European Technology Development

Providing Power & Process Plant Full Inspection & Integrity Assessment Services Worldwide

Plant Services
Brochure 2026

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Introduction

About us

ETD Ltd is a UK-based technical consultancy company established in 1998. We are a leading provider of independent services, innovative products and high-quality training for the power and process industries worldwide. We specialize in the inspection and condition/life assessment of power and process plants and structures.

Why choose our plant services?

Trusted – Over a quarter of a century consulting for power and process plants, with repeat customers worldwide.

Full support – Our comprehensive service is designed to provide clients with full support pre- and during outage and maintenance periods.

Research and development - Our continuous engagement in R&D projects in collaboration with international industrial partners allows us to provide our clients with cutting-edge tools and methodologies for inspection, repair, and monitoring.

Thought leadership in *non-destructive testing*, *condition and life assessment*.
Our experts combine experience from multiple disciplines including mechanical engineering, material engineering, metallurgy, maintenance, plant operation, inspection, and management.

Some of Our clients

We have an international client base ranging from single plant operators to national and international utilities, as well as other organisations within industry. An example of our present clients and collaborators is shown below.

Service Overview

Our comprehensive service is designed to provide clients with full support during outage and maintenance (O&M) periods.

Pre-outage planning and management:

- Analysis of historical inspection, operations, maintenance data, reports and plant drawings.
- Tailored risk-based inspection (RBI) plan identifying the critical tests for your plant.

Inspection management and operations:

- Provision and co-ordination of bespoke inspection team.
- (You provide on-site safety orientation.)

Provision of on-site services:

- Conventional NDT/NDE services.
- Innovative tools for inspection, monitoring and repair.

Post-outage analysis services and reporting:

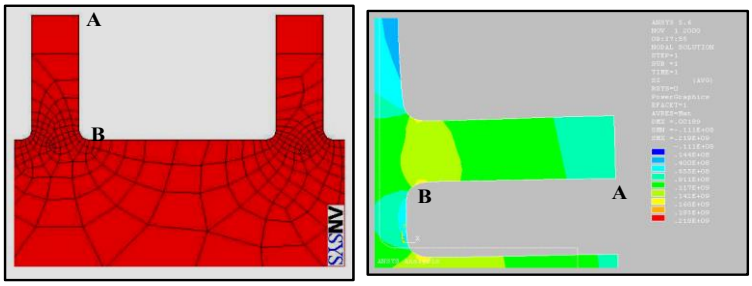
- Deterministic & probabilistic Remaining Life Assessment (RLA).
- Plant condition assessment.
- Failure and metallurgical analysis.
- Weld repair advice.
- Advice with water chemistry issues.
- Stress analysis including FEA (Finite Element Analysis).
- Fitness for service (FFS) assessment.
- Advanced reliability centered maintenance (RCM) planning for future outages.

NDT Services

Service list

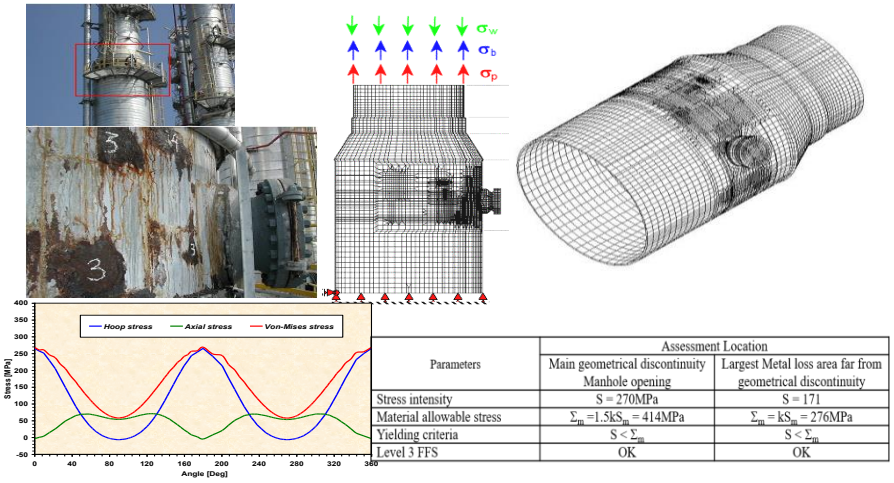
- Hot and Cold walk-down, visual inspection incl. hangers and supports.
- Laser mapping incl. piping systems and turbine rotors.
- Metallographic replication.
- Magnetic particle (MPI).
- Dye penetrant (DP).
- Boroscopy/Remote Visual (RVI).
- Rotational inspection (IRIS)
- P91 & P92 component inspection, quality checks & fast scanning for vulnerable aberrant microstructure.
- Ultrasonic testing (UT) incl. wall thickness and oxide thickness measurement.
- Phased array ultrasonic testing (PAUT).
- Remote field eddy current testing (RFET).
- Pulsed eddy current (PEC).
- Low frequency & balanced field electromagnetic testing (LFET/BFET) for fast scanning of boiler tubes for thinning & cracking.
- 'Boat' sampling and ultra-miniature specimen testing for creep, fatigue, fracture toughness, Charpy etc. for accurate component life assessment.

Examples of Various ETD Services



FE Stress Analysis *of a mono-bloc LP turbine rotor subjected to centrifugal load, bending moment & steam pressure.*

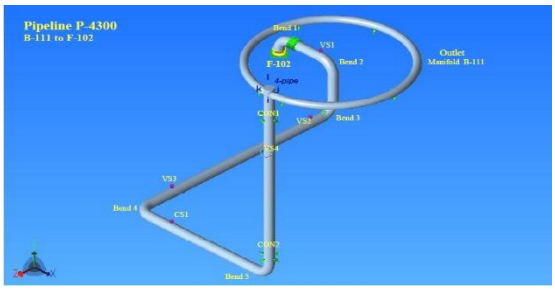
Left to right: LP turbine rotor - Detail of the mesh; Hoop stress distribution in the stage 1 region.

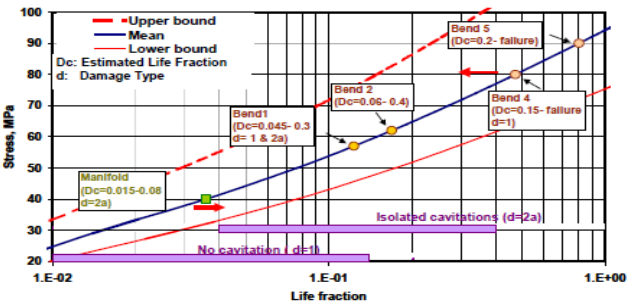


Parameters	Assessment Location	
	Main geometrical discontinuity Manhole opening	Largest Metal loss area far from geometrical discontinuity
Stress intensity	S = 270MPa	S = 171
Material allowable stress	$\Sigma_m = 1.5kS_m = 414MPa$	$\Sigma_m = kS_m = 276MPa$
Yielding criteria	$S < \Sigma_m$	$S < \Sigma_m$
Level 3 FFS	OK	OK

Level-3 Fitness for-Service (FFS) assessment of a severely corroded deethaniser column.

Pipeline Stress Analysis using Caesar II





Location	Pipe position	Axial Stress (MPa)	Bending Stress (MPa)	Torsion Stress (MPa)	Hoop Stress (MPa)	Mises Stress (MPa)
F-105	Flange	0.0	0.0	0.0	0.0	0.0
	Finish	18.1	10.5	-9.5	36.6	38.4
BEND1	BEND1-Mid	18.0	18.6	-8.7	36.6	40.7
Pipe	Flange	17.7	15.5	-3.5	36.6	37.1
	Finish	17.7	13.1	3.5	36.6	36.3
BEND2	BEND2-Mid	17.5	28.9	1.7	36.6	43.4
Pipe	Start	17.3	7.9	5.2	36.6	35.3
	Finish	17.8	18.5	-5.2	36.6	38.9
BEND3	BEND3-Mid	17.4	26.9	10.1	36.6	45.2
Pipe	Start	16.9	14.5	9.8	36.6	39.7
	VS1	16.9	19.0	9.8	36.6	41.4
	Finish	16.9	23.6	-9.8	36.6	43.5
BEND4	BEND4-Mid	16.8	56.3	11.2	36.6	67.1
Pipe	Start	17.4	28.0	-5.8	36.6	43.7
	VS2	16.9	6.8	-5.8	36.6	35.4
	VS3	16.9	8.3	-5.8	36.6	35.7
	End	16.9	8.5	-5.8	36.6	35.7
BEND5	BEND5-Mid	16.9	33.6	-5.8	36.6	47.3
Pipe	Start	14.4	50.8	7.3	36.6	62.7
	End @ TEE1-i	14.4	50.8	-7.3	36.6	62.7
Tee1	TEE1-I	14.6	48.1	6.7	36.6	60.1
	TEE1-k	14.7	45.3	6.7	36.6	57.7
	TEE1-j	16.9	21.3	-0.2	36.6	39.2
Pipe	Start @ TEE1-k	14.7	45.3	6.7	36.6	57.7
	End @ TEE2-i	17.4	17.5	10.8	36.6	41.3
Tee2	TEE2-I	14.7	41.6	-2.0	36.6	53.7
	TEE2-k	14.8	68.1	-2.0	36.6	76.7
	TEE2-j	15.1	47.9	2.3	36.6	58.5

ETD's 'RISKFIT' Procedure for Inspection and Management of Power Plants

Risk Waterfall Model

Information details & assessment accuracy increases with the depth of the process.

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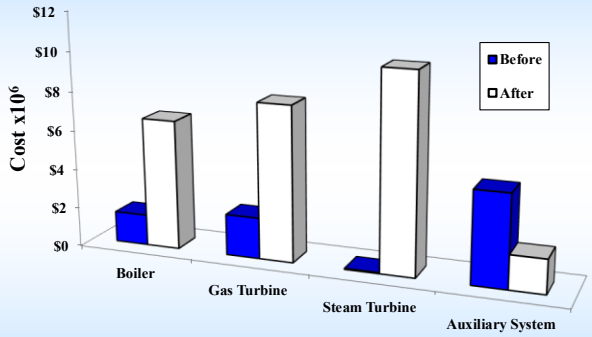
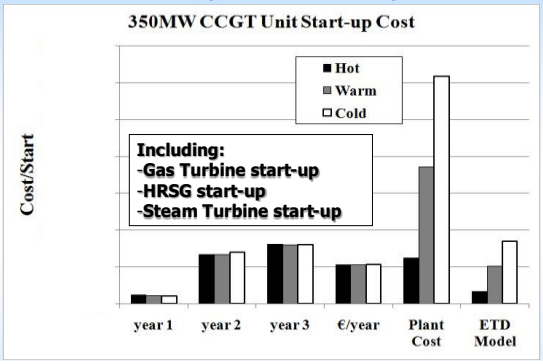
FLEXIBLE OPERATION of Power Plants – Technical & Cost Issues, and, BENCHMARKING for performance against the best base-load and cycling plants within the same utility and against ETD large database.

Impact of Cycling



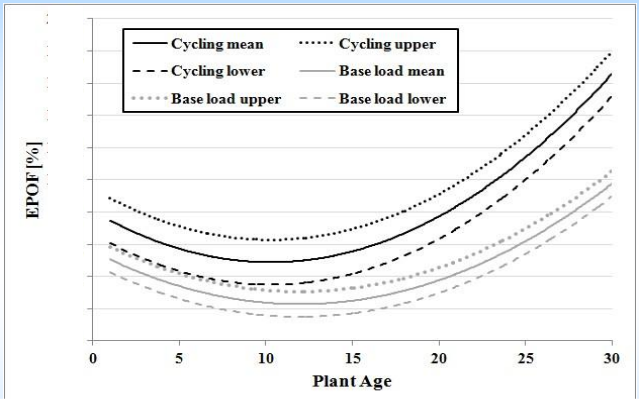
Cost of modifications before and after cycling including 20 CCGTs and CPPs.

Final Module (example)



Analysis including bidding cost, average cost, plant actual cost and ETD model

CCGT EPOF



Life cycle equivalent planned outage factor (EPOF) for CCGT plants operating in the baseload and cycling regime

BENCHMARKING:

Five Years average plant performance summary

Plant	Plant FOF	GT FOF	TAF
A	Low	Low	Low
B	Good	Acceptable	Acceptable
C	Good	Acceptable	Acceptable
D	Acceptable	Low	Acceptable
E	Good	Good	Acceptable
F	Low	Low	Acceptable
G	Good	Acceptable	Good
H	Low	Low	Acceptable
I	Good	Good	Good
J	Good	Low	Low
K	Low	Low	Low

FOF = Forced Outage Factor
TAF = Total Availability Factor

Innovative Inspection & Monitoring Tools

Our continuous engagement in R&D projects with international industrial partners allows us to provide our clients with advanced tools for monitoring, inspection, repair, and monitoring. Our innovative tools are available within our plant service an also available for purchase.

Laser Strain Gauge (LSG)

A reusable strain gauge for creep strain measurement during outages and safe life assessment of critical components.

This patented technology is useful for monitoring vulnerable components e.g. suspect welds and weld repaired components.

Benefits:

- ✓ Reusable
- ✓ Also used for laboratory specimen testing.
- ✓ Early warning of the onset of end-of-life creep failure processes.
- ✓ Enables timely run, repair, or replace decision-making.



Electrical Potential Drop (EPD) for Monitoring of critical and vulnerable

Continuous online monitoring of high temperature pipes and welds for creep damage and end of life warning.

A new contacting EM method that responds to changes in the electrical resistance (ACPD) or impedance (DCPD) in full-size metallic components. Conductivity changes due to advancing creep cavitation damage, even before crack growth, will result in a change in the EPD. This allows monitoring of critical components like weld repairs, to warn about imminent cracking and failure.

Benefits:

- ✓ Continuous online monitoring.
- ✓ Can detect subtle changes in microstructure e.g. grain size variation, creep cavitation, and even material loss through corrosion.
- ✓ Refined and tested version of the PD monitoring techniques widely used in crack growth monitoring. Shares principles with PD monitoring techniques widely used in mechanical property testing of metallic specimens.

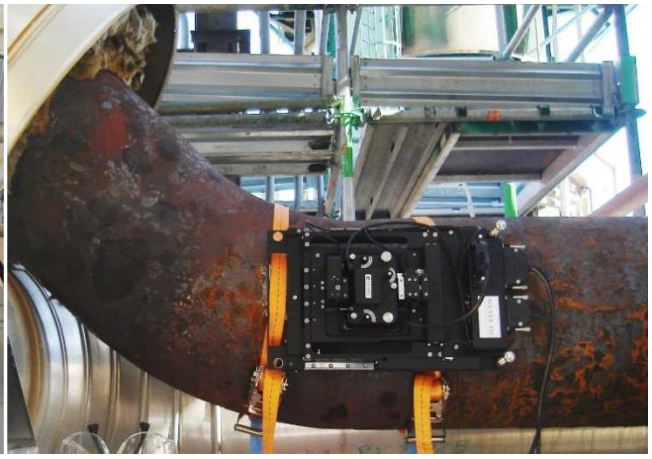
Experimental studies on full-sized P91 pressure vessels showed that EPD [1]*:*

- ✓ Provides 2-3 weeks warning of impending failure.
- ✓ Allows plant operation to be halted and components to be inspected/repaired/replaced before catastrophic failure.

***Commercial Offer**: The installation of this system at your plant to monitor vulnerable components (e.g. repaired welds, sites showing creep damage etc.) is now being offered by ETD. One equipment can be used to continuously monitor a number of locations.*

Reference:

[1] A. Wojcik, M. Waitt, A.S. Santos & A. Shibli, The use of the potential drop technique for creep damage monitoring and end of life warning for high temperature components, Materials at High Temperatures. 34 (2017). https://doi.org/10.1080/09603409.2017.1384611.


Scanning Force Microscope (SFM)

Portable atomic force microscope for high resolution imaging and microstructural analysis of metallic and non-metallic components on-site.

Effective tool for P91 and P92 component inspection where conventional techniques do not always show early-stage creep damage.

Benefits:

- ✓ Surface preparation equivalent to replication i.e. 1 µm polish and etch.
- ✓ Attaches to on-site components using straps and/or magnets.
- ✓ Spatial resolution comparable to scanning electron microscopy (SEM).
- ✓ 3D scanning provides topographical data e.g. surface roughness and cavity depth volume.
- ✓ The portable model of SFM can be used on-site, linked to a laptop, and instantaneously transmit images by internet.

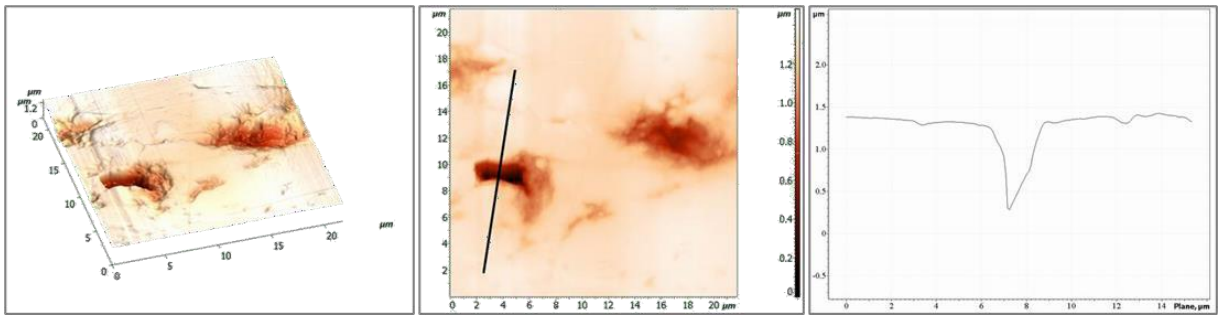


Figure 1. Example of 3D (left), 2D (middle) and 1D SFM data collected from a P91 sample containing creep cavities.

Boat Sampling

From left to right – A crack containing sample being cut out from a rotor between the two disks to determine cracking mechanism by investigating the crack tip; EDSE in action; Roud edge cavities left behind in a Tee-piece after cutting the boat samples.

Electrical Discharge Sampling Equipment (EDSE) for 'Boat' Sampling

On-site sampling for **quantitative life and condition assessment** of in-service components. Crack tip containing samples from cracked components can be removed to investigate the crack tip to determine the root cause of cracking mechanism.

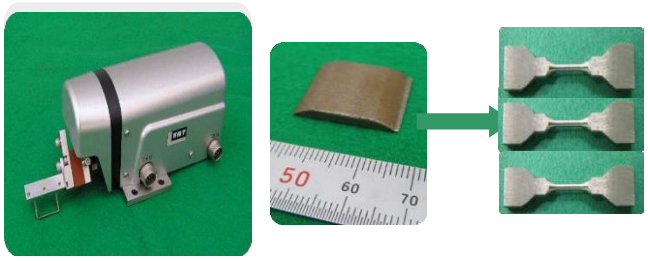
Uses a consumable electrode to cut out 'boat samples' of varying sizes and thicknesses (1 mm to ~20 mm) from high value thick section components via electric spark erosion. Water is used to remove debris and provide cooling. Straps or magnets can be used to mount the EDSE on components.

- ✓ Sampling thin pieces from surfaces of thick components.
- ✓ Unlike mechanical sampling, negligible or no damage (limited to a fraction of a grain size).
- ✓ Samples can be machined into a number of mechanical test-pieces (e.g., creep, fatigue, tensile, Charpy, compact tension (CT) to determine material properties and fitness-for-service. *See Figures on the next page.*
- ✓ Cutting electrode geometry ensures that the remaining cavity has rounded edges with 4 mm radius i.e. no stress concentration.

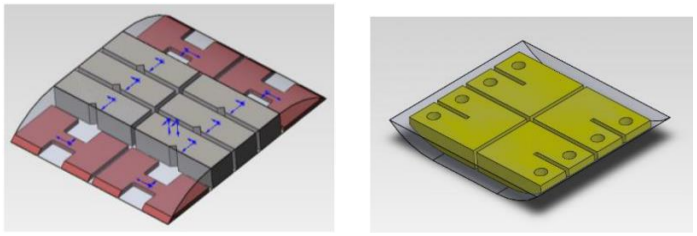
Details:

Sample thickness: ~1 to 20 mm
Sample sizes: 20 wide x 25 mm long, 40 x 40 mm, 40 x 120 mm
Cutting time: ~ 1.5 hrs for: 1 to 5 thick x 20 wide x 25 mm long

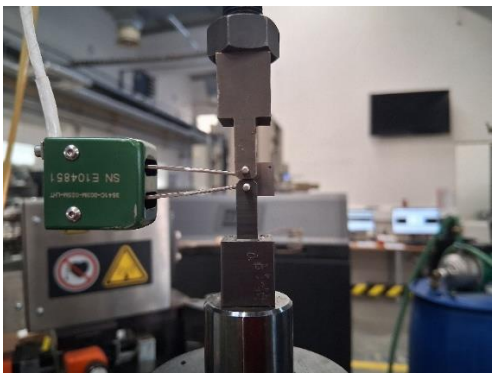
Machining & Testing of miniature tensile or ultra-miniature tensile, Charpy and Compact Tension Specimens taken out of a boat sample 1 to 5 mm thick



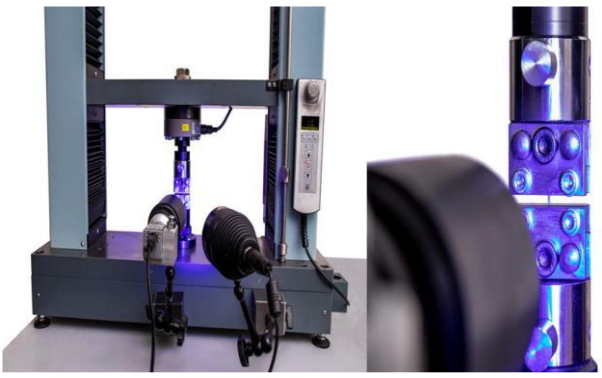
Left: EDSE head with 0.5 mm thick cutting electrode.
Middle: Boat sample, 1-5 thick x 20 wide x 25 mm long.
Right: Three miniature tensile specimens machined out of the boat sample.



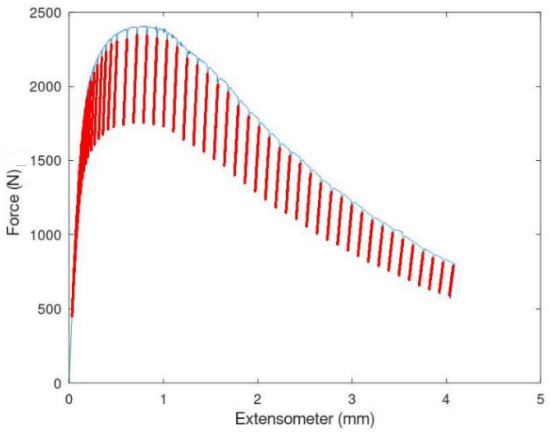
Ultra-miniature tensile, creep, fatigue, Charpy and compact tension specimens machined from 5mm thick 'boat' samples to determine pressure vessels, pipes, valves, rotors etc. temper embrittlement, fracture toughness or other such characteristics.



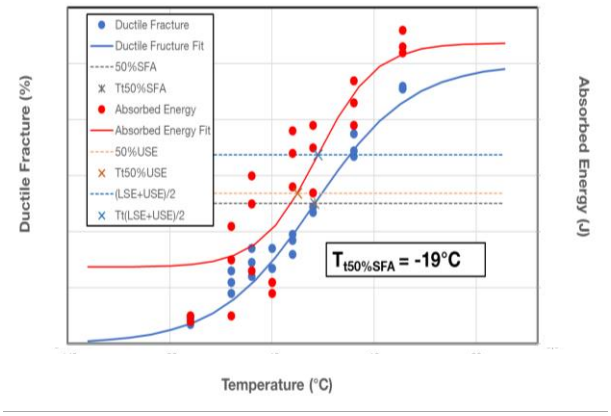
Photograph showing the test set-up for miniature CT J-R curve tests



Photograph of the miniature tensile test/DIC set-up



Loading sequence for a miniature CT test



Transition curves of absorbed energy (red) & % ductile fracture (blue) to determine $FATT_{50}$ temp.

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See later, case examples of:

a) Quality check of a newly supplied P91 steam valve,

b) Integrity assessment of an old rotor – 'boat' sampling and ultra-miniature specimen testing.

Smart Sleeve for Portable Hardness Testing

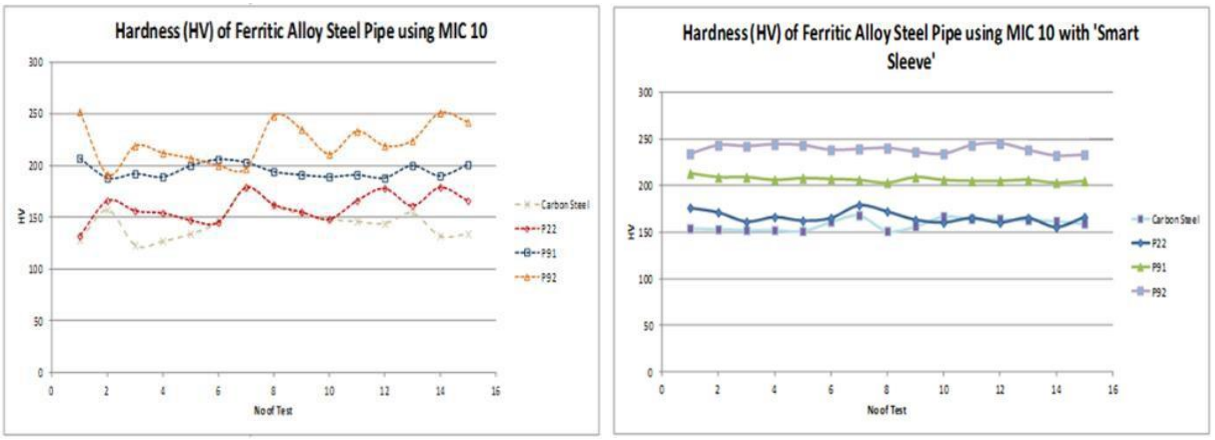
Portable hardness testing system for improving on-site data collection.

An electronic levelling system which can be attached to conventional portable hardness testers to ensure the perpendicularity of the indentor.

Benefits:

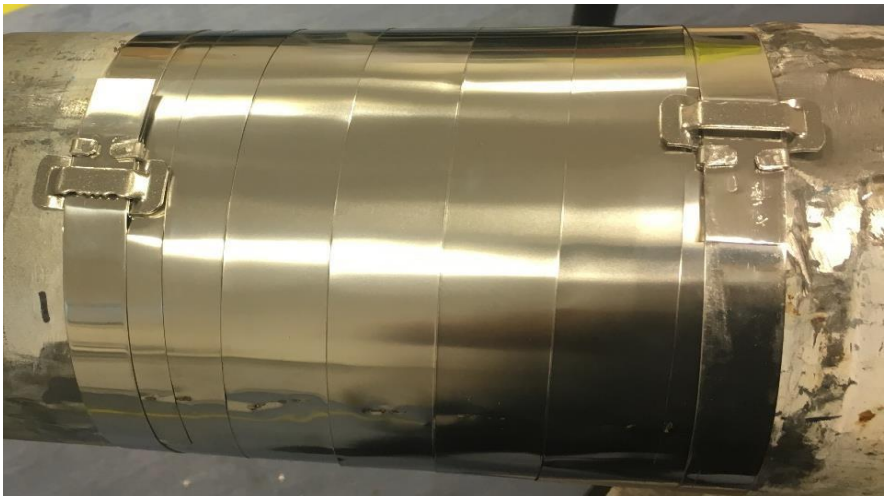
- ✓ Compatible with MIC10 and other portable hardness indentors.
- ✓ Reduced scatter from ± 20 VPN without Smart Sleeve to ± 2 VPN with Smart Sleeve.

Applications: Plates, tubes & pipes (diameter > 45 mm)



Hardness results using MIC 10 (left) and 'MIC 10 + Smart Sleeve' (right) for ferritic steel pipe alloys (Carbon, P22, P91 and P92 steels).

Repair



Obikou

Reinforcement for creep damaged or vulnerable pipes.

Thin (~ 0.1 mm thickness) stainless steel bandages provide enhanced creep strength in high temperature pipes.

Benefits:

- ✓ Simple stress analysis to determine the number of layers.
- ✓ Easy installation - straight pipes and pipe bends, seam welds and base metal.
- ✓ No limit to pipe size.

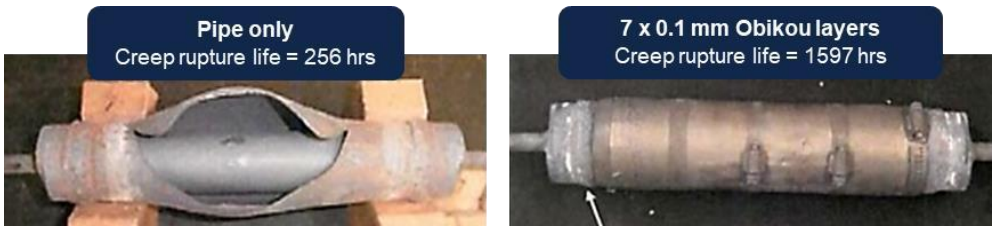


Figure 4. P22 pipes creep tested under internal pressure and high temperature with (left) and without (right) Obikou.

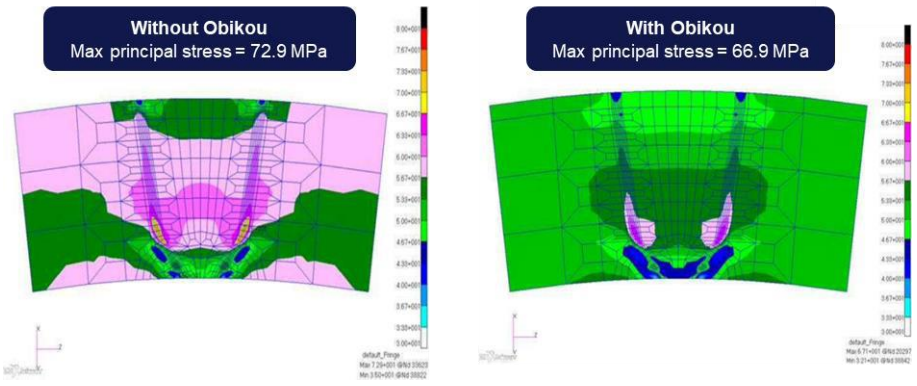


Figure 5. Simulation of max principal stress in P91 pipe after 100,000 hr. at 550 °C

Some of the Case Histories

Examples of recently completed projects and the plant services provided by ETD:

On-site Inspection and RLA of Boiler Pressure Parts

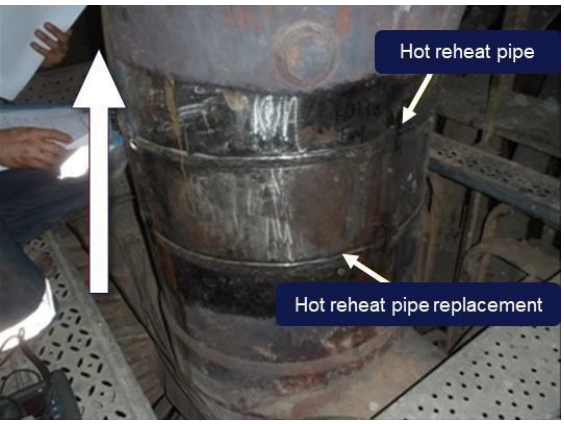
A Power Plant in the Far East contacted ETD to submit a proposal for on-site inspection, RLA and assessment of the tubes, T-piece nozzles, stub tube weldments and hot reheat pipe weldment for final superheater (FSOH) & reheater (ROH) components. The on-site inspection work involved:

Ultrasonic thickness measurements (UT) of tubes (wall thickness & bore oxide scale); EMAT (Electromagnetic Acoustic Transducer); replication, and, hardness measurements of selected locations.

The inspection data was then used to estimate effective tube metal temperature and identify material degradation which was used for damage assessment and predicting the remaining life of outlet headers and tubes of the FSOH & ROH.

Accelerated Creep Rupture Testing & Integrity/Life Assessment of an HP Steam Header

In a recent outage, damage (i.e. misalignment, bulging, graphitisation etc.) was observed on certain welds of an HP steam header. Six samples from the header material were removed for analysis to determine remaining life of the components. ETD performed accelerated creep testing to provide an estimate for the remaining life of the material. This was used to achieve the run/repair/replace decisions for this and other similar components in the plant. ETD analysed the creep test results and remaining life calculations using the Omega method. The full report to the client included photographic records from the metallographic study and provided details of the remaining life estimate based on stress rupture testing. Possible causes for concern were highlighted. Graphitisation of some of the microstructure was observed and this and other changes in the microstructure were studied and their effect on the component life determined.

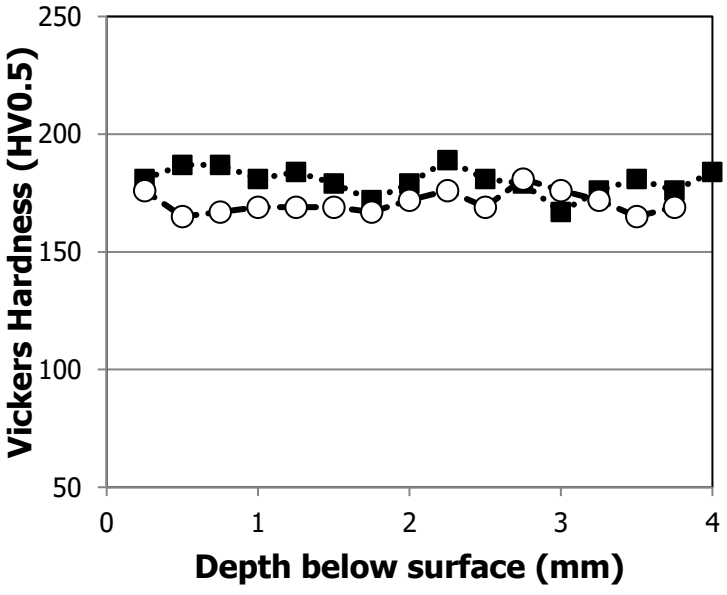


Quality Check of a newly supplied P91 Steam Valve using the EDSE boat sampler

A large P91 steam valve was supplied to a power plant in France. The valve showed a hardness of about 170 VPN, indicating that the material may not have fully martensitic microstructure and thus could be vulnerable to early cracking and failure. Clearly this was unacceptable to the client as the recommended hardness virgin P91 should about 200 VPN and not less than 190 VPN in any case.

The supplier however, turned around and argued that the surface hardness was low due to decarburization of the valve surface. Grinding and polishing still showed the low hardness of 170 VPN. The supplier then argued that in thick section components decarburization could be quite deep. The plant owner in France then approached ETD to cut out a 5 mm thick sample and investigate the material condition.

ETD examined a 5 mm boat sample and found that the material should a mixed martensitic and bainitic microstructure and the hardness remained low throughout the sample thickness, as shown in the Figures below. The plant owner then had a strong case to return the valve and demand a new properly heat-treated valve.



Mixed martensite-bainite microstructure
Left to right: Close to the valve surface, 2 mm and 4 mm below the valve surface.

Investigation of the root cause of cracking in an in-service rotor using the EDSE boat sampler

In addition to the usual NDE inspection of steam and gas turbine rotors, ETD has developed unique methodologies to inspect crack tips in rotors (as identified by UT inspection) by cutting out 'boat' samples, either from rotor outside surface or bore, that contain these crack-tips. These boat samples and their crack tips are then investigated to find out the root cause of cracking in order to avoid future cracking. Boat sampling is carried out by ETD using its portable spark erosion machines (called EDSE - Electrical Discharge Sampling Equipment - developed in collaboration with its Japanese partners CRIEPI and KMTL) and ETD's especially developed bespoke mounting frames to fit the difficult and narrow spaces between disks or inside the bore where cracking may have been found by UT inspection. Metallographic, tensile and other specimens can also be machined from these boat samples for further investigation, if required.

Integrity Assessment of an old rotor

EDSE has recently been used to cut out thin slices (boat samples) of exactly the same size from both the hot and cold ends of an old rotor which had seen service much beyond its design life. Ultra-miniature tensile, creep, fatigue, Charpy impact, compact tension (CT) and Small Punch (SP) specimens were machined out of the 5 mm thick boat samples to evaluate the rotor suitability and integrity for further service especially. A number of boat samples were cut out from 12, 3, 6 and 9 O'clock positions on the rotor such that the rotor balancing remains intact. FE analysis was used to ensure that boat samples have no adverse effect on the performance and integrity of the rotor.

Fatigue, Tensile, Charpy & Compact Test (CT) specimens machined out of the EDSE cut 5 mm thick slice/ boat sample (center). These tests determine Fatigue Endurance, Impact Strength and Fracture Toughness of the rotor and the potential of its continued use beyond design life.

Note: Where it may not be possible to cut out small slices (boat samples) from the rotors due to the geometrical features hindrance, boat samples may be cut out from the rotor disks, as shown below, if these are integral part of the rotor - again keeping the rotor balance intact.

An EDSE 'boat' sample being cut out from a rotor disk at the hot end of the rotor.

Renewables & Low- or No-Carbon Fuels

Auditing of New Towers and Blades being built for Wind Turbines in Egypt and China

To continue on a similar theme on renewable power, in Feb 2024 ETD conducted a wind turbine tower manufacturing process and facility audit in Egypt for a large 500-MWe WT on behalf of a European utility. ETD team carried out the manufacturing specifications, procedures, and quality records review as well as inspection of tower fabrication welding and related inspection and testing processes live at the time.

The above audit followed a similar wind turbine and turbine tower manufacturing process audit in several factory locations in China in 2023.

Low or No-Carbon Fuels for Power Generation

1) Thermal Power Plant Modifications in order to burn Low Carbon or Carbon Free Fuels

ETD has recently completed a project, for a group of Canadian and USA utilities, reviewing the use of **Hydrogen** and **Ammonia** for combustion in gas turbines and its effect on combustion, hot-gas path components and HRSGs. The projects also looked at hydrogen production, transport, storage and a mix-of hydrogen or ammonia with the natural gas for combustion. Cost of hydrogen on-site production and storage or transport was studied and compared. The damage to GT, HRSG, hydrogen storage and transportation materials was also reviewed.

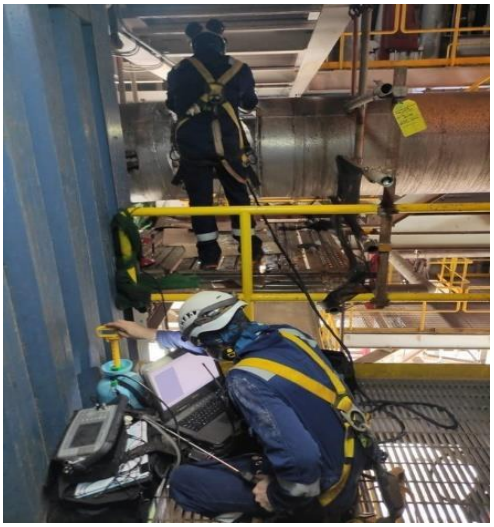
This project then led to another one year duration project studying worldwide development of all 'low or no carbon' fuels for use in the existing and new fossil power plants by 2030 and beyond. (see below).

2) Low Carbon or Carbon Free Fuels for the Next Decades

Following the above project ETD worked on another significant project for the same group of North American utilities to investigate a wide range of low- or no-carbon fuels that can be potentially used to decarbonize global economy, by reducing the emission of Green House Gases (GHG) that are generated during power generation. The study evaluated the feasibility and application of such fuels, as well as their production, transportation, storage, regulatory and health & safety handling requirements. These fuels included: *Renewable green hydrogen, Ammonia as a fuel, Pyrolysis (biomass), Gasification (biomass), Conversion of non-recyclable residual material, wood waste into advanced biofuels, Fermentation technology to capture CO-rich gases and convert the carbon to fuels, Production of renewable diesel using ethanol from waste streams, E-fuels (E-ammonia, E-ethanol, E-hydrogen, E-methanol), Bio -LNG, Renewable Compressed natural gas and other technologies such as; hydropower technology for pumped storage and back-up - Carbon capture and storage technology etc.*

ETD's NDT Experts

Our network of NDT and condition/life assessment specialists enables us to select the right team for our client's needs. The following section summarises our network's expertise in these areas (detailed CVs are available on request for more information).



Our NDT Inspection engineers are:

- ✓ Certified to industry standards incl. PCN (e.g. Level I, II, III), IVB, ASNT (e.g. Level II, III), ISO (e.g. 9712), ASME (e.g. ASME FFS-1, ASME B31G) API (e.g. API-579-1, API 1104), BS (e.g. BS7910).
- ✓ Use conventional NDT methods (incl VI, MPI, DP, UT, EM etc.) and our own advanced inspection tools.
- ✓ Operate worldwide, including UK, Australia, US, Europe (incl. Turkey, Latvia, Greece), Middle-East (incl. Oman, Saudi Arabia), Asia (incl. Pakistan, Philippines, Malaysia, Bangladesh, Hong Kong).
- ✓ Inspect numerous components, including pipes, turbines, rotors and welds (incl. new, repaired and in-service).
- ✓ Can provide metallurgical assessment, damage mechanism identification and weld repair advice.
- ✓ Experienced in; NDT project management and RBI advice; production and assessment of NDT methods and development of new NDT inspection systems.

ETD's Condition & Life Assessment Expertise & Experts

Our condition and life assessment specialists have over 20 years industry experience in:

Power & Process Plants
Flexible/Cyclic Operation
Cost analysis
Structural Engineering
Defect/crack assessment
Stress Analysis
CAESAR II, FEA
Asset Integrity Management
Risk & Reliability Engineering
Technical and Process Safety Management
Ageing Assets
Reliability Centred Maintenance (RCM)
Risk-Based Asset Integrity Management
Risk-Based Inspection (RBI)
Fitness for Service (FFS)

Materials Science & Metallurgy
Root cause analysis
Power and Process Plant materials
High Cr martensitic steels
P91, P92, MARBN
Welding
Material/Mechanical Property Testing
Material Selection
Materials and Corrosion Engineering
Corrosion Assessment & Management
Cathodic Protection
Coating Selection

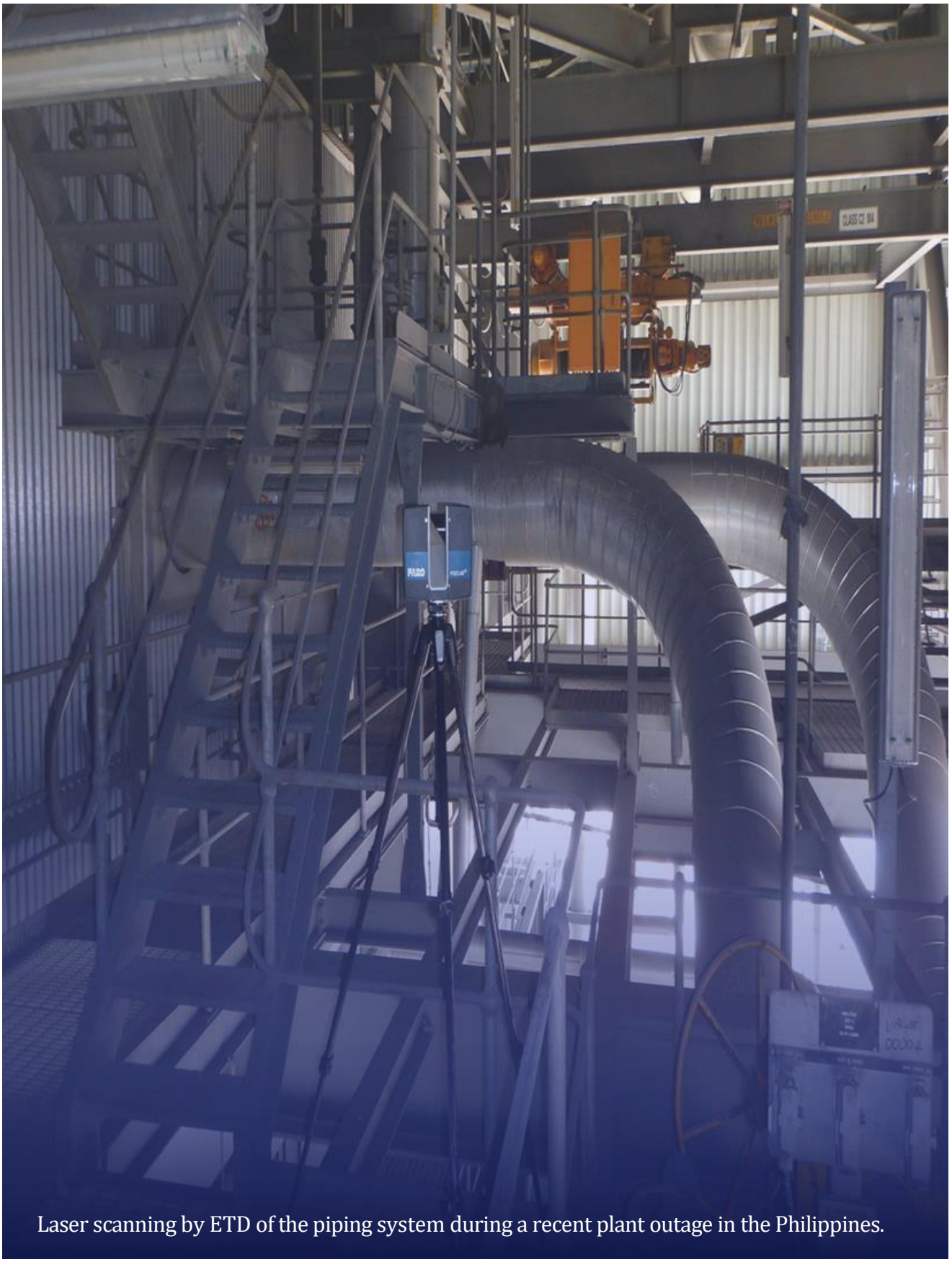
Oil and Gas
Project Engineering and Management
Onshore and Subsea Pipelines Design
Advice on Construction, Installation and Operations.
Facilities Inspection Maintenance and Repair
Financing and Management
Structural Engineering
Asset Integrity Management
Technical and Process Safety Management
Education, Training and Mentoring

Gas and Steam Turbines
Life-time Assessment
Combined Cycle Gas Turbines (CCGT)
Heat Recovery Steam Generators (HRSG)
Design Review, Development and Optimization
Design for manufacture,
Mechanical Integrity Assessment
Condition Based Monitoring
Methods & Software Development
Advanced Design & Simulation

Industries/Sectors: Power (Conventional, CCGT, HRSG); Cogeneration; Petrochemical and Refinery; Oil and Gas (Onshore, Offshore and Subsea).

Titles/Qualifications:

- PhD, MSc, BSc (incl. Metallurgy, Materials Engineering, Fracture & Fatigue, Welding)
- Chartered Engineers (incl. Engineering Council of UK and European Engineer).
- Professional institute members/fellows (incl. Pipeline Engineers, Welding Institute, Asset Management, Corrosion, Institute of Metals, Minerals and Mining, Energy Institute, Royal Society of Chemistry and Society of Underwater Technology).



Laser scanning by ETD of the piping system during a recent plant outage in the Philippines.

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