASNT for Active Participation as an invited speaker (2009)
- Recognition of Participation as an invited speaker at 6th International Conference by MICMEP (2009)
- Appreciation from ‘NACE West Africa (Africa Region), Dhahran (Saudi Arabia section) & Bahrain society for engineers’ for presenting a technical paper at the 13th Middle East Corrosion Conference & Exhibition (February 14th – 17th 2010)
- Recognition of Active Participation as an invited speaker at International conference & exhibition by American Society of Metals (Heat treat show in 2010)
- Appreciation from 13th Middle East Corrosion Conference by NACE, Middle East Section for Active Participation as an invited speaker (2010)
- Appreciation from Saudi Aramco GO Inspection & Corrosion Forum, Shedgum Gas Plant for Active Participation as an invited speaker (2010)
- Recognition of Active Participation as an invited speaker at 1st NACE – Jubail Industrial Forum organized by NACE – Jubail KSA Section (2011)
- Recognition of Joint partnership with Indian Institute of Metals (IIM) for delivering an advance workshop on Remaining Life Assessment of Power & Progress Boilers (December 13th – 14th 2013) Awarded for valuable participation at Saudi Aramco: Corrosion Awareness Day (June 5th 2014) Appreciation from American Society of Metals as author during International Conference on Material Testing and Characterization (December 4th - 6th 2014)
- Appreciation from Jeddah Refinery for a valuable presentation on “Fitness For Service” (2015)
- Recognition of Active Participation as an invited speaker at SABIC STM 12 organized by SABIC (2016) Appreciation from HADEED, SABIC, KSA for active participation in Reliability Campaign (2016)
- Recognition of Active Participation as an invited speaker at M.S. University (Baroda) for Meta-Fiesta organized by Society of Metallurgical Engineering (SME) (March 30th 2017)
- Recognition of Active Participation as an invited speaker at Indian Society for Non-Destructive Testing (September 1st 2018)
- Recognition of Active Participation as an invited speaker at “Two Day symposium on Corrosion & Its Control, SCES 2018” organized by Society of Metallurgical Engineering at M.S. University Baroda (October 3rd & 4th 2018)
- Recognition of Active Participation as an invited speaker at 12th National Conference on Boiler & Steam Systems (SteamTech 2019)

Avinash S. Tambewagh – Technical Head

Mr. Avinash has through knowledge of Mechanical/Chemical Testing and corrosion testing as per National/International specification, like, NACE MR0175/ISO15156, TM0284, TM0177, MR0103, TM0103, TM0316, ASTM B117, G28, G31, G36, G39, G47, G48, G66, G67, G78, ISO 3651-2, GHOST-6032 etc. He has handled the Four Point Bend SSC Testing by strain gauge method for Thai-Nippon Steel for his Myanmar Oil & Gas Project.

He has Hands on experience on Advanced testing in Fatigue test (ASTM E466, ASTM E606). He is well versed with Fracture Mechanics including KIC, JIC, CTOD testing at room temperature & at sub-zero temperature.

Mr. Avinash assists in Failure Analysis/Root Cause Analysis of product received from different environments like Chemical plant, Petroleum/Refineries industries, Oil field/Oil Well.

Mr. Avinash is well conversant with in-depth understanding of national and international codes/specification like ASTM, BS, EN, BIS, IS, ISO, GHOST, NACE. He is also a Certified ISO internal Auditor with over 18 years of experience in the area of Metallurgical Laboratory Operations – Technical support & administration in Corrosion Testing, In-Situ metallography, Consultancy, Failure Analysis, Organizing & Handling all Third Party Inspection. He holds a ASNT Level II in UT and PT. He has guided many National & International Companies to establish the corrosion testing Lab for sour service application.

Mr. Avinash manages the entire advanced testing department of Fatigue test (ASTM E466, ASTM E606) and Fracture toughness tests like KIC, JIC, CTOD testing at room temperature & at sub-zero temperature as per ASTM E399, E1820, E647, BS 7448, ISO 12135, ISO 15653 etc. He has successfully handled many special & Tailor-made tests in Fracture appearance, Fatigue & Fracture Toughness for NAVY & Defense Projects.

The HCF & LCF, Slip Test for reinforcement bar coupler/Mechanical splices as per ASTM A1034, IS16172, ISO 15630 etc. & Accelerated Creep Ruptured Test (ACRT) as per ASTM E139 & API standards by using of Larson-Miller parameter. He has successfully handled the ACRT for Aramco-Yanbu Refinery for his RLA (using Omega Method) study. He has handled FCGR Testing as per EN 13674, ISO 12108 for JSPL for his Railway applications - Track-Rail product.

He undertakes Organizing & Handling all Third-Party Inspection under LRIS, BVIS, IRS, NTPC, TOYO, ONGC, BHEL-CQS, TPL, QUEST, IL, ABS, Multitex, GESCO, DNV, TUV, NPCIL, BARC, EIL, UDHE, FEDO, IBR, L&T, IQC, A Four Associates, Joshi & Associates, ICIS, NCPL, HPCL, Stewarts & Lloyds, Met Scan, QSS, HDO, KPGIL. He has successfully organized several second & third-party audits and Audit for integrity of plant behalf of MECON.

Mr. Avinash has in depth knowledge in Foundry department like Melting, Moulding, Methoding & Gating system for Corrosion & Heat-Resistant alloy steel castings. He has rewarded in Alloy Steel Cast Foundry in M/s. KBL for his valuable contribution for control in rejection of impeller of chemical handling centrifugal pumps.

Prabhakar Singh – Head (Conventional & Corrosion Testing)

He has an extensive knowledge of Conventional Mechanical Testing and Corrosion testing as per National/International specifications.

Analyzing 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, he is good with material testing knowledge. He looks after all the third party inspections that take place at our laboratory, handles their technical queries efficiently and

interprets/analyses the testing results. He also assists his seniors with supervising machining department to make sure whether the machining of material takes place as per standards.

He has an experience in the field of Foundry, Fabrication as well as in the material testing laboratory. A sweet-mouth person who knows how to get work done from subordinates. He has hands on practice in the Mechanical testing which includes the components like springs, seat belts, Reinforcement Couplers, Aluminum Profiles etc.

He has extensive knowledge in heat treatment of Industrial Ferrous Materials, Design for Steel / Alloy development.

His experience ranges from cast iron, general engineering steels, aluminum, copper alloys, stainless steels, and nickel base alloys to titanium. This includes all aspects of Mechanical 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. His expertise in Corrosion testing includes inter-granular corrosion test practice AS per ASTM A262. Pitting corrosion test, crevice corrosion test, HIC, SSCC,CSCC,MgCl2 as per NACE TM0177,TM0284,MR0175 ,MR0103,Salt Spray Test as per ASTM B117.

Mr. Singh is a Science Graduate from Venkateshwara Open University, Itanagar.

Dr. Krishnam Raju – Head Metallurgy

With over three decades of experience spanning research, academia, and industry, Dr. Krishnam Raju is a distinguished metallurgist known for his deep expertise in material science, mechanical behavior, and advanced manufacturing processes. His career has been dedicated to pushing the boundaries of metallurgical research, optimizing material properties, and enhancing quality control in engineering applications.

Formerly as a senior researcher at the Indian Institute of Technology, Bombay (IIT Bombay), Dr. Raju has made significant contributions to the study of austenitic stainless steel (AISI 304), investigating its mechanical behavior, forming limits, and fracture properties. His research focuses on material forming techniques, microstructure evolution, and failure mechanisms, particularly in welded blanks and tube-based applications. His findings have been published in renowned international journals, including Metallurgical and Materials Transactions A (MMTA), Journal of Advanced Manufacturing Systems (JAMS), and the International Journal on Interactive Design and Manufacturing (IJIDEM).

Beyond research, Dr. Raju has had an impressive tenure in academia, serving as an Associate Professor at Jawaharlal Nehru Technological University (JNTU Hyderabad), where he mentored countless students in materials science, manufacturing engineering, and mechanical design. As the Head of the Mechanical Engineering Department at multiple JNTUH-affiliated institutions, he played a pivotal role in shaping the next generation of engineers, fostering innovation, and integrating real-world industry applications into academic curricula.

His professional journey also includes key leadership roles in the manufacturing sector. As Cold Rolling Mill In-Charge at Malhotra Shaving Products, he managed the production of high-precision stainless steel foils (AISI 440) used in razor blade manufacturing. Earlier in his career, he served as a Quality Control Inspector at Nagarjuna Steels, where he specialized in mechanical and microstructural testing of cold-rolled carbon steel coils and strips, ensuring compliance with stringent industrial standards.

Dr. Raju holds a Ph.D. in Metallurgical and Materials Engineering from IIT Bombay, an M.Tech in Industrial Metallurgy from JNTU Hyderabad, and multiple prestigious engineering certifications, including AMIIM in Metallurgical Engineering from the Indian Institute of Metals, Calcutta. His technical skill set includes expertise in Finite Element Modeling (FEM) with PAM-STAMP 2G and proficiency in CAD software such as SolidWorks and AutoCAD, enabling him to bridge the gap between theoretical research and practical engineering applications.

Recognized for his unwavering dedication to excellence, Dr. Raju has been a key figure in collaborative research projects with industry leaders, leveraging his expertise to enhance materials performance and optimize production processes. His association with renowned professors such as Prof. N. Prabhu (IIT Bombay), Prof. K. Narasimhan (IIT Bombay), and Prof. D. Ravi Kumar (IIT Delhi) further reinforces his credibility in the field of materials engineering.

A passionate educator, meticulous researcher, and strategic industry expert, Dr. Krishnam Raju continues to be at the forefront of metallurgical advancements, driving innovation and fostering technical excellence across academia and industry. Whether through groundbreaking research, hands-on industry experience, or inspiring the next generation of engineers, his contributions leave an indelible mark on the field of metallurgical and materials science.

Rihan Baig – Assistant Technical Head (Advance Testing)

Mr. Rihan Baig brings over six years of hands-on experience in Advanced Testing, specializing in various national and international specifications such as NACE MR0175/ISO15156, ASTM B117, G28, G31, G36, G47, and G48. His expertise extends to conducting advanced Fatigue Tests (ASTM E466, ASTM E606) and Fracture Mechanics analysis, including KIC, JIC, and CTOD testing at both room temperature and sub-zero temperatures.

Rihan is skilled in Failure Analysis and Root Cause Analysis, especially for products from industries such as chemical plants, petroleum refineries, and oil fields. He is proficient in assessing material performance under extreme conditions and providing technical support to resolve complex engineering challenges.

His in-depth knowledge of national and international codes and standards—including ASTM, BS, EN, ISO, and NACE—combined with his hands-on experience in corrosion testing, makes him an invaluable asset to the team. Rihan also contributes to Third-Party Inspections, handling audits and ensuring compliance with industry standards, and has successfully organized numerous audits for prominent organizations such as ONGC, BHEL, and NPCIL.

As the Assistant Technical Head (Advanced Testing), Rihan is instrumental in managing fatigue and fracture toughness testing, and is constantly exploring innovative solutions for specialized testing requirements, particularly in the Defense and Navy projects. His ability to apply advanced testing techniques to solve real-world problems sets him apart as a leader in the field.

Through his work, Rihan continues to push the boundaries of what's possible in advanced testing and failure analysis, ensuring the highest level of technical excellence in every project he manages.

Seema Rajpure – Quality Assurance Head

With 19 years of experience in the testing and manufacturing industry, Ms. Seema Rajpure brings unmatched expertise in ensuring the highest quality standards across all processes at TCR Engineering Services. Holding a master's degree in Organic Chemistry from Mumbai University, she combines her deep scientific knowledge with a sharp eye for detail to lead the organization's Quality Assurance efforts effectively.

Seema excels in designing and implementing robust quality management systems, ensuring service compliance with national and international standards. Her role in TCR Engineering Services involves overseeing all quality testing procedures, conducting internal and external audits, and managing risk assessments to maintain a consistently high level of quality across all our services.

Her vast experience spans across quality control, regulatory compliance, and driving continuous improvement initiatives that enhance both service reliability and operational efficiency. Seema is known for fostering a culture of excellence within the team, ensuring a rigorous approach to quality at every level of the organization.

As the Head of Quality Assurance, Seema Rajpure is a key driver of operational integrity, working tirelessly to uphold the company's reputation for delivering services of the highest standard in the industry.

Shaila Kadam – Senior Chemist

With over 25 years of experience in chemical testing and quality assurance, Ms. Shaila Kadam brings extensive expertise in analytical procedures, laboratory supervision, and regulatory compliance. Her deep understanding of chemical testing methodologies, combined with her meticulous attention to detail, ensures the highest standards of accuracy and reliability in laboratory operations.

Shaila specializes in operating chemical test equipment, conducting precise chemical analyses, and supervising testing procedures to maintain consistency and adherence to industry standards. Her role involves overseeing laboratory teams, reviewing and authorizing test data, and ensuring compliance with national and international regulatory guidelines.

With a strong background in preparing and validating chemical test reports, Shaila plays a critical role in maintaining the integrity of analytical results. She is also instrumental in developing and implementing work instructions for chemical testing, optimizing processes to enhance efficiency and quality.

As a senior professional in chemical testing and quality control, Shaila Kadam is committed to upholding the highest levels of accuracy and reliability, contributing to a culture of excellence in laboratory operations.

Parul Hariya – Head Civil Testing

With over 15 years of expertise in the field of building material testing, Parul Hariya is a seasoned professional known for her technical precision, leadership, and commitment to quality assurance. As the Head of Civil Testing, she plays a pivotal role in ensuring the highest standards of material integrity, reliability, and compliance in the construction industry.

Armed with a Master of Science in Physics, Parul combines her strong academic foundation with deep hands-on experience in mechanical and physical material testing. Her expertise

spans material durability assessment, structural performance evaluation, and adherence to National and International testing standards. She has been instrumental in developing and validating mechanical building material test reports, ensuring data-driven insights that empower engineers, architects, and construction firms to build with confidence.

Parul's leadership in civil testing has led to the optimization of testing protocols, enhancing efficiency and accuracy across laboratory operations. Her ability to bridge the gap between theoretical material science and real-world application has made her an invaluable asset to industry stakeholders looking for cutting-edge solutions in material evaluation.

A results-driven professional, Parul is dedicated to continuous improvement, innovation, and industry best practices. Her expertise helps clients mitigate risks, enhance structural safety, and ensure compliance with regulatory requirements. She is passionate about pushing the boundaries of material science to support sustainable and high-performance construction practices.

Shemi Bhaskaran - ASNT Level III Radiography Expert

Mr. Bhaskaran has 25 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. Mr. Bhaskaran's major strength is in Radiography for Cross Country Pipelines using crawlers and computerized Radiography.

Samir Choudhury, General Manager (TCR Eastern)

Mr. Samir Choudhury is a Science Graduate from Utkal University, DME with CSWIP 3.1 Welding Inspector, ASNT Level-II in RT, UT,MPI & PT with over 20 years of experience managing many cross-country pipeline projects and other Oil & gas sector in India as well as in abroad.

Has managed a variety of projects and contracts of NDT jobs to specialized projects in oil and natural gas companies.

Mr. Samir Choudhury has tremendous experience in advanced NDT technology to elaborate the day-to-day project execution activity.

Has 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.

He develops business practices that encourage team building and participation by others within the organization. Includes responsibility for technical performance, schedule, budget, coordination of proposal responses, and decision making in business development.

He leads a multi-disciplinary filed services team within TCR and provides leadership, vision and direction.

Abhay Dhuri, NDT Operation Manager

Mr. Abhay Dhuri has tremendous 20 years of experience in NDT inspection in Oil & Gas industry.

He has extensive working experience in Cross Country Pipeline and Station Piping at various Oil and Gas projects, he has excellent Knowledge of offshore (ONGC) and onshore petrochemical

Projects as NDT Coordinator. Abhay has leadership to handle various Projects and Trained NDT personal with all American and British Standard Code and Specifications.

Mr. Abhay has intimate knowledge of Radiography Films interpretation and Film Digitalization. He is very enthusiastic to learn new things and make others to grow along with him. His desired result oriented ability to make work place a professional and friendly to work with.

His major strength is to handle all NDT and Cross-Country related Audit as BARC and NABL Certification in Various NDT methods.

Mr. Abhay qualified BARC RT Level I, ASNT LEVEL II in RT, UT, PT, MT. He also qualified as ISNT LEVEL II in PT and MT.

Atul Yadav – Head Human Resources

With over 15 years of experience in the field of Human Resources, Mr. Atul Yadav is a seasoned professional who leads HR operations with a strategic vision and a focus on organizational growth. Throughout his career, Atul has been instrumental in shaping and implementing HR strategies that align with business objectives, fostering a productive and engaged workforce.

Atul has a comprehensive understanding of talent management, employee relations, recruitment, performance management, and organizational development. He excels in building strong organizational cultures, driving employee engagement, and ensuring that the company's human capital is utilized effectively to meet business goals.

He is skilled in leading large teams, driving change management initiatives, and creating policies that encourage a positive work environment while also ensuring compliance with labor laws and industry standards. Atul's expertise also extends to managing HR technology, compensation and benefits structures, and providing strategic insights to leadership for optimizing workforce productivity.

As the Head of Human Resources, Atul Yadav continuously drives HR excellence by promoting a culture of inclusivity, performance, and continuous improvement, ensuring that the company remains a leading employer in the industry.

Sagar Salvi – Accounts and Purchase Head

With over 15 years of extensive experience in Accounts and Procurement, Mr. Sagar Salvi is a seasoned professional who brings strategic insight and operational excellence to the organization. His vast experience spans across managing financial operations, procurement processes, and ensuring seamless integration between accounting and purchasing functions.

Sagar is highly proficient in financial management, including budgeting, financial reporting, and ensuring that all financial activities align with the company's goals and industry standards. He also oversees the purchasing department, managing supplier relationships, contract negotiations, and procurement strategies to ensure cost-effective sourcing of materials and services.

He has a deep understanding of financial compliance, internal controls, and audit procedures, ensuring the company maintains financial integrity and meets regulatory requirements. Sagar's ability to streamline processes and create synergies between accounts and purchasing enables the organization to function efficiently and effectively.

As the Head of Accounts and Purchase, Sagar Salvi plays a key role in driving both financial stability and operational excellence, supporting the organization's growth, and enhancing its procurement capabilities to achieve long-term success.

Lalit Surve – General Manager

Mr. Lalit Surve is a dynamic and results-driven General Manager with 25 years of extensive experience in laboratory operations and management. With a strong background in finance, regulatory compliance, and strategic planning, he ensures the seamless functioning of the laboratory while maintaining the highest standards of efficiency and accuracy.

As a visionary leader, he is committed to optimizing workflows, enhancing team performance, and driving business growth. His expertise in financial management, client relations, and operational excellence enables him to oversee all aspects of the laboratory, from staff supervision to ensuring strict compliance with industry regulations.

Under his leadership, the laboratory continues to innovate and expand its capabilities, ensuring superior service delivery and adherence to the latest industry standards. His dedication to quality, safety, and operational efficiency makes him a valuable asset in the field.

Mr. Surve is a strategic thinker with a deep understanding of financial analysis and budgeting. His expertise in financial planning and resource allocation ensures precise budget management, backed by his extensive experience in the domain.

He excels in building and maintaining strong client relationships, fostering a customer-centric approach among the sales team to create lasting partnerships. Managing key accounts, he implements tailored strategies to achieve sales targets and drive business growth.

Additionally, he possesses exceptional proficiency in preparing and analyzing various reports, including monthly sales performance, annual forecasts, and account status reports, which he presents to senior management for strategic decision-making.

With strong leadership and motivational skills, he drives teams toward achieving targets efficiently. He also excels in reviewing and managing procurement transactions, ensuring cost-effectiveness and operational efficiency.

Lalit is a graduate with a B. Com degree from Mumbai University.

Ashwant Singh – Assistant General Manager

Ashwant Singh is not only part of a 50-year-old legacy TCR Engineering Services but is actively shaping its future. With a sharp strategic mind and a relentless drive for excellence, he has rapidly ascended the corporate ladder, proving that leadership is about impact, not just experience.

His journey began at VSR Enpro Consultants, where he honed his financial acumen as an Accounting Intern, managing site expenses, worker salaries, and sales monitoring. This hands-on experience provided a strong foundation in financial management and business operations.

He later joined TCR Engineering Services where he played a crucial role in streamlining executive operations. From optimizing workflows and coordinating meetings to managing key reports and business communications, he became an integral part of the company's decision-making process. His ability to bring structure and efficiency to operations set him apart.

With a Bachelor of Commerce from Mumbai University and currently pursuing an MBA in Finance, he possesses a deep understanding of financial strategies that drive business growth.

His expertise in financial enables him to make data-driven decisions that contribute to the company's success.

As Assistant General Manager, he now leads with the same intensity and precision that have defined his career. Focused on innovation, strategic execution, and operational excellence, he is committed to driving the company forward. For him, leadership is not just about managing—it's about transforming challenges into opportunities and vision into reality.

Rohit Bafna, President

With an innate drive to propel companies to their full potential, Rohit has dedicated his career to identifying opportunities that align with his values of integrity, precision, and growth. His investment philosophy is rooted in a deep respect for the legacy of TCR, yet his focus is distinctly modern, channeling his expertise into ventures that create tangible, impactful change. Rohit Bafna doesn't just lead with purpose—he redefines what leadership means, carrying TCR's legacy forward with boundless vision and heart.

Rohit Bafna embodies the vision, energy, and bold foresight that drives TCR Engineering to new heights. Fuelled by a relentless passion for building and transforming businesses, Rohit has been instrumental in propelling TCR's global presence with a unique mix of strategic insight and hands-on leadership.

Passionate about every facet of business, Rohit is known for his strategic acumen and keen eye for value creation, whether he's analyzing emerging markets or expanding TCR's influence across borders. He stands on the shoulders of his family's pioneering spirit, carrying forward his father's legacy while introducing fresh perspectives to stay ahead of industry advancements. Rohit has also cultivated relationships with partners worldwide, seamlessly expanding TCR's footprint and enabling innovative solutions that resonate globally.

Rohit's leadership is driven by his innate ability to see the big picture and his unmatched knack for rallying high-performance teams. Under his guidance, TCR transformed the landscape of material testing, forging ahead with digital solutions and building a robust online community. His career has been defined by a hands-on approach that's strategic, visionary, and laser-focused on the customer. With previous leadership roles in international business development at Mphasis and Verizon, Rohit earned a reputation for deeply understanding customer pain points and crafting powerful, tech-forward solutions for clients like Chase, ABN AMRO, and Singapore Airlines.

Rohit is a true people-first leader whose joi de vivre and dedication to empowering others have a lasting impact on everyone he meets. His commitment goes beyond business: he's a dedicated board member of "Each One, Teach One," a philanthropic organization dedicated to educating and uplifting underprivileged children in India.

In the Bafna tradition, Rohit sees investment as more than just financial growth—it's about nurturing companies to embody excellence, ethics, and endurance. His commitment to these ideals drives him to uphold the family's core values, making each venture a testament to TCR's legacy of trust and quality. Through his unique blend of passion and expertise, Rohit Bafna ensures that TCR's story continues, reaching new heights with every investment and every partnership.

Viren Khandwala, Director

Mr. Khandwala 's deep expertise and broad experience make him a valuable asset to TCR's Board of Directors, adding both strategic depth and financial rigor. His contributions continue to be instrumental in TCR's ongoing success and its reputation as a leader in the materials testing and engineering industry.

Viren Chandrasen Khandwala is a seasoned Chartered Accountant with over 25 years of extensive experience in accountancy and taxation. Graduating with a Bachelor of Commerce from Bombay University in 1988, he pursued his Chartered Accountancy qualification, which he completed in 1995 through the prestigious Institute of Chartered Accountants of India. His early career included a rigorous three-year articleship with Lovelock & Lewes Chartered Accountants in Bombay, then affiliated with Coopers & Lybrand Deloitte (now a key part of Price Waterhouse Coopers). Following his article ship, he continued with the firm as a Junior Assistant for two years, gaining a solid foundation in accounts, audits, and income tax.

Since joining TCR Engineering as a Consultant in 1999, Mr. Khandwala has played an integral role in shaping the company's financial strategies. In 2014, he was appointed to the Board of Directors, where he brings his expertise in accountancy, audit, and taxation to the forefront of TCR's leadership. His comprehensive understanding of financial systems and regulatory compliance enhances TCR's commitment to sound governance, supporting the company's growth in a complex and competitive landscape.

Beyond his technical skills, Mr. Khandwala is a trusted advisor, offering insights that benefit not only TCR but also the broader business community. He has been invited to deliver lectures on topics such as wills, investment opportunities for senior citizens, and budget proposals at esteemed platforms like SGBMM and the Rotary Club. His dedication to sharing his knowledge reflects his commitment to enhancing financial literacy and supporting community empowerment.

List of Equipment's

Name of Equipment	Equipment ID	Model/ Type/ Make & IN SERVICE	Capacity / Range / L.C.
Mechanical			
Universal Testing Machine ZD 100 : Mechanical Lab 1	TCR/MEC/EQP/01	Make VEB WPM LEIPZIG-GERMANY ZD-100 Sr. No-283/40 -1975	0-1000 kNLC 5kN/ ±1%-
Extensometers of UTM ZD 100	200 mm GL (ZD-100)	Make-SATYA Sr.No. 267	0-200 mm LC 0.001
Electronic Extensometer	125 mm GL (ZD-100)	Make Satya Sr.No.18034	125-200 mm LC 0.001
Electronic Extensometer	300 mm GL (ZD-100)	Make Satya Sr.No.18037	100-300 mm LC 0.001
Electronic Extensometer	100 mm GL (ZD-100)	Make Satya Sr.No.18033	40-100 mm LC 0.001
Electronic Extensometer	25 & 50 mm GL (ZD-100)	Make Satya Sr.No.23101	25-50 mm LC 0.001
Electronic Extensometer	25 & 50 mm GL (ZD-100)	Make Satya Sr.No.23102	25-50 mm LC 0.001
IZOD &Charpy Impact Testing Machine Location: Mechanical Lab-1	TCR/MEC/EQP/04	Make-FIE Model –IT 30Sr. No-789/ 1975,	Izod-156JLC 2 J
Brinell / Vickers Hardness Tester Location: Mechanical Lab-1	TCR/MEC/EQP/06	Make HECKERT Model- HPO 250 F.Nr-308/92,/ 1979	HBW 15.625-50Kg-Hv, 5-120Kg, ±2%
Digital RockwellHardness tester Location-Met. Lab	TCR/MEC/EQP/07	Make FIE Model-RA Sr.No.-77/021 / 1976	HRB 20- 100-HRC 20-70-±1%
Brinell / Vickers Hardness Tester Location: Mechanical Lab-1	TCR/MEC/EQP/08	Make HECKERT Model- HPO 250/Sr.No. -308/27, 1981,	HBW 15.625-250Kg-Hv 5-120Kg-±2%
Universal Testing Machine Location: Mechanical Lab-1	TCR/MEC/EQP/09	Make KALPAK INSTRUMENTS Model KIC-2-1000-C Sr. No.: 110402/ 2011	0-100 kN / LC 0.01Kn, ±1%
Extensometer of UTM KIC-100 kN	25&50 mm GL (KALPAK)	Make MCS Sr.NO. 186 - 0207	0-25 mm LC 0.001
Universal Testing Machine(Servo Hydraulic) Location:Mechanical Lab-2	TCR/MEC/EQP/13	MTS System (china) Co.Ltd-SHT4106/309110/ Nov - 2009	0-1000kN/ LC0.003Kn ±1%
Extensometers of UTM SHT 4106	25 mm GL (SHT-4106)	Make: United Sr.No. 21094	0-25 mm LC 0.001
Extensometers of UTM SHT 4106	25 mm GL (UTN-40HGFL)	Make Epsilon Sr. E 86918	0-25 mm LC 0.0001
Extensometers of UTM SHT 4106	50 mm GL (UTN-40HGFL)	Make Epsilon Sr. 3448-050M-020	0-50mm LC 0.0001

Extensometers of UTM SHT 4106	50 mm GL (SHT-4106)	Make: United Sr.No. 21086/50	0-50mm LC 0.0001
Shadowgraph checking Machine(profile Projector) with Tracing Paper - Location: Metallurgical Lab	TCR/MEC/EQP/14	Make Metzer	50X Range X-25 mm/Y- 25mm LC 0.005
V Notching Machine-Location: Machine Shop	TCR/MEC/EQP/15	Fine Marketing-1976	2 mm VNotch
Hydraulic Test Pump& Compressor-Location: HydroTesting lab	TCR/MEC/EQP/16	MAKE-HARSHMI,Sr. No. 5456-19,PUMP MODEL NO. AMTMH-1000	1000 kg/cm2
Hydraulic Pipe Bending Machine - Location: Hydro Testing lab	TCR/MEC/EQP/20	Sr. No.: 965	NA
Digital Weighing Balance- Location: Mechanical Lab-1	TCR/MEC/EQP/21	Make-PENTA Electronics- Sr. No. 4981 Model ILW300	0.1 to 30Kg. LC 0.002 kg
Low temperature chamber DWC 80with sensor-(Mechanical Lab-2)	TCR/MEC/EQP/22	Make-Ace instruments Model- DWC 80, SrNo.5990612	(-100 to +200 °C - Calib. -80to 30 °C)
Universal Testing Machine Location:Fatigue Lab	TCR/MEC/EQP/23	Make-BISS/ Model-BIS-BI-04-CP-310, Sr.No.11100431	50 KN LC 0.001kN
Room Temp. -COD	RT 5 mm G.L.	Make-Epsilon ,Model- 3541-005M-070M-ST Sr.No. E113275	G.L.5mm,Travel:+7mm
High Temp. -COD	HT 5 mm G.L.	Make-Biss,Model-Bi-06-252,Sr. No.06252004	G.L.5mm,Travel :+2mm&-0.5mm
Room Temp. -COD	RT 5 mm G.L.	Make-Biss,Model-AC-007-0010,Sr. No.070010054	G.L.5mm,Travel :+7mm& -1mm
Room Temp. -COD	RT 10 mm G.L.	Make-Biss,Model-Bi-06-203,Sr. No.06203028	G.L.10mm, Travel :+7mm& -1mm
Room Temp.- Extensometer	RT 25 mm G.L.	Make-Biss,Model-Bi-06-309,Sr. No.06309011	G.L.25mm, Travel :+6mm& -3mm
Room Temp.- Extensometer	RT 50 mm G.L.	Make-Biss,Model-Bi-06-309,Sr. No.06309011	G.L.50mm, Travel :+6mm& -3mm
Room Temp.- Extensometer	RT 12.5 mm G.L.	Make-Biss,Model-Bi-06-301,Sr. No.06301024	G.L.12.5mm, Travel :+1mm& -1mm
High Temp.- Extensometer	HT 10 mm G.L.	Make-Biss,Model-Bi-06-0401,Sr.	G.L.10mm, Travel

		No.06401016	:+1.5mm & -1.5mm
Universal Testing Machine Location:Fatigue Lab	TCR/MEC/EQP/24	Make-BISS/Model-BI-CP-310 BISS Sr.No.11100432	250 KN LC 0.001 kN
Universal TestingMachine Location:Mechanical Lab-2	TCR/MEC/EQP/25	Make-FIE, Model -UTN-40HGFL Sr. No.: 9/2015-5603-	0-400KN LC 0.01 Kn
Rockwell Hardnesstester-Location: Mechanical Lab-1	TCR/MEC/EQP/26	FIE / RASN -T Sr. No- 05/2013-2856	HRB 20-100-HRC 20-70-HRA 30100±1%
Cupping machine (Scale)-Location: Metallurgy Lab	TCR/MEC/EQP/27	Make-FIE	0-20 mm-scale LC 1 mm
Digital Thermometer with sensor - Location Fatigue Lab	TCR/MEC/EQP/28	YCT- TC-117C Tempsens, Sr. No.76706/08060/ 10060848	-250 °C to 400 °C
Digital Thermometer with sensor	TCR/MEC/EQP/29	Make-SELEC/ TC303AX, Sr No- 1809T09-3367	- 196°C to +300 °C L.C. 1°C
BEVEL PROTECTOR-Location: Mechanical Lab-1	TCR/MEC/EQP/30	Make-AerospaceSr. No.-4-601196	0-360 Degree LC 5 minute
Stop Watch - Location: Mechanical Lab-1	TCR/MEC/EQP/31	Make-Flott -Sr. no. A-015	0-24 hrs.- L.C. 1/100sec.
Digital Temp. Controller with Sensor Location: Mechanical Lab-2	Eurotherm Mini 8	Make-Hittites Technology,Model- HI13-1200,n type	Amb.- 1200°C L.C. +-2°C
Temp. Controller with Sensor Location: Mechanical Lab-2	TCR/MEC/EQP/32	Make-TALTECH ,Model-SHIMADEN/FP93,Sr.No.EP002	Amb. to 1200°C
OVEN (Weldingshop)	TCR/MEC/EQP/34	Sr. No. 412104	Amb. to 250 °C, L.C.1°C
Creep Testing Machine-1 Location-Creep LAB	TCR/MEC/EQP/35	Make-Star Testing System Model-STS-01 Sr. no. 150	50 kN L.C. 2.5 N
3 Zone Furnace Location- Creep LAB	Id. No.-STS – 150 Sr.No.-150	Make- Star TestingSystem	Ambient to 1200C L.C.0.1C
Dead Weight(STS-150&STS-168)	STS-150&STS-168	Make- Star Testing System	2.5N,5N,25 N,50N,100 N&150N
Creep TestingMachine-2 Location-Creep Lab	TCR/MEC/EQP/36	Make-Star Testing System Model-STS-02 Sr. no.168	50 kN L.C. 2.5 N
3 Zone Furnace Location- Creep Lab	Id. No.-STS - 168	Make- Star Testing System	Ambient to 1200C L.C.0.1C
Digital Plunger Gauge Location-Creep Lab	TCR/MEC/DG/3	Make-Mitutoto Sr.No.17119719	0-25.4mm L.C.0.001mm

Digital Plunger Gauge Location- Creep Lab	TCR/MEC/DG/4	Make-Mitutoto Sr.No.18299330	0-50.8mm L.C. 0.001mm
Cold Test Chamber (Fatigue Lab)	TCR/MEC/EQP/37	Make ENVISYS Model ET144-25T, Sr. No. ET/009/17 -18	-25 °C to Amb. L.C. 0.1°C
Weighing Balance	TCR/MEC/EQP/38	Make Contech Model CP1T200 Sr. 170319	2 kg to 1ton L.C. 100 g
Charpy Impact Testing Machine Location:Mechanical Lab-1	TCR/MEC/EQP/39	Make-FIE, Model- IT-40 (ASTM)Sr.No. 04/2018 - 1459 Mfg.2018	400 J Charpy
Surface Roughness Tester	-----	Make TIME,Sr.No. 00000106630006	0-10 Micron
High temperature Extensometer Location- Fatigue Lab	TCR/MEC/EQP/41	Make-Satya, Sr. No: 21089 Extension Capacity: 12mm	0-25 mm LC 0.001 mm
Universal Testing Machine Location: Mechanical Lab-2	TCR/MEC/EQP/ 42	Make-FIE, Model –UTES100-HGFL Sr. No.: 03/2022-6751 Installed in Apr-2022	0-1000KN LC 0.01 KN
Muffle furnace UTM-HOT Tensile with controller Location:Metallurgy Lab-	TCR/MEC/EQP/43	MAKE: TCR Sr.no.-TCR-001	Amb.-1200°C LC 1°C
3 Zone Furnace	TCR/MEC/EQP/44	Make-Hittities Model- HI13- 1200 Sr.No.H13-1200-22-03	Ambient to1200 C
Universal Testing Machine Location:Fatigue Lab	TCR/MEC/EQP/46	Make-Hittites/ Model-UTS 1000 / HI-01-01000 Sr.No.23-HI01-01000-01	1000 KN LC 0.001 kN
Room Temp. -COD	RT 10 mm G.L.	Make-Epsilon,Model- 3541- 010M-070M-ST,Sr.No. E105687	G.L.10mm, Travel :+7mm
Room Temp.- Extensometer	RT 50 mm G.L.	Make-Epsilon,Model- 3442- 050M-050M-ST, Sr.No.E105579	G.L.50mm, Travel +5mm, -1mm
Measuring Instruments			
Micrometer (Singleball)- Location: Mechanical Lab-1	TCR/MM/Single ball/01	Make-Mitutoyo ,Sr. No. 9169	0-25 mm LC 0.01 mm
Pin Micrometer	TCR/PIN/01	Make-Mitutoyo	0-15 mm LC 0.01 mm
Digital VernierCaliper Location: Mechanical Lab-1	TCR/MEC/VC/200	Make-Baker/ Sr. No. - DD306718	0-200mm LC 0.01 mm
Micrometer (Doubleball) Location: Mechanical Lab-1	TCR/MM/MEC/11	Mitutoyo Sr.No.56063638	0-25 mm LC 0.01 mm
External Micrometer-Location:Mechanical Lab-1	TCR/MEC/MM/25	Make-Mitutoyo Sr.No.2031020	0-25 mm LC 0.01 mm
Micrometer (Machine shop)	TCR/MS/MM/25	Make-Mitutoyo Sr. No. 1220084	0 – 25 mm LC 0.01 mm

Dial Vernier Caliper- Location:Mechanical Lab-1	TCR/MEC/DVC/ 300	Make-Mitutoyo Sr. No. 06536922	0-300mm LC 0.02 mm
Vernier Caliper- Location:Mechanical Lab-1	TCR/MEC/VC/600	Make-Aerospace Sr. no. 209043	0-600 mm LC 0.02 mm
External Micrometer- Location:Mechanical Lab-1	TCR/ MEC/ OM/200	Make- QLR,Sr No.04020- 7137	200-300 mm LC 0.01 mm
Measuring Scale- Location: Mechanical Lab-1	TCR/MEC/MS/1000	Make-Technika	0-1000 mm LC 0.5Mm upto100& above 100- 1mm
Measuring Tape	TCR/MEC/MT/02	Make- Swift	0 to 5000 mm, LC1mm
Digital Vernier Caliper- Location: FatigueLab	TCR/DVC/SE/01	Make Insize Sr. No. 0807232551	0-200 mm LC 0.01 mm
External Micrometer- Location: Mechanical Lab-1	TCR/MEC/MM/50	Make-Mitutoyo Sr.No.7749020-	25-50 mm LC 0.01 mm
External Micrometer- Location: Mechanical Lab-1	TCR/MEC/MM/50 - 1	Make-Yuzuki Sr.No.160445362	0-50 mm LC 0.01 mm
Digital Vernier Caliper - Location: Metallography Lab	TCR/MET/VC/01	Make INSIZE Sr. No. 1208171281	0 to 150 mm LC 0.01 mm
Digital Vernier Caliper Location: corrosion Lab	TCR/COR/VC/01	Make INSIZE Sr. No. 2706221761	0 to 150 mm LC 0.01 mm
Pi tape Mechanical Lab	TCR/Pi/01	Make-Blazer Made in Germany	60-8900 mm 0.1 mm
Outside Micrometer	TCR/MM/MS/WEG/ 01	Make- PROPLUNT – Sr.No. 20268489	0-25 mm LC 0.01 mm
Vernier Caliper-	TCR/MS/VC/WEG/02	Make- Insize Sr. No 0505191354	0-200 mm LC 0.01 mm
Dial Gauge (Impact)- Location: Mechanical Lab-1	TCR/MEC/DG/1	Make-Mitutoyo Sr. No.: LVA826-	0-1 mm LC 0.01 mm
Dial Gauge(Impact)- Location: Mechanical Lab-2	TCR/MEC/DG/2	Mitutoyo Model no -2109,Sr No. 9813K7-	0-5mm
Pressure Gauges- Location: Hydro Testing	TCR/PG/HT/ Pioneer/600	Make-Pioneer	0-600 Kg/Cm2 LC 20 Kg/cm2
Pressure Gauges- Location: Hydro Testing	TCR/PG/HT/Wika 1000	Make-Wika	0-1000 Kg/Cm2 LC 20 Kg/cm2
Pressure Gauges- Location: Hydro Testing	TCR/HDT/PG/ UDAY/420	Make- Hi-tech	0-420 Kg/cm2 LC 10 Kg/cm2
Pressure Gauges- Location: Hydro testing	TCR/PG/HT/A RBUD A/28	Make-ARBUDA, ModelNo.- 1F1222, Sr. No.- EN837-1	0-28 Kg/cm2 LC 0.5 Kg/cm2
Pressure Gauges- Location: Hydro testing	TCR/PG/HT/Hi - Tech/140	Make- Hi-Tech	0-140 Kg/ cm2 LC 2 kg/CM2

Moisture Coating Unit With Heating Furnace , controller-Analog - Voltmeter & Ammeter & Indicator	TCR/COR/MOC/1	Venus Equipment- TCR/AM/06 - TCR/VM/03; sensor 1&2	0-15 A AC/0-300 VAC LC 10 VAC
Temperature Indicator with Sensor (Welding Room)	TCR/TI/WELD/01	-UDIAN Sr. No :2K21242 - Model - PRC-8000 0-15 A DC/0-300 V DC	Amb. to 250°C L.C. 1 °C
Measuring Tape	TCR/MT/03	Make- Freemans	0-10000mm LC 1 mm
Pressure Gauges- Location: Hydro testing	TCR/PG/HT/280	Make-Hi-tech	0-280 Kg/cm2 LC 10 kg/ cm2
Pressure Gauges- Location: Hydro testing	TCR/PG/HT/70	Make-Hi-tech	0-70 Kg/cm2 LC 2 kg/ cm2
Digital Clamp Meter (Welding Room) AC/DC	TCR /CLM/02	Make- Meco, Sr. No :3690	N.A.
Digital Vernier Caliper - Location:Machine Shop Ramsingh	TCR/MEC/VC/01	Make INSIZE Sr. No. 24066222382	0 to 150mm LC 0.01 mm
Lateral Exp. Gauge	TCR/LEG/01	Make-Mitutoyo Sr.No.AJQB00	0-10mm LC 0.01 mm
Digital Vernier Caliper- Location: Mech.2	TCR/MEC/VC/14	Make INSIZE Sr. No. 0403222695	0-200mm LC 0.01 mm
Digital Vernier Caliper- Location: Mech.1	TCR/MEC/VC/17	Make INSIZE Sr. No. 0807232609	0-200mm LC 0.01 mm
Digital Vernier Caliper- Location: Mech.2	TCR/MEC/VC/18	Make INSIZE Sr. No. 0806231312	0-150mm LC 0.01 mm
Digital Vernier Caliper- Location:Mech.2	TCR/MEC/VC/15	Make INSIZE Sr. No. 0403222484	0-200mm LC 0.01 mm
Digital Vernier Caliper- Location:Mech.1	TCR/MEC/VC/16	Make INSIZESr. No. 19052229333	0-300mm LC 0.01 mm
Building Materials			
Compression Testing Machine 3000kn	TCR/CIVIL/01	Make- Multitech,Sr. No.- 2023075,Model- MSI2061	0.1 to 3000kN
Flakiness Apparatus	TCR/CIVIL/02	Make- Multitech,Sr. No.- 2023010,Model-MSI5001	6.3mm to 63mm
Elongation Apparatus	TCR/CIVIL/03	Make- Multitech,Sr. No.- 23011,Model-MSI5001	6.3mm to 63mm
Hot Air Oven	TCR/CIVIL/04	Make- Multitech,Sr. No.- 2023008,Model-MSI9013	0 to 250 deg. C
Buoyancy Weighing Balance	TCR/CIVIL/05	Make- Multitech,Sr. No.- 2023025,Model-MSI5010	0.5 to 15 Kg
IS Sieve Size 40 mm	TCR/CIVIL/06	Make- Multitech,Sr. No.- 2023026,Model-MSI3079	40mm
IS Sieve Size 20 mm	TCR/CIVIL/07	Make- Multitech,Sr. No.- 2023027,Model-MSI3079	20mm
IS Sieve Size 16 mm	TCR/CIVIL/08	Make- Multitech,Sr. No.- 2023028,Model-MSI3079	16mm
IS Sieve Size 12.5 mm	TCR/CIVIL/09	Make- Multitech,Sr. No.- 2023029,Model-MSI3079	12.5mm
IS Sieve Size 10 mm	TCR/CIVIL/10	Make- Multitech,Sr. No.- 2023030,Model-MSI3079	10mm

IS Sieve Size 4.75 mm	TCR/CIVIL/11	Make- Multitech,Sr. No.-2023031,Model-MSI3079	4.75mm
IS Sieve Size 3.35 mm	TCR/CIVIL/12	Make- Multitech,Sr. No.-2023032,Model-MSI3079	3.35mm
IS Sieve Size 2.36 mm	TCR/CIVIL/13	Make- Multitech,Sr. No.-2023033,Model-MSI3079	2.36mm
IS Sieve Size 1.18 mm	TCR/CIVIL/14	Make- Multitech,Sr. No.-2023034,Model-MSI3079	1.18mm
IS Sieve Size 600 Micron	TCR/CIVIL/15	Make- Multitech,Sr. No.-2023035,Model-MSI3080	600 micron
IS Sieve Size 300 Micron	TCR/CIVIL/16	Make- Multitech,Sr. No.-2023036,Model-MSI3080	300 micron
IS Sieve Size 150 Micron	TCR/CIVIL/17	Make- Multitech,Sr. No.-2023037,Model-MSI3080	150 micron
IS Sieve Size 75 Micron	TCR/CIVIL/18	Make- Multitech,Sr. No.-2023038,Model-MSI3080	75 micron
IS Sieve Size 45 Micron	TCR/CIVIL/19	Make- Multitech,Sr. No.-2023039,Model-MSI3080	45 micron
Weighing Balance100 kg	TCR/CIVIL/20	Make- Denver,Sr. No.-023039A, Model-Standard	100 kg
Weighing Balance15 kg	TCR/CIVIL/21	Make- Denver,Sr. No.2023039B, Model-Standard	15 kg
Vernier Caliper300mm	TCR/CIVIL/22	Make- Insize,Sr. No.2023012A, Model-Standard	0 to 300mm
Curing Tank with refrigerator	TCR/CIVIL/23	Make- Multitech,Sr. No.-2023012,Model-MSI2045	-20 to 100 deg.C
Measuring Tape - 5mtr	TCR/CIVIL/24	Make- Freeman,Sr. No.-2023012B,Model-Standard	0 to 5 mtr.
Bulk Density Container 3kg	TCR/CIVIL/25	Make- Multitech,Sr. No.-2023013,Model-MSI5008	3 kg
Bulk Density Container 15kg	TCR/CIVIL/26	Make- Multitech,Sr. No.-2023014 ,Model-MSI5008	15 kg
Crushing Value Apparatus with Base Plate & Plunger	TCR/CIVIL/27	Make- Multitech,Sr. No.-2023015 ,Model-MSI5014	5 to 40 %
Impact Value App.With Measure, Cylindrical Cup,Tamping Road	TCR/CIVIL/28	Make- Multitech,Sr. No.-2023016 ,Model- MSI5015	5 to 30 %
Specific gravity & Water Absorption Apparatus	TCR/CIVIL/29	Make- Multitech,Sr. No.-2023017 ,Model- MSI5010	Chain pully arrangement
Pycnometer	TCR/CIVIL/30	Make- Multitech, Sr. No.-2023013,Model-MSI5008	1000ML
Sieve Shekher	TCR/CIVIL/31	Make- Multitech,Sr. No.-2023013,Model-MSI5008	Lab Type
Flexural strength accessories (with pace rate controlling CTM Machine)	TCR/CIVIL/32	Make- Multitech,Sr. No.-2023075J ,Model- MSI2057-Jig	Fixture
Sample Tray	TCR/CIVIL/33	Make- Multitech,Sr. No.-2023020 ,Model- MSI9001	5 ltr
Hair Dryer for sand drying.	TCR/CIVIL/34	NA	NA

Corrosion			
Dial Gauge-Corrosion	TCR/COR/DG/01	Make-Baker Sr. No. DCH499	0- 10 mm L.C.0.01mm
Dial Gauge-Corrosion	TCR/COR/DG/02	Make-Baker Sr. No. ACD959	0- 10 mm L.C.0.01mm
Plunger Dial-Corrosion	TCR/COR/DG/03	Make-Baker, Sr. No. FDA307	0 – 10 mm L.C.-0.01mm
Digital Pitting Gauge digital type-Corrosion Lab	TCR/COR/PDG/01	Make-Caltech Engineering	0-12.7 mm LC 0.001mm
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/01	Make – SELEC	Amb. To 750 °C L.C. 1 °C
Temperature controller ith sensor (Cor. Lab)	TCR/COR/PID/01A	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/02	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/02A	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/03	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/03A	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/04	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/04A	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/05	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/05A	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller withsensor (Cor. Lab)	TCR/COR/PID/06	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller with sensor (Cor. Lab)	TCR/COR/PID/06A	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller With Sensor 8 Channel (Cor. Lab)	TCR/COR/PID/07	Make – SELEC	Amb. to 750 °C L.C. 1 °C
Temperature controller With Sensor 8 Channel (Cor.Lab)	TCR/COR/PID/08	Make – SELEC	Amb. to 800°C L.C. 1 °C
Temperature controller With Sensor 8 Channel	TCR/COR/PID/09	Make – SELEC	Amb. to 800 °C L.C. 1 °C

(Cor. Lab)			
Temperature controller With Sensor 8 Channel (Cor. Lab)	TCR/COR/PID/10	Make – SELEC	Amb. to 800 °C L.C. 1 °C
Temperature controller With Sensor 8 Channel (Cor. Lab)	TCR/COR/PID/11	Make – SELEC	Amb. to 800 °C L.C. 1 °C
Temperature controller with Sensor 8 Channel (Cor. Lab)	TCR/COR/PID/12	Make – SELEC	Amb. to 800 °C L.C. 1 °C
Temperature controller with Sensor 8 Channel (Cor. Lab)	TCR/COR/PID/13	Make – SELEC	Amb. to 800 °C L.C. 1 °C
Temperature controller With Sensor 8 Channel (Cor.Lab)	TCR/COR/PID/14	Libratherm / PID 8000High Temp-	Amb. to 800 °C L.C. 1 °C
Temperature Controller with Sensors 2 channel	TCR/TCS/19	Make - Marvel-080227/1	Amb. –250 °C L.C. 1 °C
Temperature Controller with Sensors 2 channel	TCR/TCS/20	Make - Marvel-080227/2	Amb. – 250°C L.C. 1 °C
Temperature Indicator with Sensor	TCR/COR/001	Make-SELEC, Sr. No. 1801T01-4785, ModelTC303	Amb. -250°C L.C. 1°C
Temperature Controller with Sensors 12 channel	TCR/TCS/01	Make - SELEC	Amb.– 250 °C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/01A	Make - SELEC	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/02	Make - YUDIAN	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/02A	Make - UDIAN	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/03	Make - SELEC	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/03A	Make - SELEC	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/04	Make - UDIAN	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/04A	Make - UDIAN	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/05	Make - SELEC	Amb.– 250°C L.C. 1 °C

Temperature Controller with Sensors 12 channel	TCR/TCS/05A	Make - SELEC	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/06	Make - SELEC	Amb.– 250°C L.C. 1 °C
Temperature Controller with Sensors 12 channel	TCR/TCS/06A	Make - SELEC	Amb.– 250°C L.C. 1 °C
Pressure Gauges- Location: Corrosion lab	TCR/COR/PG/ 01	Make-A LOT Id. No.05230201	0 to 70 Kg/cm2 LC1Kg/cm2
Pressure Gauges- Location: Corrosion lab	TCR/COR/PG/ 02	Make-A LOT Id. No.05230200	0 to 70 Kg/cm2 LC 1Kg/cm2
Pressure Gauges- Location: Corrosion lab	TCR/COR/PG/ 03	Make-A LOT Id. No.05230203	0 to 70 Kg/cm2 LC 1Kg/cm2
Pressure Gauges- Location: Corrosion lab	TCR/COR/PG/ 04	Make-A LOT Id. No.05230206	0 to 70 Kg/cm2 LC 1Kg/cm2
Pressure Gauges- Location: Corrosion lab	TCR/COR/PG/ 05	Make-A LOT Id. No.05230202	0 to 70 Kg/cm2 LC 1Kg/cm2
Constant temp. Bath- Corrosion Lab	TCR/COR/TB/01	I THERM(Universal)	Amb. to 100 °C L.C. 0.1°C
Constant Water Bath- (5 Nos.) Corrosion Lab	W.B./01,02,03,04,05	UNIVESAL INST.	Amb. to 100 °C L.C. 0.1 °C
Temperature controller with sensor	TCR/COR/MOC/ 01,01A	Sr. No.-SELEC/TC303	Amb. to 1200°C L.C. 1 °C
Salt Spray Chamber- Corrosion Lab	TCR/COR/SSC/01	Kaleidoscope, KEW/SPTC-50/9 KEW/0126/2008 -09- sensor 1&2	0-60 °C LC 1 °C
Salt Spray Chamber- Corrosion Lab	TCR/COR/SSC/02	Kaleidoscope, KCS/SSC- 45 KCS/0219/15 - 16,Sensor 1&2	Amb. to 65°C L.C. 0.1 °C
Rota meter-Nitrogen	-----	Control/CD/CS/ABR/393 - 1/05-06	0.5 to 10pm, L.C.0.21pm
Rota meter-Oxygen	-----	Flow Point FP/ABR/1163/2021 -22	25 to 400 ml/min L.C. 12.5ml/min
Rota meter-H2S	-----	Control Devices/CD /ABR/A79/97 -98	20 to 200ml/min L.C.10 ml/min
Rota meter-Nitrogen	-----	Control/CD/CS/ABR/104 - 24/14-15	0 to 1000 ml/min L.C. 50ml/min
DIGITAL SURFACE PROFILE GUAGE For Pitting Depth Measurement	-----	Dial gauge set Make Mikronix Sr.No. 7161	0-12.7 mm
Proving Rings			

Proving Rings	TCR-PVR-32	Sr.No.97502	0-25kN
Proving Rings	TCR-PVR-33	Sr.No.97503	0-25kN
Proving Rings	TCR-PVR-34	Sr.No.97504	0-25kN
Proving Rings	TCR-PVR-35	Sr.No.97506	0-25kN
Proving Rings	TCR-PVR-36	Sr.No.97507	0-25kN
Proving Rings	TCR-PVR-37	Sr.No.97508	0-25kN
Proving Rings	TCR-PVR-38	Sr.No.13071	0-30kN
Proving Rings	TCR-PVR-39	Sr.No.13072	0-30kN
Proving Rings	TCR-PVR-40	Sr.No.13073	0-30kN
Proving Rings	TCR-PVR-41	Sr.No.13074	0-30kN
Proving Rings	TCR-PVR-42	Sr.No.13075	0-30kN
Proving Rings	TCR-PVR-43	Sr.No.13076	0-30kN
Proving Rings	TCR-PVR-44	Sr.No.4142	0-20kN
Proving Rings	TCR-PVR-45	Sr.No.4143	0-20kN
Proving Rings	TCR-PVR-46	Sr.No.4144	0-20kN
Proving Rings	TCR-PVR-47	Sr.No.4146	0-20kN
Proving Rings	TCR-PVR-48	Sr.No.4147	0-20kN
Proving Rings	TCR-PVR-49	Sr.No.4148	0-20kN
Proving Rings	TCR-PVR-50	Sr.No.5005	0-50kN
Proving Rings	TCR-PVR-51	Sr.No.5006	0-50kN
Proving Rings	TCR-PVR-52	Sr.No.5007	0-50kN
Proving Rings	TCR-PVR-53	Sr.No.5008	0-50kN
Proving Rings	TCR-PVR-54	Sr.No.5009	0-50kN
Proving Rings	TCR-PVR-55	Sr.No.5010	0-50kN
Proving Rings	TCR-PVR-56	Sr.No.5011	0-50kN
Proving Rings	TCR-PVR-57	Sr.No.5012	0-50kN
PH meter (Corrosion Lab)	TCR-PH-02	TOSHNIWAL,CL-54 , Sr. No. 7437	0-14 PH LC 0.01 PH
PH meter (Corrosion Lab)	TCR-PH-01	TOSHNIWAL, CL-54 , Sr. No. 7483	0-14 PH 0.01 PH
High Pressure vessel (Autoclave)		2T2-6175-327-0606 & 328	NA
Control Dynamics P H Meter		APX175 EICSr. No.-6794	NA
HIC Vessel		NA	NA
Hydrogen Sulphide Controller		NA	NA
HOT PLATE	TCR/HP/01	Make-Caltech,Sr. No 19529,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/02	Make-Caltech,Sr. No 19532,L.C-1 Deg.Cent	Amb. to 250°C

HOT PLATE	TCR/HP/03	Make-Caltech,Sr. No 19528,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/04	Make-Caltech,Sr. No 19530,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/05	Make-Caltech,Sr. No 19531,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/06	Make-Caltech,Sr. No 1121,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/07	Make-Caltech,Sr. No - 1124,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/08	Make-Caltech,Sr. No 1125,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/09	Make-Caltech,Sr. No 1122,L.C-1 Deg.Cent	Amb. to 250°C
HOT PLATE	TCR/HP/10	Make-Caltech,Sr. No 1123,L.C-1 Deg.Cent	Amb. to 250°C
Metallography			
Metallurgical Microscope with image analyzer-Location: Metallurgy Lab	TCR/MET/EQP/01	LECO 500-USA, 1989	Mag. 50X to 2000X
Stereo Microscope-Location: Metallurgy Lab	TCR/MET/EQP -03	Banbros Engineering Pvt Ltd.,- Model: BSZ-41T- 2008	10X-40X
Metallurgical Microscope with image analyzer-Location: Metallurgy Lab	TCR/MET/EQP/04	OLYMPUS GX 51F- Sr. No.- 3644093 Japan – 2013	Mag. 50X to 1000X
Electrolytic Polisher-Location: Metallurgy Lab	TCR/MET/EQP/05	Bainpol	NA
Micro Hardness Tester/Location: Metallurgy Lab	TCR/MET/EQP/06	Make :LECO USA M -400- H1Sr No-170765,1996-	50-1000 gms ±3%
Muffle furnace withrecorder (Heat Treatment) Location-Wet Chemical	TCR/MET/EQP/07	Make-Indeecon Model-Indee-MFSr.No.-MF/01/2019 -20 In Service-2020	Amb. to 1200 °C
Micro Hardness Tester/ Location: Metallurgy Lab	TCR/MET/EQP/08	Make- Banbros / Model : VH 1000BSr No-15009112 -2015/	10-1000gms ±3%
Grinder/ Polisher/Location: Metallurgy Lab	TCR/MET/EQP/09	MoPao 260	NA
Micro/Macro Etching Machine/Location: Metallurgy Lab	TCR/MET/EQP/10	Davecine Sound Corp/Sr. No. Gre29097/	NA
Air Dryer for Etching/ Location: Metallurgy Lab	TCR/MET/EQP/11	QMAT	NA
Automatic Mounting Machine /Location: Metallurgy Lab	TCR/MET/EQP/12	Bain mount-P Auto,METCO/	NA

Electrolytic etchingcell /With ammeter	TCR/MET/EQP/13	Marvel Electronic, Sr. No 091102-552/DPM -101/	0-19.99A/ Resolution- 0.01A
FerritoscopeMP30E-S	TCR/MET/EQP/14	Fischer Technology Inc./ MP30E-S/106-23060A/	0-86%
Adhesion Tester	TCR/MET/EQP/15	Deflsko Corporation/Positest AT-M , Sr. No.AT07972-	0-3000 PSI or 0-20Mpa
Digital Coating Thickness Gauge(DFT Meter)	TCR/MET/EQP/16	Defelsko / USA. /Model No.- PosiTector 6000-FNSProbe/ Probe sr. No.288985/ -	0-1500 Micron
Ferritoscope FMP30	TCR/MET/EQP/17	Fischer Technology Inc./ FMP30/ Sr. 100115480	0-88%
Stereo Digital Microscope- Location:Fatigue Lab	TCR/MET/EQP/18	Make-Dino-LiteSr.No.6285930	10X- 140x 5 MP resolution
Chemical-Instruments			
Optical Emission Spectrometer (OES)	TCR/INT/EQP/01	Make-Thermo Model-ARL QUANTRIS/Switzerland. /Sr. No. 15/ JUNE 2006	±1% of Concentration
Optical Emission Spectrometer (OES)	TCR/INT/EQP/02	Make Thermo fisher scientific/ARL 460/Switzerland Sr. No. 4948/ year 2012/	±1% of Concentration
Carbon Sulphur Analyser	TCR/INT/EQP/03	LECO/CS230/USA /Sr. No. 4930/Model No. 619 - 000-200/ APR 2009	C- 0.001- 4.50 ± 0.005 S- 0.0001-0.60 ±0.0005
UV Spectrophotometer	TCR/INT/EQP/08	Make: Chemito/Model 2100 Sr. 3370/1007/2007	NA
Atomic Absorption Spectrometer (AAS)	TCR/INT/EQP/09	Make -Thermo - Model- iCE-3300 Eqp.No. - 14836706 Sr. No.AA01172309/ March 2018	±1% of Concentration
Digital Weighing Balance/Corrosion Lab	TCR/INT/EQP/11	Make- Mettler/Model AJ150, /Sr. no. M97889/	150 gm. ±0.0001 gm.
Electrical Conductivity Meter	TCR/INT/EQP/12	Technofour/CM -979 Sr.No DCM 1043-2010	NA
Digital Weighing Balance/LECO	TCR/INT/EQP/13	Make- Mettler/Model ME204/A04/Sr.No. 2738491353/ 2018	220 gm ±0.0001 gm
Atomic Absorption Spectrometer (AAS)	TCR/INT/EQP/14	LABINDIA-AA 8000/Sr.No. AA 23240201/230 VAC/ 50 - 60Hz	±1% of Concentration
ICP-THERMO	TCR/INT/EQP/15	MODEL-Thermo Fisher Scientific-ICAP PRO DUO, Sr. No. ICAPPRO12704	±1% of Concentration
Chemical -WET			
Oven (Wet Analysis)	TCR/WET/EQP/06	Make EXPO	Amb to 110°C, L.C.5°C
Oven (Wet Analysis)	TCR/WET/EQP/07	Make- HOSP, Sr. No.901115	Amb. to 250°C L.C.10°C
Muffle furnace/Wet Chemical	TCR/WET/EQP/08	Bio-Technics India/ ModelBTT36 Sr. No. 74419	Amb. to 1000°C L.C.1°C

Muffle furnace/Wet Chemical	TCR/WET/EQP/09	Marvel Electronics/SE-200	Amb. to 1200°C L.C.1°C
Electrolytic AnalyzerWith Analog Ammeter & Voltmeter(Wet Lab)	TCR/WET/EQP/11	TCR/AM/01/TCR/VM/01/	10A/15 V ±1% FSD
Electrolytic Analyzerwith Analog Ammeter & Voltmeter (Wet Lab)	TCR/WET/EQP/16	Make Toshniwal- Model-E30- TCR/AM/03, TCR/VM/03	0-12 ADC, 0-12 VDC, ±0.3ADC/VDC
Digital Weighting Balance (Wet Lab)	TCR/WET/EQP/17	Make- Shimadzu /ATX224R, Sr.No. D326005241	0.1g to 220g LC 0.0001g
Glass Thermometer	TCR/WET/TM/ GHZL/3	Make-G H ZEAL LTD	-10 to 360°C
Glass Thermometer	TCR/WET/TM/ JRM/10	Make-JRM Sr No. T 09036	-10 to 360°C
Portable Instruments			
XRF PMI Analyser	TCR/PMI/01	Innov-X system USA- DC-2000/Sr. NO 560099 /2011	±10 %
XRF PMI Analyser	TCR/PMI/02	Niton XL2 800 Sr. No : 113195/USA/2020	±10 %
XRF PMI Analyser	TCR/PMI/04	Niton XL2 800 Sr. No : 91602/USA/2015	±10 %
ARC-MET 8000 Mobile OES analyzer	TCR/ARC/02	Make Oxford Instrument USA Sr.No 8004412005	±10 %
PMI Master Smart Mobile OES analyzer	TCR/ARC/03 Key-LPPT-XLSU-VTLR- LZUS	Make-Hitachi Model-PMI Master Smart Sr. No. 57Y0090, Feb 2021	±10 %
Surface Roughness Tester	-----	Make Mitutyo, Mode - SJ210 Sr.No 505381706	0-10 Micron
Magnetic Permeability Meter		Ferromaster Sr. no.- 899.2016	1.01 to 1.99 FN
Portable HardnessTester with block	TCR/HT/003	Make MitechInc Ltd Model MH310, Sr No. HL0112033115	600 BHN Max
Portable UCI-Hardness Tester	TCR/UCI/001	Make- Mash Project Model-TKM-459CE Russia Sr.No. 21025	90-450 HB 20-70 HRC 240-940 HV
NDT			
Ultrasonic Flaw-Detector	TCR/NDT/02	Modsonic Instrument Da Vinci Delta Sr. No. D0335-3316/2016	5mm-5m (± 5% FS)
FMPI-Yoke	TCR/NDT/03	East west eng. Sr. No3E/MEY-2/J13/2020	AC – 4.5 kg DC – 18 kg
MPI-Yoke	TCR/NDT/04	East west eng. Sr. No3E/MEY-2/J14/2020	AC – 4.5 kg DC – 18 kg
Radiation Survey Meter	TCR/NDT/05	East west eng. Radax SM-5000, 3E/SM5000/C - 010/2015	0-5000mR (± 20 %)
Radiation Survey Meter	TCR/NDT/06	East west eng. Radax SM-003E/SM5000/E14 2015	0-5000mR (± 20 %)

Radiation Survey Meter	TCR/NDT/08	EECI EECI RAD-5S/AD134LP, 2016	0.1-5R/hr (± 15 %)
Radiation Survey Meter	TCR/NDT/09	EECI EECI RAD-5S/ AD133LP 2016	0.1-5R/hr (± 15 %)
Digital Gauss Meter	TCR/NDT/10	ESC-18B, 2014/17/2 2014	1 gauss to 20,000 gauss
Ultrasonic Thickness gauge	TCR/NDT/12	Modsonic Edison-1 Sr. No. 6867-9130, 2019	1-200mm L.C -0.1mm
Optical Densitometer	TCR/NDT/13	OPTEL TRANS 4V J3588, 2015	0.2- 4D
Optical Densitometer	TCR/NDT/14	OPTEL TRANS 4V J3589, 2015	0.2- 4D
Optical Densitometer	TCR/NDT/15	OPTEL TRANS 4V J3420, 2014	0.2- 4D
Radiation Pocket Dosimeter	TCR/NDT/16	Arrow Tech OH303542-2018	0-500m (+/ -10%)
Radiation Pocket Dosimeter	TCR/NDT/17	Arrow Tech MA254526-2018	0-500m (+/ -10%)
Temperature and humidity meters, NDT Lab	TCR/NDT/18	Make- ABS,Model- HTC-1	Temp.10°-50°c & 99% RH Accu.= ± 1°c & ± 5 % RH
Digital UV Meter	TCR/NDT/19	U V-340A Sr. No. – Q965960 2014	o-1,99,990 µw/cm2
Digital Lux Meter	TCR/NDT/20	Lutron –Lx-101A Sr.No.-T026226, 2014	0-50,000 LUX
X ray Tube	TCR/NDT/21	Dang-dong XXQ-2505 /80674 2014	250Kv/5mA
X ray Control Panel	TCR/NDT/22	Dang-dong XXQ-2505 /80674 2014	250Kv/5mA
X ray Tube	TCR/NDT/23	Dang-dong XXQ-2505 /2329 2015	250Kv/5mA
X ray Control Panel	TCR/NDT/24	Dang-dong XXQ-2505 /2329 2015	250Kv/5mA
Radiography Camera	TCR/NDT/25	Sentinel Delta (880) D-11465	150 Ci
MPI Coil/Prod Machine	TCR/NDT/26	Model-AD1500 P Sr.No.03/12	AC – 1000Amp. DC – 1500Amp.
Stabilizer	TCR/NDT/27	East West Eng & Elec./maxi flux, 2014	300 Volts
Film Viewer	TCR/NDT/28	Online System07-2013-0702 2015	300 Volts
Film Viewer	TCR/NDT/29	East West Eng &Elec LH-25(LED), 2014	150 Ci
Radiography Camera	TCR/NDT/30	Sentinel Delta (880) D-14148, 2018	150 Ci
Radiography Camera	TCR/NDT/31	Sentinel Delta (880) D-14150, 2018	250Kv/5mA
X ray Control Panel	TCR/NDT/32	Dang-dong XXQ-2505 / T-70635, 2018	250Kv/5mA
Optical Densitometer	TCR/NDT/34	East West Eng & Elec3E/CD-1/H-34, 2018	0.2- 4D
Optical Densitometer	TCR/NDT/35	East West Eng & Elec3E/CD-1/H-35, 2019	0.2- 4D

X ray Tube	TCR/NDT/36	Dang-dong XXQ-2505/80438, 2019	200Kv/ 5mA
X ray Control Panel	TCR/NDT/37	Dang-dong XXQ-2505/80438 2019	200Kv/ 5mA
X ray Tube	TCR/NDT/38	Dang-dong XXQ-3005/6/1501 2019	300Kv/ 5mA
X ray Control Panel	TCR/NDT/39	Dang-dong XXQ-3005/6/1501 2019	300Kv/ 5mA
Crawler M/C X ray Tube, Pilot	TCR/NDT/40	Liaoning Instruments, China XXH-1605, Sr.No.100612 2019	12" Dia to 22" Dia Pipeline 160 Kv (tube)
Ultrasonic Flaw-Detector	TCR/NDT/41	Modsonic Instrument- Arjun30 Sr.no. AJO484-9150 2019	5mm-5m (± 5% HL±5% VL)
Optical Densitometer	TCR/NDT/42	East West Eng & Elec 3E/CD-1/J-19 - 2019	0.2- 4D
Radiation Survey Meter	TCR/NDT/43	East west eng.Radax SM -5000 Sr. No. 3E/SM5000/J - 00017 2019	0-5000mR (± 20 % FAS)
Radiation Pocket Dosimeter	TCR/NDT/44	Arrow Tech RK336434, 2019	0-200mR (+/ -10%)
X ray Tube & Control Panel	TCR/NDT/45	ICM-Belgium3006-OAC-1/0802497-03 - 2019	300Kv/ 5mA
X ray Tube & Control Panel	TCR/NDT/46	Dang-dong/90683 2019	250Kv/ 5mA
X ray Tube & Control Panel	TCR/NDT/47	Dang-dong XXQ-2005/K80439 - 2019	200Kv/ 5mA
Radiography Camera	TCR/NDT/48	Sentinel Delta (880) D-16176/ 2019	150 Ci
Optical Densitometer	TCR/NDT/49	East West Eng & Elec3E/CD-1/J41-2019	0.2- 4D
Optical Densitometer	TCR/NDT/50	East West Eng & Elec3E/CD-1/J42-2019	0.2- 4D
Radiation Survey Meter	TCR/NDT/51	EECIRAD 5S AD565LS- 2019	0-2500mR (± 15 % FS)
Radiation Survey Meter	TCR/NDT/52	SM-5000-Radax3E/SM-5000/ J-00027-2019	0-5000mR (± 20 % FS)
Radiation Pocket Dosimeter	TCR/NDT/53	Arrow Tech SF-342206/ 2019	0-200mR (+/ -10%)
Radiation Pocket Dosimeter	TCR/NDT/54	Eastwest/Arrow Tech SF-342207/2019	0-200mR (+/ -10%)
Radiation Pocket Dosimeter	TCR/NDT/55	Eastwest/ Arrow Tech SF-342208/ 2019	0-200mR (+/ -10%)
Radiation Pocket Dosimeter	TCR/NDT/56	Eastwest/ Arrow Tech SF-342209/2019	0-200mR (+/ -10%)
Crawler M/C X ray Tube, Pilot Battery	TCR/NDT/57	CMC - China Sr.No.1909052	16" Dia to 45" Dia Pipeline 250 Kv(tube)
X ray Tube & Control Panel	TCR/NDT/58	Dang-dong Sr.no.90132	300Kv/ 5mA
Area Zone Monitor	TCR/NDT/59	Model ZM -100 Sr.No.3E/ZM - 100/J-31	0-5000MR
X ray Tube &	TCR/NDT/60	Dang-dong Sr.no.90133	300Kv/5mA

Control Panel			
Crawler M/C X ray Tube, Pilot battery	TCR/NDT/61	Check o Fab CMS/00601/2020	16" Dia to 45" Dia Pipeline 200Kv (tube)
Digital Gauss Meter	TCR/NDT/62	D20B / Sr.No.361/2K22 - 2K33/03	3250 Gauss (+/ - 1.0%)
Residual Field Meter	TCR/NDT/63	RM200D/sr.no.171/2K23 - 2K24/09	200 Gause (+/ -1.0%)
Machine Shop			
Drilling Machine	TCR/MC/01	SKI/ Sr. No 12481	13mm
Lathe Machine -1	TCR/MC/02	Gujarat Lathe Machine / Panther/	-
Lathe Machine-2	TCR/MC/03	Rajesh Trading Co. /	-
Bend Grinding & Polishing Machine-Spectro	TCR/MC/04	Asia Engg. Co.	
Milling Machine	TCR/MC/05	Rajesh Trading Co.	
Surface Grinding Machine	TCR/MC/06	Parrot / Quality Machine Tools/	
Shaping Machine-1	TCR/MC/07	Sagar Sales Co.	24" Grade 1
Shaping Machine-2	TCR/MC/08	Sagar Sales Co. Sr.No. 841	24" Grade 1
Hydraulic Power Cutting Machine	TCR/MC/09	INDO TECH Make	16"
Hydraulic Power Cutting Machine	TCR/MC/10	Swing Cut -	12"
Gander Cold Cutting Machine/Wheel	TCR/MC/11		-
Power Hacksaw Cutting Machine-2	TCR/MC/12	JEW	
Power Hacksaw Cutting Machine -1	TCR/MC/13	JEW	-
Bandsaw Machine-1 (TMT)	TCR/MC/14	Warrier-	-
Welding Machine-1	TCR/MC/15	Make Premier Model MMA400D -	
Welding Machine-2	TCR/MC/16	Make Earth SANC ARC-	
Air Compressor	TCR/MC/17	Horizon Make, TSO5	
Drilling Machine – Pillar Type	TCR/MC/18	Satya Prakash Machine Com.	
Spectro Polishing machine-2	TCR/MC/19	Make Unimol-	
Drilling Machine		SKI/ Sr. No 12481 TCR/MC/01	13mm
Lathe Machine -1		Gujarat Lathe Machine / Panther/ TCR/MC/02	-
Lathe Machine-2		Rajesh Trading Co. / TCR/MC/03	-

Bend Grinding & Polishing Machine-Spectro		Asia Engg. Co. TCR/MC/04	
Milling Machine		Rajesh Trading Co. TCR/MC/05	
Surface Grinding Machine		Parrot / Quality Machine Tools/ TCR/MC/06	
Shaping Machine-1		Sagar Sales Co. TCR/MC/07	24" Grade 1
Shaping Machine-2		Sagar Sales Co. Sr.No. 841 TCR/MC/08	24" Grade 1
Hydraulic Power Cutting Machine		INDO TECH Make TCR/MC/09	16"
Hydraulic Power Cutting Machine		Swing Cut - TCR/MC/10	12"
Gander Cold Cutting Machine/Wheel		TCR/MC/11	-
Bandsaw Machine-1 (TMT)		Warrier- TCR/MC/14	-
Power Hacksaw Cutting Machine-2		JEW /TCR/MC/12	16"
Power Hacksaw Cutting Machine-1		JEW /TCR/MC/13	22"
Welding Machine-1		Make Premier Model MMA400D -TCR/MC/15	
Welding Machine-2		Make Earth SANC ARC-TCR/MC/16	
Air Compressor		Horizon Make, TSO5 TCR/MC/17	
Drilling Machine – Pillar Type		Satya Prakash Machine Com. TCR/MC/18	
Spectro Polishing machine-2	TCR/MC/20	Make Unimol	

TCR Health, Safety And Environmental Policy

TCR upholds rigorous Health, Safety, and Environment (HSE) standards, grounded in comprehensive risk assessments and ongoing training. With a zero-tolerance stance on HSE compliance, TCR has maintained an exemplary safety record since its founding, with no major lost-time incidents related to health, safety, or environmental concerns. TCR's proactive, risk-aversion approach has established it as the safest chain of commercial laboratories in the region. By setting high standards, TCR ensures all managers actively engage in safeguarding every stakeholder—clients, visitors, contractors, and the public alike—on company premises.

Safety measures are diligently maintained, including:

- Fire alarm systems and extinguisher maintenance
- H2S safety protocols
- Training documentation
- Injury records
- Control measures for flammable substances and acids

This thorough approach underscores TCR's commitment to safety excellence at every level of operation. TCR is committed to conducting its activities as per 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 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 have 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 disposals 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 areas 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

MSME and Company Data

TCR Engineering Services Pvt. Ltd. is registered in the "**Medium**" Category of the MSME declaration under the MSMED Act, 2006.

Udyam Registration Number: UDYAM-MH-33-0006262

GST: 27AAACT1966D1ZG (Mumbai)

GST: 21AAACT1966D1ZS (Odisha)

SAC / HSN : 998346

ARN: AA270617006549X

CIN: U28920MH1973PTC016780

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