MINTON, TREHARNE & DAVIES GROUP

METALLURGY & MATERIALS SCIENCE

WWW.MINTON.GROUP

MINTON,TREHARNE
& DAVIES GROUP

METALLURGY & MATERIALS SCIENCE

MINTON,TREHARNE
& DAVIES GROUP

COMPANY OVERVIEW

THE MTD GROUP PROVIDES INDEPENDENT SCIENTIFIC CONSULTANCY, ANALYSIS, SURVEYING AND EXPERT WITNESS SERVICES TO A WORLDWIDE CLIENT BASE FROM OFFICES IN THE UK, EUROPE, USA AND ASIA.

MTD has been involved in the testing and investigation of materials for over 100 years. Throughout this time we have added to and improved our capabilities and expertise to meet the changing needs of our clients, industrial markets and developing technologies. Nowadays our metallurgists and material scientists are supported by in-house metallurgical, chemical and non destructive facilities; allowing us to conduct fully independent in-house investigations.

01

The facilities and capabilities of our laboratories are interwoven and complementary to the expert services of our consultants; enabling us to investigate and resolve diverse scientific issues. This winning combination has earned us an international reputation for superior and independent scientific expertise, providing support to industries across the globe.

Our laboratories are one of the most comprehensive, independent facilities in Europe; providing extensive analytical, testing and inspection services. We hold an unusually wide range of accreditations and approvals including UKAS (ISO 17025) and NADCAP, and are accredited Expert Witnesses under a number of schemes. All work is conducted in accordance with forensic standards.

The technical knowledge and experience of our expert consultants encompasses many industries and technologies, enabling us to offer practical, expert support in investigating failures, defects or quality issues in many types of materials. We regularly act as expert witnesses in court and arbitration both in the UK and around the world.

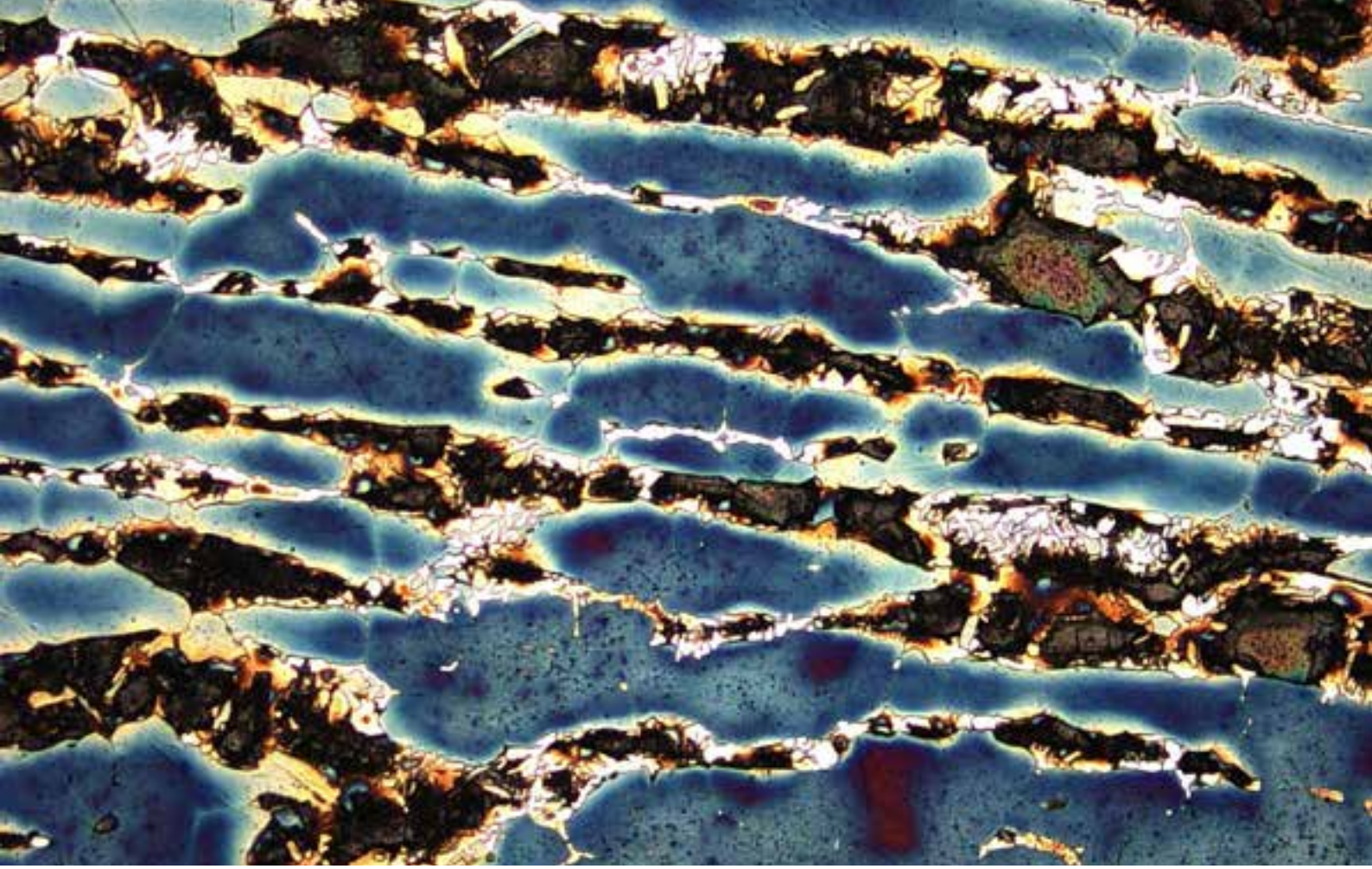
MINTON,TREHARNE
& DAVIES GROUP

DIVISIONAL OVERVIEW

OUR METALLURGY AND MATERIALS SCIENCE DEPARTMENT HAS TWO CORE, INTERWOVEN AND COMPLEMENTARY ACTIVITIES, THESE BEING CONSULTANCY AND TESTING

MTD supplies metallurgical and materials services to a wide variety of clients in the UK and around the world. These services are rooted in our materials and NDT laboratories where our technical staff have the facilities and experience to investigate and analyse the issues of importance to our clients. Our consultants provide expertise in root cause failure analysis and bring extensive industrial knowledge to bear in providing expert materials advice to all our clients.

02



All our consultant Metallurgists and Materials Scientists are both experienced experts and have first hand industrial experience of applying their technical skills to real world situations. Their backgrounds assist them in dealing with the practical constraints of real industrial situations, and their experience as experts enables them to construct and conduct investigations to rigorous forensic standards, enabling us to provide expert witness services in courts and arbitrations around the world.

Our consultants investigate and test materials with the assistance and skills of our Engineering Services Division which includes both an accredited metallurgical laboratory and comprehensive on-site non-destructive testing laboratory facilities.

Our staff in these departments are qualified in their disciplines and used to working alongside our consultants.

MTD have provided Metallurgy and Materials Science services to industry for many years, and our services have changed with the industries we support. Whilst we originally worked primarily with the heavy industries of South Wales in the 1950's we now provide a comprehensive, global service investigating the latest high technology materials in the aerospace and composite sectors, whilst retaining skills in the heavy industries that underlie large sections of the energy and mineral extraction sectors.

MINTON,TREHARNE
& DAVIES GROUP

METALLURGY CONSULTANCY

MTD WORK WITH MANY OF THE WORLD'S LARGEST HIGH TECHNOLOGY COMPANIES, SUCH AS ROLLS ROYCE, AIRBUS AND GE, IN VARIOUS INDUSTRY SECTORS INCLUDING AEROSPACE AND RENEWABLES.

This work often involves the very latest materials, new alloys and super-alloys in metals, super thin and super strength composites and more exotic products such as metal matrix composites.

We are involved from the earliest stages of prototyping, through manufacture up to installation and, once in service, specialist non destructive testing to confirm ongoing satisfactory operation.

03

The rigorous in-service and efficiency demands of modern industries has led to the requirement for specialist inspection and investigation when problems occur. MTD's metallurgists have been involved in many projects, providing solutions and advice around the world for many years.

METALLURGY

Our expert metallurgists, supported by our comprehensive in-house metallurgical laboratory facilities, regularly provide expert advice to companies across industry. With first hand experience of a wide variety of metals we provide support, advice and investigation services at all stages of product development and production; from design and protyping issues, through manufacture fabrication and into final service.

Our clients operate in a diverse range of industries serving the Energy, Aerospace, Defence, Marine, Power Generation, Chemical and Engineering sectors. Many metallurgical issues are common to all sectors, even across our diverse client base. We possess specialist knowledge and experience of sector specific issues, enabling us to support our customers.

NON DESTRUCTIVE TESTING

NDT is an important science in the assessment of metallic structures and frequently plays a critical role in many of our investigations. Our NDT department provides a comprehensive range of UKAS accredited on-site and laboratory testing facilities; which include ultrasonics, penetrants, magnetics, radiography, eddy currents and visual inspection.

MINTON,TREHARNE
& DAVIES GROUP

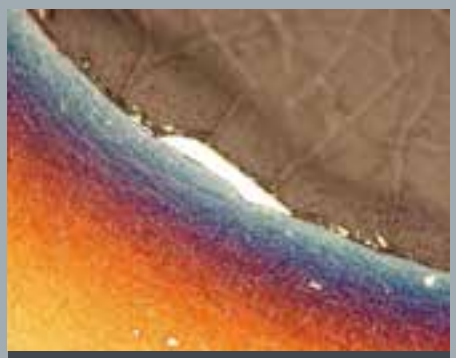
CASE STUDY 01
TURBINE BLADE DAMAGE

METALLURGY CONSULTANCY

MTD were asked to investigate damage to turbine blades within an engine booster; this damage was located after removal of the engine from service and static testing. Work commenced with an on-site inspection recording the location, nature and severity of the blade damages, taking samples of residues and using black (ultraviolet) light to check for evidence of bird strikes. In the laboratory we analysed the samples using a variety of techniques to ensure that we could cross reference our results so as to exclude secondary contamination since the incident.

Microscopic analysis located hard particles embedded in the damaged areas; metallurgical and chemical analysis confirmed these to be martensitic stainless steel, a material not used within the engine. Investigation of the jet engine testing site found that martensitic stainless steel was used in the test rig, and that a bolt was missing from the structure. The damage was therefore surmised to have occurred under test, and not in service.

The engine booster ready for inspection



Stainless steel smeared on blade edge

CASE STUDY 02
FLARE STACK CRACKING

METALLURGY CONSULTANCY

MTD were asked to investigate the metallic materials used in gas flares in offshore structures and determine the reason for their cracking.

The materials used in gas flares are highly specialised alloys, designed to resist the intense heat of flares, and the chemical residues resultant from burning gas. The cracking had resulted in gas leaking out and burning around the flare stacks, rather than above them.

Non destructive Inspection found widespread cracking in the flares, metallurgical inspection revealed that the internal metallic surfaces of the flares had undergone significant changes in service due to absorption of carbon.

It was determined that long term use of the flares with a low flow of gas had enabled burning in areas not designed for long term use, this had resulted in changes to the metal, embrittlement and cracking.

X-Ray image of a cracked flare stack

Surface changes and associated cracking

Gas burning around, not inside the flares

MINTON,TREHARNE
& DAVIES GROUP

MATERIALS CONSULTANCY

OVER THE YEARS MTD HAVE BEEN INVOLVED IN MANY CASES WHERE THE MATERIALS INVOLVED HAVE BEEN BEYOND THOSE ASSOCIATED WITH TRADITIONAL METALLURGY.

Materials Science covers a wide ranging variety of industries and applications. The demand for our services in this area involves both new materials and new industries, but also encompasses more tradional materials elements in the mining and coatings inductries. This varied demand has driven us to continually expand our expertise and laboratory facilities to enable us to offer comprehensive support and assistance to our clients.

04

EXTRACTIVE METALLURGY

In the mining sector MTD's work encompasses all stages of extractive metallurgy, from mine to metal. We deal with the producers, refiners and traders of ores, concentrates and finished product across the globe. We have first hand knowledge and experience of contamination, substitution, degradation and theft at all stages of the supply chain. The increasing global demand for raw materials of ever increasing variety has led to the development of new reserves often coupled with new and dedicated extractive technologies. MTD's experienced consultants are used to dealing with these ever changing industries.

COMPOSITE INSPECTION

The increasing use of complex composite materials and structures in the Aerospace, Energy and Marine industries, demands a unique approach to their inspection. Composites, by their nature, are inhomogeneous and require a wide range of NDT techniques including Laser Shearography, Thermography and Mechanical Impedance Analysis for defect detection. These techniques provide us with the capability of inspecting a vast range of composite structures, from super yachts to stealth aircraft, often with minimal contact and always without damage to the materials.

POLYMERS

MTD has experience of a wide range of polymers including thermoplastics, thermosets, resins and elastomers. These materials are common place in industry and society and are always evolving to meet the demands imposed upon them.

Understanding the many and varied properties of these materials is essential in making any correct materials selection. Our laboratory facilities provide many test methods to assess these types of materials. These, coupled with our consultants' expertise, enable us to assist and advise our clients in this diverse materials field.

MINTON,TREHARNE
& DAVIES GROUP

CASE STUDY 01
CONTAMINATION OF CONCENTRATE

MATERIALS CONSULTANCY

An international mining company was faced with a problem when several large export orders of gold and copper concentrate were tainted with foreign materials due to criminal activity. Whilst the concentrates were initially viewed as unsaleable, MTD were brought in to investigate. Site surveys in Africa and China determined that the contamination was discrete, not throughout the shipments. This was confirmed by laboratory analysis, which also provided evidence as to the nature of the contaminants. On the basis of this work a remediation strategy was developed to separate out the contaminants and recover the concentrate. MTD oversaw the setting up of a recovery operation in East Africa which successfully separated the contaminants and the original concentrate. This sorting operation proved so successful that the recovered concentrate was sold as normal, prime, quality material with no loss in value.

Contaminated concentrate

Contaminants removed from the concentrate

CASE STUDY 02
COMPOSITE MATERIAL DAMAGE

MATERIALS CONSULTANCY

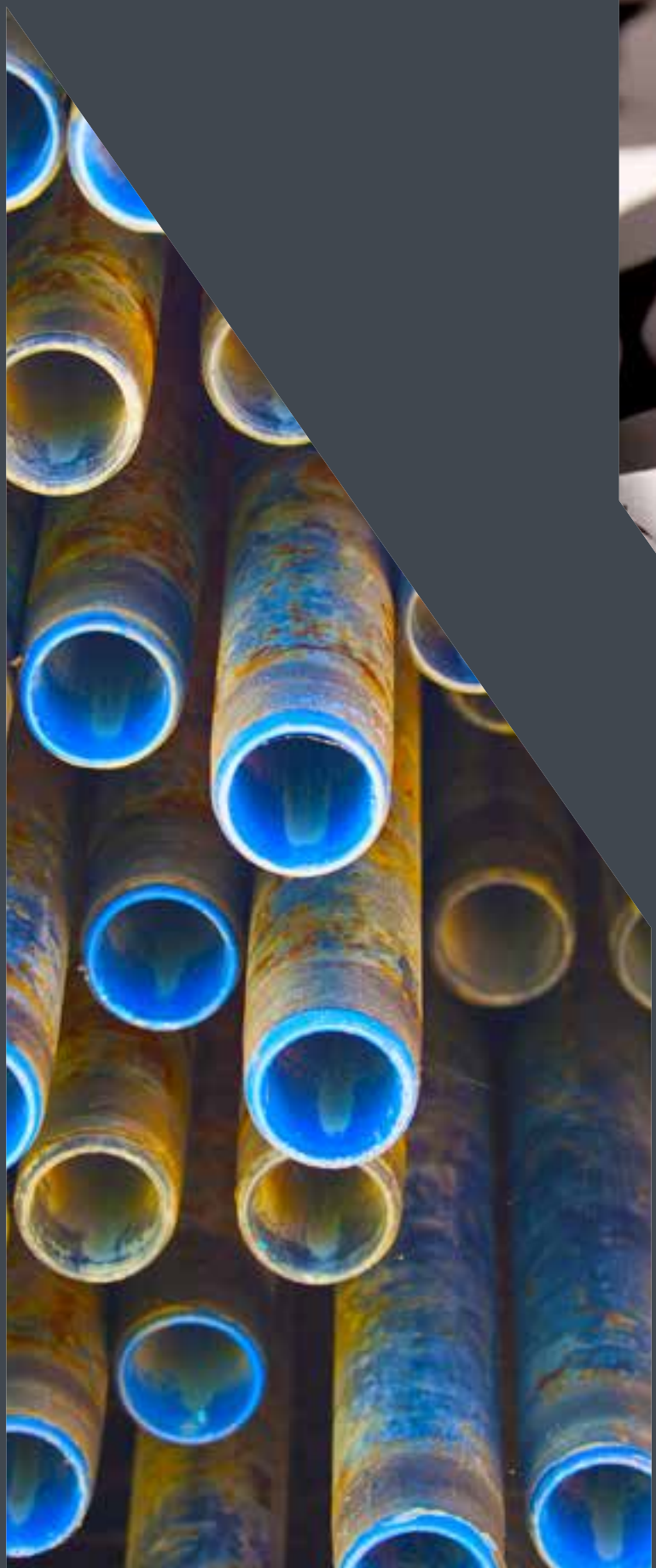
A chemical processing facility was exposed to the blast from an explosion at an adjacent premises. It was initially claimed that chemical processing equipment, manufactured from composite materials, had been damaged by the blast and was unserviceable. MTD conducted NDT inspection of composite materials on site and found some damages, albeit these were not typical of blast damage.

Laboratory evaluation (including mechanical and thermal analysis) of composite samples found evidence for poor construction and in service degradation of the resin and fibres in the composite. This enabled us to conclude that the composites were in a damaged state due to long term degradation, and as such this was unrelated to the blast.

Composite surface degraded due to chemical attack

Poor composite construction, porosity in the resin matrix

MINTON,TREHARNE
& DAVIES GROUP



MINTON,TREHARNE
& DAVIES GROUP

TESTING & ANALYSIS

MTD HAVE EXPERTISE IN TESTING A WIDE RANGE OF MATERIALS INCLUDING COMPOSITES, POLYMERS AND METALS OF ALMOST EVERY FORM (SUCH AS PLATES, RODS, PIPES, FORGINGS, SHAFTS, BOLTS, STRUCTURAL SECTIONS, FABRICATIONS AND CASTINGS).

PHYSICAL TESTING

Our UKAS accredited metallurgical and materials testing laboratories have mechanical test facilities which include tensile, impact and hardness testing. We test materials in accordance with various national and International standards; such as British Standards, European standards, ISO and ASME.

05

NON DESTRUCTIVE TESTING

Our NDT department provides a comprehensive range of UKAS accredited site and laboratory testing facilities, serving the Energy, Aerospace, Defence, Marine, Power Generation, Chemical and Engineering sectors. Testing facilities include ultrasonics, penetrants, magnetics, radiography, eddy currents and visual inspection. We have the largest resource of Level III engineers in the UK, covering all NDT techniques; and these inspectors are able to provide expert support in the assessment and investigation of material damage.

CHEMICAL ANALYSIS

We often undertake chemical analysis in materials cases to assess a product's quality, analyse corrosion products and system debris, or to determine the corrosivity of an environment. Our extensive range of analytical methods including IC, ICP-OES, ICP-MS, Fluorimeter, DMTA, DSC, TGA, AAS, HPLC, FTIR, FTIR Microscope, UV-Vis, XRF, SEM, SEM-EDAX, GC and GCMS. All these methods are performed in house by qualified and experienced technicians.

BIOLOGICAL TESTING

At MTD we have experience in identifying and analysing corrosion caused by microbial activity, as well as the cultivation and subsequent identification of the forms of bacteria by DNA analysis. This work is undertaken by our microbiologists, again using our in-house facilities.

ON-SITE TESTING

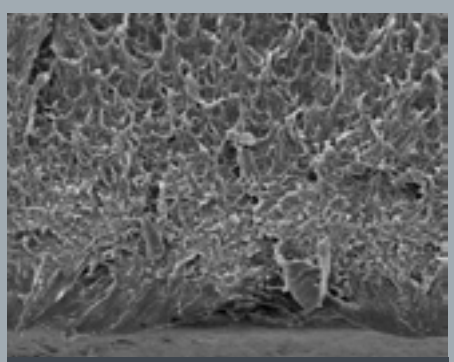
Whilst many of the tests discussed on this page are generally performed in our laboratory on samples taken from site, we can also utilise a variety of these test methods on site; including hardness testing, material analysis by XRF and cultivation of bacteria using portable instrumentation.

MINTON,TREHARNE
& DAVIES GROUP

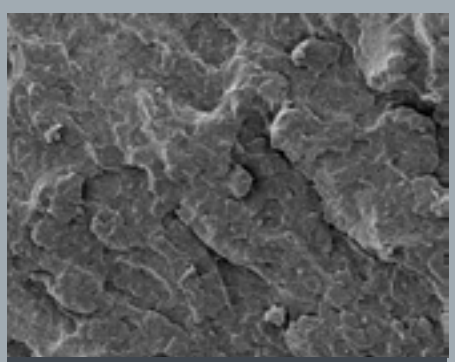
CASE STUDY 01
POLYMER ANALYSIS

TESTING & ANALYSIS

MTD investigated the failure of an offshore flexible flowline which had leaked crude oil in service due to failure of its internal polymeric pressure sheath. Early reports had blamed chemical degradation due to anti-bacterial additives in the oil, but doubt remained that this was the root cause. We dissected a section of the flowline and investigated the various layers therein. Testing of the tape and polymer layers within the flowline revealed some degradation due to excessive service temperatures. However mechanical and chemical laboratory analysis also determined that the pressure sheath was neither chemically degraded nor had degraded due to high service temperatures. Further study of this layer revealed the presence of an unexpected crystalline phase within the polymer, which had resulted in embrittlement and cracking. The crystalline phase was determined to be a product of manufacture, not service. Study of manufacturing records located when and where the problem arose.



Electron microscope image of normal, ductile polymer failure surface



Electron microscope image of brittle Polymer failure surface

CASE STUDY 02
WELD QUALITY TESTING

TESTING & ANALYSIS

MTD provided expert support and testing services in the investigation of widespread cracking and failure of small bore welds in a gas processing facility. This involved the sectioning, testing and assessment of over 1,000 welds in a very tight time frame. The data generated by our testing enabled us to reach a definitive conclusion that the cracking was due to hydrogen embrittlement associated with sulfide stress cracking (SSC) due to poor welding, not in accordance with approved weld procedures. The welds we examined showed that the facility still contained many welds susceptible to this failure mechanism and, hence, that further failures could be expected in future. A major programme of refurbishment was undertaken to remove or remediate the bad welds.

Small bore pipe to flange weld

Defective weld cross section

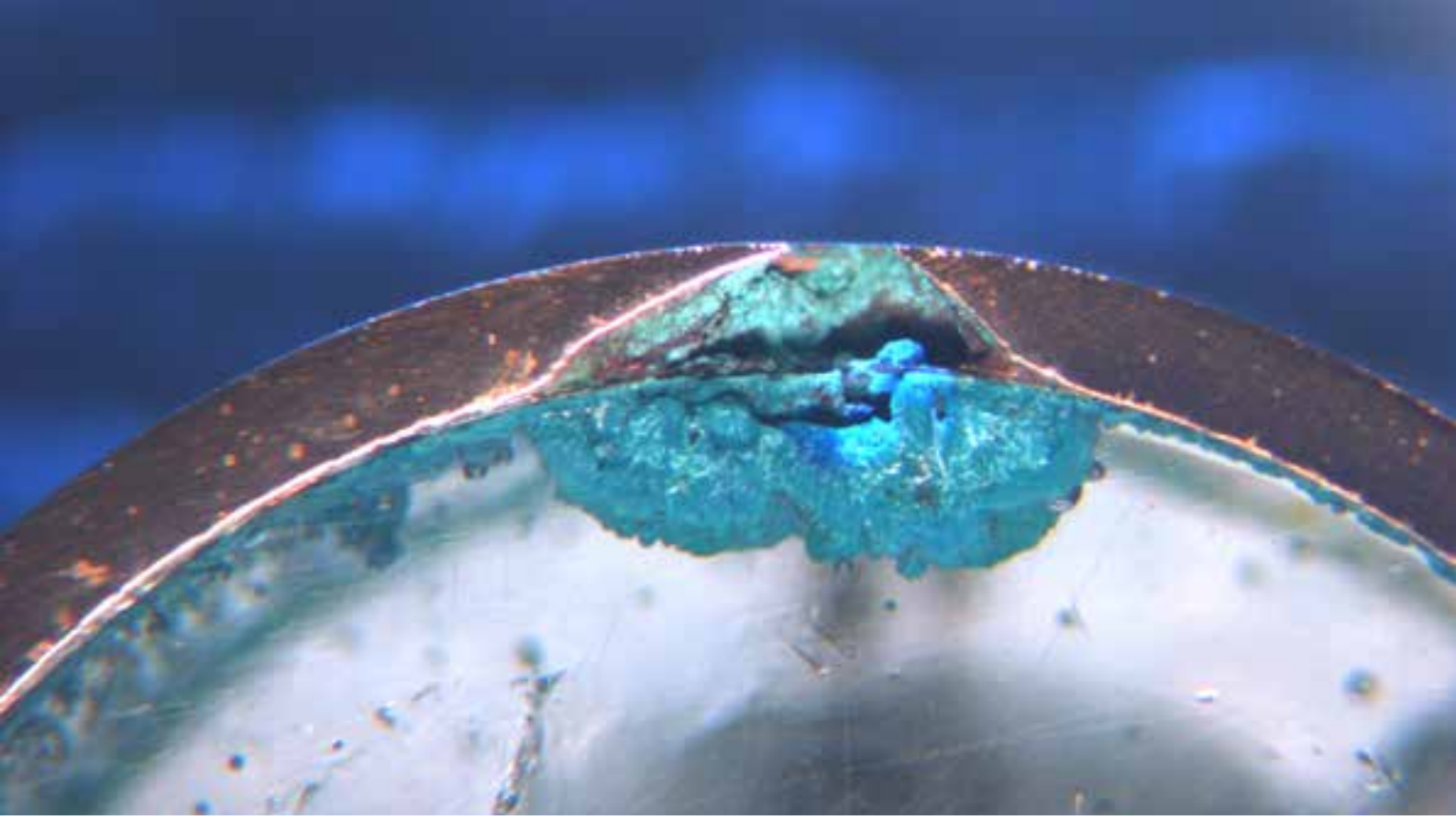
MINTON,TREHARNE
& DAVIES GROUP

FAILURE INVESTIGATION: METALLURGY

FAILURE OF COMPONENTS AND MATERIALS CAN OCCUR FOR A WIDE VARIETY OF REASONS INCLUDING CORROSION, FATIGUE, OVERLOAD AND EMBRITTLEMENT.

At MTD our metallurgists undertake Root Cause Failure investigations utilising the comprehensive capabilities of our in house laboratories to determine the root cause of many failures. Investigations can determine a material's history, including information on its manufacture and service conditions, which, in conjunction with the failure analysis, is important in arriving at accurate and fully supported conclusions.

06



CORROSION

Corrosion is a common cause of material failure. It can result in the rapid degradation, perforation or cracking of components long before their design life is reached. Corrosion can be exacerbated by (among other things) the choice of materials, their manufacturing process, the service environment and the presence of bacteria.

In corrosion investigations it is important to determine the type of corrosion, the environment and the service conditions. Only with a thorough investigation can the root cause be definitively determined. Our consultants experience and the facilities of our laboratories enable such complex determinations.

FATIGUE

Metal fatigue and fatigue cracking are issues which we are often called to investigate. Fatigue failures occur as result of a slow accumulation of microstructural damage within a component, followed by the initiation and propagation of cracks. Fatigue typically occurs over many load cycles, and ofen lead to premature catastrophic failure. At MTD we regularly investigate fatigue failures in items ranging in size from a few millimetres up to large engineering sections. Whilst fatigue affects all industries those involved with the enrgy sector are often exposed to more severe service conditions; we have particular expertise in investigating fatigue failure in these industries.

ROOT CAUSE INVESTIGATION

Corrosion and fatigue are two of the most common root causes of metallurgical failures, however there are many other failure modes. Some of these are specific to certain industries, alloys or environments. At MTD we investigate a wide variety of these, including Stress Corrosion Cracking, Sulfide Stress Cracking, overload, hydrogen embrittlement and cavitation erosion.

MINTON,TREHARNE
& DAVIES GROUP

CASE STUDY 01
STAINLESS STEEL CORROSION

FAILURE INVESTIGATION: METALLURGY

MTD were appointed to investigate a systemic corrosion problem affecting the stainless steel hot water systems in cruise ships. The corrosion had resulted in pinholes and leaks throughout the ships, with consequent water damage. The cause of the problem had to be swiftly ascertained as the ships involved were due to be shortly sold at auction. We surveyed the vessels and selected samples for laboratory investigation. Our survey revealed that the problem was more widespread than previously determined and that further failures were imminent. Our analysis revealed that corrosion was due to an inherent mismatch between the grade of stainless steel used in the hot water system and the quality of water produced in the vessel. However the incipient damages could not be rectified by a change in water chemistry and full replacement of the pipework was advised.

Pinhole corrosion pit inside a pipe

Cross section through pinhole revealing large underlying corrosion pits

CASE STUDY 02
CRACKING OF A PIPELINE

FAILURE INVESTIGATION: METALLURGY

A subsea pipeline failed in at a welded joint soon after entering service. This was initially blamed on abnormal stresses during installation, but further investigation was deemed appropriate. MTD were sent samples from the failed weld for analysis, as well as full manufacturing records. Analysis of the welded joint found that cracks had propagated through the pipe from the weld toes (the weld edges) by fatigue; various small manufacturing defects were also found in the weld. Study of our results and comparison with manufacturing records revealed that the manufacturer's quality control had not detected these defects. More importantly we also determined that the pipe on one side of the weld did not correspond to quality records, and was made from a material 40% weaker than specified. FEA (Finite Element Analysis) Modelling revealed that normal bending loads during installation could produce overload and cracking.

The failed pipeline cracked next to a weld

A fatigue crack propagating top to bottom through the pipe

MINTON,TREHARNE
& DAVIES GROUP

FAILURE INVESTIGATION:
NON-METALLIC MATERIALS

WHILST MOST ENGINEERING STRUCTURES HAVE TRADITIONALLY BEEN MANUFACTURED FROM METAL, THE USE OF NON-METALLIC MATERIALS IS INCREASING EVERY YEAR, AND IS LIKELY TO CONTINUE FAR INTO THE FORESEEABLE FUTURE

Whilst non-metallic materials often bring savings in weight, an increased corrosion resistance and (in some cases) an increase in strength they can often bring new problems such as degradation in ultraviolet light, inherent flaws and a poor technical understanding of their compatibility with service environments.

07

MTD's laboratories have the facility to investigate a wide variety of non-metallic materials; conducting tests to the latest standards and, if these do not exist, designing our own tests to supplement our failure investigations.

We are involved in the investigation of polymer failures in the energy industry as well as composite structures in the marine, aerospace, chemical and renewable sectors. MTD's experts have wide ranging experience of investigating non-metallic materials.

NEW MATERIALS AND NEW TECHNOLOGY

Changes in technology over the last decade have introduced a huge variety of new materials and new manufacturing methods across many industries. The scaling up of these materials from prototypes to production pieces, and from bespoke manufacturing to production line operations often introduces numerous obstacles which may become evident immediately, or after some time in service.

Our expertise and in house laboratories have enabled us to design new and appropriate test methods for such materials and, if required, to provide solutions in similarly innovative ways.

PAINTS, COATINGS & SURFACE FINISHING

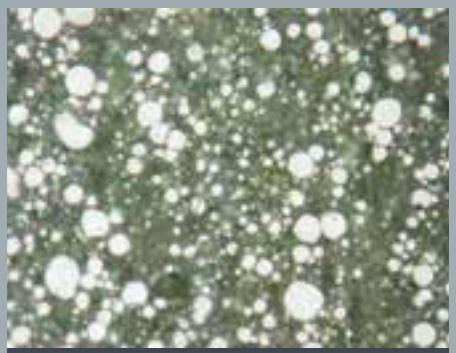
Few components enter service in a 'raw' state; their surfaces are finished, plated, coated or clad before being exposed to service conditions. Anomalies in these final stages of production can lead to rapid deterioration of a component once in service. At MTD we have first hand experience of the inspection and testing of such finishing processes. We have the equipment and expertise to inspect engineering structures on site regardless of their size or the nature of their coating.

MINTON,TREHARNE
& DAVIES GROUP

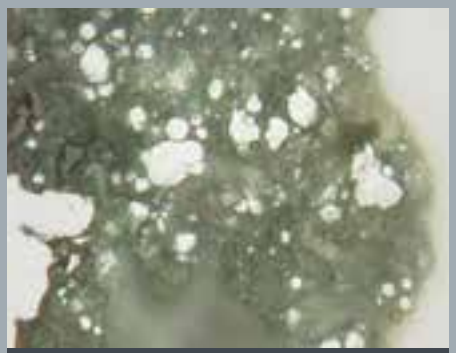
CASE STUDY 01
PAINT FAILURE INVESTIGATION

FAILURE INVESTIGATION:
NON-METALLIC MATERIALS

MTD acted as experts in a billion dollar claim relating to the failure of the coating on an offshore steel structure. The coating was designed as a multi-layer, multi-component system to provide both barrier protection and galvanic protection due to the presence of zinc particles within the first paint layer. Shortly after entering service the paint system began to fail, and spall off the structure. We analysed the coating and found evidence for poor surface preparation and failure to follow specified application parameters, however our most importantfinding was that the first paint layer contained much less zinc than specified. The absence of sufficient zinc meant that if the coating was breached there was no local galvanic protection, and corrosion could undercut the coating and lift it off the underlying steel.



Zinc (small circles) in the coating as specified

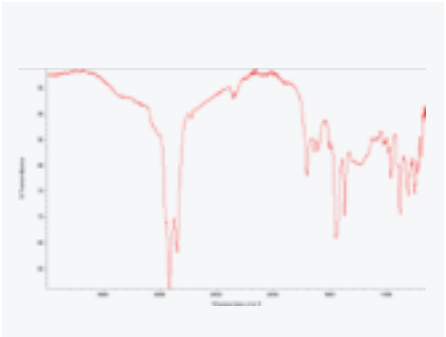


Zinc in the coating as applied

CASE STUDY 02
CRACKING OF RUBBER GASKETS

FAILURE INVESTIGATION:
NON-METALLIC MATERIALS

MTD were appointed in a court case concerning the failure of large rubber gaskets used to retain oil in high technology medical imaging equipment. Due to our expertise in this area we were instructed to act as single joint experts. A large number of sample gaskets in varying conditions and the transformer oil they retained in service were supplied to us for our investigation. This work involved the use of many different analysis techniques (including TGA, FTIR, GCMS and EDX) on the gaskets and the oil to investigate both the qualities of the original material and the reason for degradation. Our investigations determined that the grade of rubber supplied was not consistent with that specified, and in service had absorbed the transformer oil, and subsequently degraded.



FTIR spectrum of the degraded rubber

Cracks in the gasket edges

MINTON, TREHARNE & DAVIES GROUP

DELIVERING INDEPENDENT SCIENTIFIC & TECHNICAL SERVICES TO INDUSTRY

The Minton, Treharne & Davies Group provides scientific consultancy, surveying, testing and training services to a worldwide client base from offices and laboratories in the UK, Europe, USA, Singapore and Australia.

AREAS OF EXPERTISE

- Aerospace
- Agriculture & Food
- Chemicals & Pharmaceuticals
- Energy
- Engineering & Construction
- Environmental
- Insurance
- Marine
- Materials Science
- Metallurgy
- Minerals
- Petroleum & Petrochemicals
- Property
- Renewable Energy
- Solid Fuels
- Super Yachts & Leisure Craft

UK
USA
SINGAPORE
AUSTRALIA
NETHERLANDS

MINTON,TREHARNE
& DAVIES GROUP

Minton, Treharne & Davies Group
Forest Farm Industrial Estate, Coryton,
Cardiff CF14 7HY. United Kingdom.

+44 (0) 29 2054 0000
+44 (0) 29 2054 0111
enquiries@minton.global

WWW.MINTON.GLOBAL