AMCO
Consulting Services

Your Engineering Consulting Partner

- Petrochemical
- Power: HRSG/CCGT
- Chemical/Processing
- Refining
- Fertilizer
- Waste Incineration
- Oil and Gas
- Mining
- Space & Defense
- Manufacturing

AMCO Profile

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Who We Are?

AMCO Integrity is an independent and highly innovative engineering and consulting company engaged in state of the art R&D and product development in the energy sector, power generations, refining, fertilizer, petrochemical, processing, manufacturing, defense, mining, automobiles and in high temperature plant issues in general.

We have teams of experts around the world available to provide specialized business solutions that align with client needs. The company works through a corporate model of core staff and a pool of internationally known technical experts with practical experience, background and expertise in plant.

AMCO Integrity have always retained a uniqueness that has allowed us to truly understand the industry, encouraging innovation and an entrepreneurial spirit that creates strong links between our global business operations.

AMCO is the global benchmark for quality and integrity, and we have built our reputation on quality, client service, innovation, and technical excellence. Our commitment to systemization and standardization allows our people to focus on what is important?

We measure success by the satisfaction of our clients. We are committed to providing a level of service that provides our clients with the confidence to make timely, accurate and informed decisions. As our company continues to develop and grow, so do our systems that make it increasingly easier to partner with **AMCO Integrity** and receive data and reports that not only meet but exceed client expectations.

At AMCO, we are committed to the health and safety of our people, the environment and the communities in which we operate; allowing us to establish long-lasting relationships with clients and make positive contributions to the regions in which we live and work.

The reassurance to know you are working with a Winning Team. We are all working towards the same goal – our team is your team!

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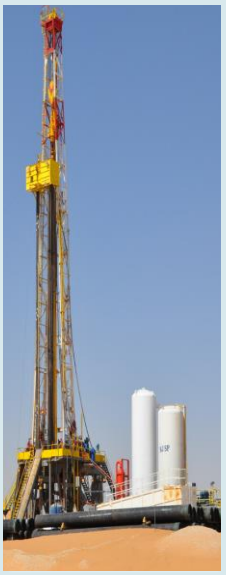
WHAT WE DO?

- Asset Management
- Asset Management Plan (AMP)
- Strategic Asset Management Plan (SAMP)
- Asset Data Analytics
- Asset Management Strategies
- Reliability Analysis
- Reliability Centered Maintenance (RCM)
- Risk Based Maintenance
- FMEA, FMECA and RCA Services
- Asset Criticality Analysis
- Pipeline Integrity Management
- Structure Integrity Assessment
- Training and Courses
- Research and Development

- Asset Integrity Services
- Corrosion Management
- Failure Analysis/Investigation
- Risk Based Inspection
- Fitness for Services (FFS)
- Life Assessment Services
- Boiler Inspection
- Turbine Assessment
- Third party Inspection
- Engineering Design Analysis
- Stress Analysis



WE DEAL WITH

- Petrochemicals
- Oil and Gas
- Power Sectors
- Fertilizers
- Refineries
- Pharmaceutical
- Construction

- Chemical and Processing Plants
- Mining and Metal
- Manufacturing Industry
- Waste Incineration
- Automobile
- Aerospace
- Cement

- Food
- Defense
- Railway
- Shipping
- Drilling
- Exploration
- Pulping

AMCO
Consulting Services

Asset Integrity Services

Asset Integrity

The company works through a corporate model of core staff and a pool of internationally known technical experts with practical experience, background and expertise in power, petrochemical, refining, fertilizer, oil & gas and process plant.

Asset Integrity Services

AMCO Integrity's Asset Integrity Services assist clients in making informed decisions on the operation and maintenance of their plant and to manage the risks their operations place upon the assets they own or operate. The benefits can include:

- Improved safety and reliability
- Reduced downtime
- Scheduled repair or replacement
- Cost savings

Asset Integrity Services provides information on the condition of a component under 'current' and 'planned' future operating conditions enabling the operator to plan for the remaining life of that component. AMCO offers an array of tools, skills and techniques for assessment and analysis of component integrity in:

STRUCTURAL INTEGRITY

- Design and life assessment
- Defect assessment
- On-line monitoring
- Life extension

FAILURE ANALYSIS

Structural Integrity: covers a broad range of services aimed at assessing the fitness for service of plant and equipment subject to thermal and/or mechanical loading under steady state or transient conditions.

Design code and life assessment: A key activity of Asset Integrity Services is in the area of fitness-for service assessments of a range of plant and equipment. Assessments of this type may be performed on new plant entering service or on existing plant where changes in service are planned or as a result of degradation of the component.

AMCO are familiar with British, European and ASME standards and can provide assessments for:

- Temperature distributions
- Mechanical & thermal stress levels and distributions in structures subjected to transient and/or steady state loading
- Dynamic response of components, including natural frequencies & mode shapes
- Stress concentration factors, particularly used for assessing grind-out repair of small defects
- Life prediction under creep and/or fatigue conditions.

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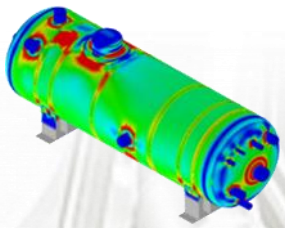
Fitness for Service/ Purpose

AMCO Integrity offers expert services in the evaluation of petrochemical/process/ refining and power plant covering a range of potential damage mechanisms (and their interaction) including but not limited to:

- ✓ Corrosion
- ✓ Creep
- ✓ Hydrogen Damage
- ✓ Fatigue
- ✓ Embrittlement



AMCO Integrity assesses the fitness for service of plant under operating conditions which can give advanced warning of in-service failures. This can help the plant operators in reducing cost by avoiding costly unplanned outages and at the same time minimize excessive maintenance or premature inspection.

AMCO Integrity has experience of using standardized approaches such as those outlined in API 579. Furthermore, we have initiated and led the development of some of the European approaches to fitness-for-service in addition to its extensive experience in life assessment.

We implements this assessment in a staged way as follows:

STEP 1:
Preliminary Fitness-For-Service Assessment and Inspection
STEP 2:
Implementation of the Inspection Programme.
STEP 3:
Final Fitness-For-Service Assessment

Depending on the site findings, this may involve all three Levels (i.e. Levels I to III) of FFS assessment, with Level III fitness being the most detailed calculational phase involving finite element modeling to refine the stress analysis of the component investigated. This assessment may include evaluation of a wide range of damage mechanisms including (but not limited to):

- Loss in wall thickness
- Defect assessment
- Pitting corrosion
- Creep damage
- Crack growth assessment
- Temper embrittlement
- Hydrogen damage

Based on the conclusions of the FFS assessment, the plant components suitability for further service may be drawn. Where the condition of the plant does not allow for continued operation, AMCO can provide appropriate advice/ recommendations on safe operation, repair or replacement strategies.

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Life Assessment and Extension

Why AMCO Integrity ?

AMCO Integrity has established expertise in the Life Assessment of components from Petrochemical, Chemical, Processing, Refinery, Fertilizer, Oil & Gas, and power plants operating in the creep regime.

We can assess the remaining life of plant components under operating conditions, offering real increases in safe operating life or increase in inspection intervals where appropriate. Advanced warning of creep, creep/corrosion and creep fatigue failures can avoid expensive unplanned outages while avoiding undue maintenance or premature replication surveys. Improved repair welds, including cold weld repairs, can reduce the delay in returning a plant to service and may be suitable for long term service, thus avoiding replacement at the next scheduled outage.

The determination of maintenance costs relating to equipment life extension requires an assessment of remaining life in critical components. Maintenance recommendations can then be made to extend equipment life for a desired period. Analysis will include recommendations for future preventative maintenance scheduling, operating condition improvements, repairs and replacement.

What is Remaining Life Assessment (RLA)?

Remaining life assessment (RLA) is method and procedure used to predict the remaining life of equipment, structures or facility that have been in service for an extended period of time, usually close to or beyond the design life. The RLA offers a possible tool to estimate the useful remaining lifetime and avoid premature failure or scrapping of the part.

What is Life Extension?

Life Extension analysis is further step or effort to extend the calculated remaining life of the equipment or facility until their economic life is met. The extension procedure could involve various actions of maintenance, repair, replacement, or down rate decision making.

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Life Assessment and Extension

Remaining Life Assessment technology can be used to assess:

- ✓ Boiler components
- ✓ Steam-turbine components
- ✓ Combustion turbine components
- ✓ Hydraulic turbine components
- ✓ Pressure vessels
- ✓ Welded structural components
- ✓ Storage tanks
- ✓ Pipes and pipelines

AMCO Integrity can provide a full Component Life Assessment Service

Which can include the following -

- On-site inspection using advanced NDE
- Metallographic evaluation
- Review of design drawings
- Finite Element modelling and stress analysis
- Remaining Life Assessment calculations
- Development of inspection procedures
- Life Extension recommendations
- Weld repair (including advanced techniques for cold weld repair)
- Component replacements where appropriate

Related Services

- Fitness For Service (FFS)
- Risk Based Inspection (RBI)
- Defect Assessment
- Condition Assessment
- Failure Analysis
- Probabilistic Life Assessment
- Critical Analysis

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Boiler Inspection Services

In plants, the boiler has typically been the most trouble prone piece of equipment, being the most likely to be the origin of a problem that leads to a forced outage. Because of this, there are well defined techniques to assess the condition and manage the lifecycle of boiler equipment for optimum reliability and operate efficiently.

AMCO Integrity has established expertise in the life assessment of components from boilers operating in the creep and fatigue conditions. The viability of future operation can be called in to question when a boiler begins experiencing failures, reducing production, increasing forced shutdowns and low efficiency. Today, plants are being operated to meet new financial expectations, and that combined with limited financial resources, reduced maintenance budgets, staff reductions, and fewer, shorter outages, makes managing these plants a difficult challenge. The pressures of power generation efficiency have also led to higher operating temperatures and newer materials, some of which are leading to new types of problems and failures in power plants.

The decision to run, re-rate, replace or retire is one that can only be answered by in-depth, cross-discipline analysis. In particular, the gap between engineering and economic questions can be difficult to bridge.

AMCO Integrity can provide a full Boiler Life Assessment service which can include the following –

- On-site inspection using advanced NDE.
- Metallographic evaluation.
- Review of design drawings.
- Finite Element modeling and stress analysis.
- Remaining Life Assessment calculations.
- Development of inspection procedures.
- Life Extension recommendations.
- Weld repair (including advanced techniques for cold weld repair).
- Component replacements where appropriate.

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Boiler Inspection Services

AMCO Integrity is more than ready to help clients meet the new challenges that face both older and newer plants. We can assess the remaining life of boiler components under operating conditions, offering real increases in safe operating life or increase in inspection intervals where appropriate. Advanced warning of creep, creep/corrosion and creep fatigue failures can avoid expensive unplanned outages while avoiding undue maintenance or premature replication surveys. Improved repair welds, including cold weld repairs, can reduce the delay in returning a plant to service and may be suitable for long term service, thus avoiding replacement at the next scheduled outage.

In many boilers, the design life of the unit is determined by the creep properties of the tubing. In almost all cases the initial tube thickness will be greater than the theoretical minimum used in the original calculations, resulting in lower operating stresses than those used to calculate the design life. The actual life of the tubing depends on the real properties of the tubing, the rate of tube thinning (due to corrosion and/or erosion) and the operating conditions throughout the boiler life.

We have provided support and consulting services to the plant industry for more than 15 years, and has transformed that formidable experience and expertise into an integrated, multidisciplinary approach that combines engineering analysis, advanced nondestructive examination, materials evaluations, design review, repair technologies, and data management to attain the best possible solutions for plant owners and operators.

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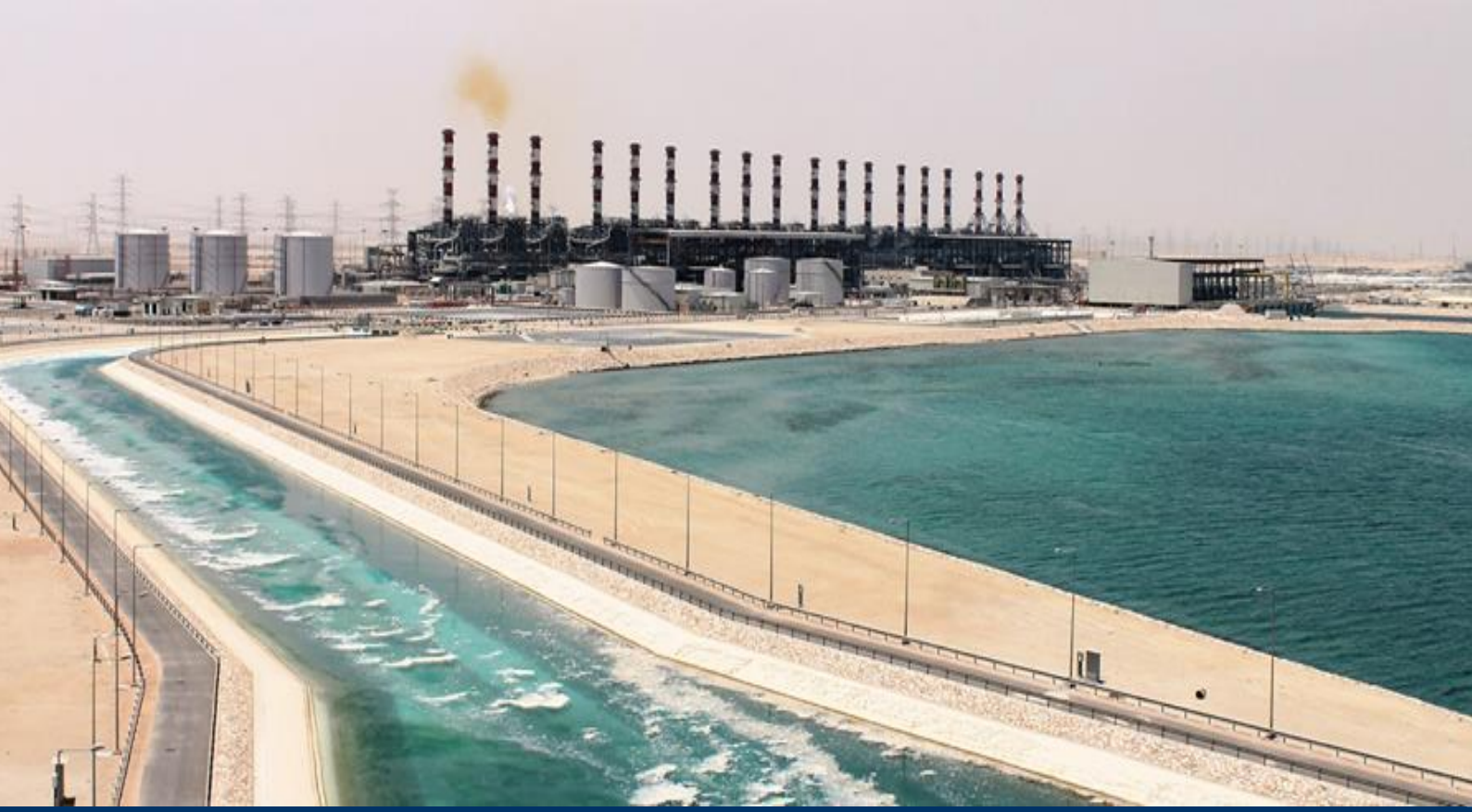

Boiler Component Lifing Services

The significance of life assessment of older power plant components has taken on a new impetus in the present competitive environment where scrapping of a plant is the last thing that an owner wishes to do or can afford to do. Moreover, due to the use of the deterministic methods for plant design many of the components are designed very conservatively and experience has shown that most plant can operate way beyond their design life and all that needs to be done is to repair or replace a few of the critical components. Thus the development of AMCO's Boiler Component Lifing Services is very timely. This is especially so since for nearly two decades or more no such development has come to light in spite of the new developments in many of the life assessment methodologies and technologies.

To minimize lost production, AMCO detailed program for boiler asset management includes component Lifing methods used to provide information for inspection and replacement planning. AMCO's has the expertise to apply state of the art methods for evaluating the remaining life of boiler key system components, including advanced NDE, application of a wide variety of data from industry sources, (AMCO own data base) and information obtained from destructive metallurgical testing of tubes and other components of the boiler system.

Fully-Integrated Approach to Component Lifing Assessments

Non-destructive Evaluation

Non-destructive evaluations are key for determining the overall extent and severity of any damage that may be present in tubing sections or within headers and connected piping system in the boiler. Component Lifing is often based on data obtained from common condition assessment activities, such as:

- Evaluations of water-wall tubes with potential waterside corrosion issues such as hydrogen damage, caustic gouging, corrosion fatigue cracking, and flow-accelerated corrosion.
- Creep damage evaluations of super-heater and re-heater tubing operating at elevated temperatures.

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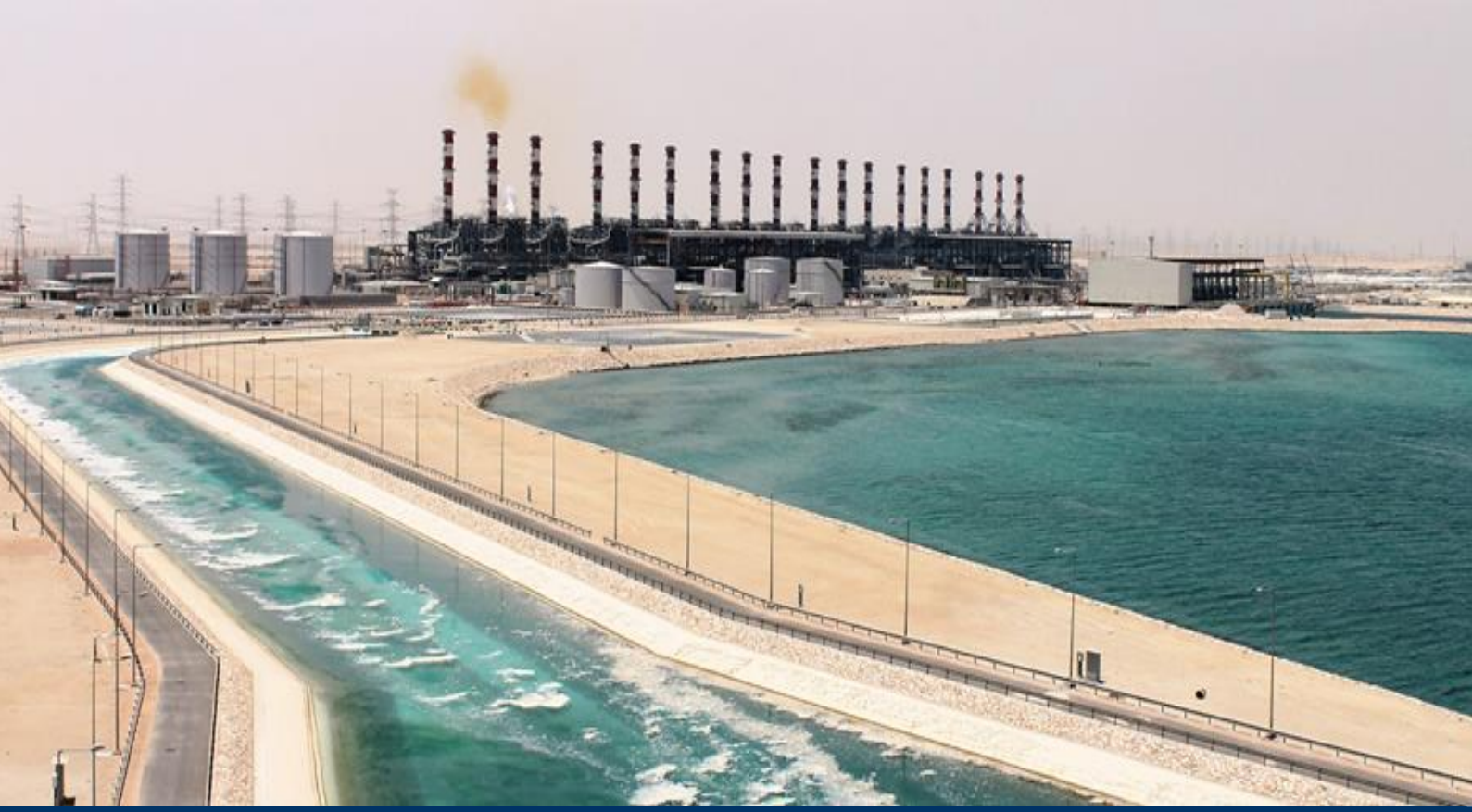

Boiler Component Lifing Services

- Evaluations of super-heater and re-heater dissimilar metal welds for creep fatigue, oxide notching, and carbide coarsening.
- Examination of super-heater and re-heater sections for external wastage caused by soot blower erosion, fly ash erosion, or abrasion

Destructive Examination

In order to determine the metallurgical condition of a tube or verify any NDE results, it is vital to perform destructive examinations. A destructive examination can provide detailed information on:

- Microstructural Condition to determine any degradation, creep damage, etc.
- Dimensions measurement to check if wall loss or any swelling is present.
- Hardness to assess the extent of thermal softening or mechanical property changes.
- Internal and External Oxides/Deposits analysis.

Remaining Life Assessments

For boiler tubes, including steam-touched tubing samples evaluated in AMCO's laboratory, the approximate remaining life of tube samples can be calculated using the dimensional, oxide thickness, and microstructural evaluation results.

BOILER CONDITION ASSESSMENT OVERVIEW

Pressure part failures not only raise personnel safety concerns, but they are a major source of lost revenue for plants owners. To minimize the potential for failures, unplanned outages and related business interruption and repair costs.

AMCO's provides a comprehensive boiler asset management program that's unique in generation industry. A key component to successful boiler management is the implementation of efficient, thorough, and accurate condition assessment processes.

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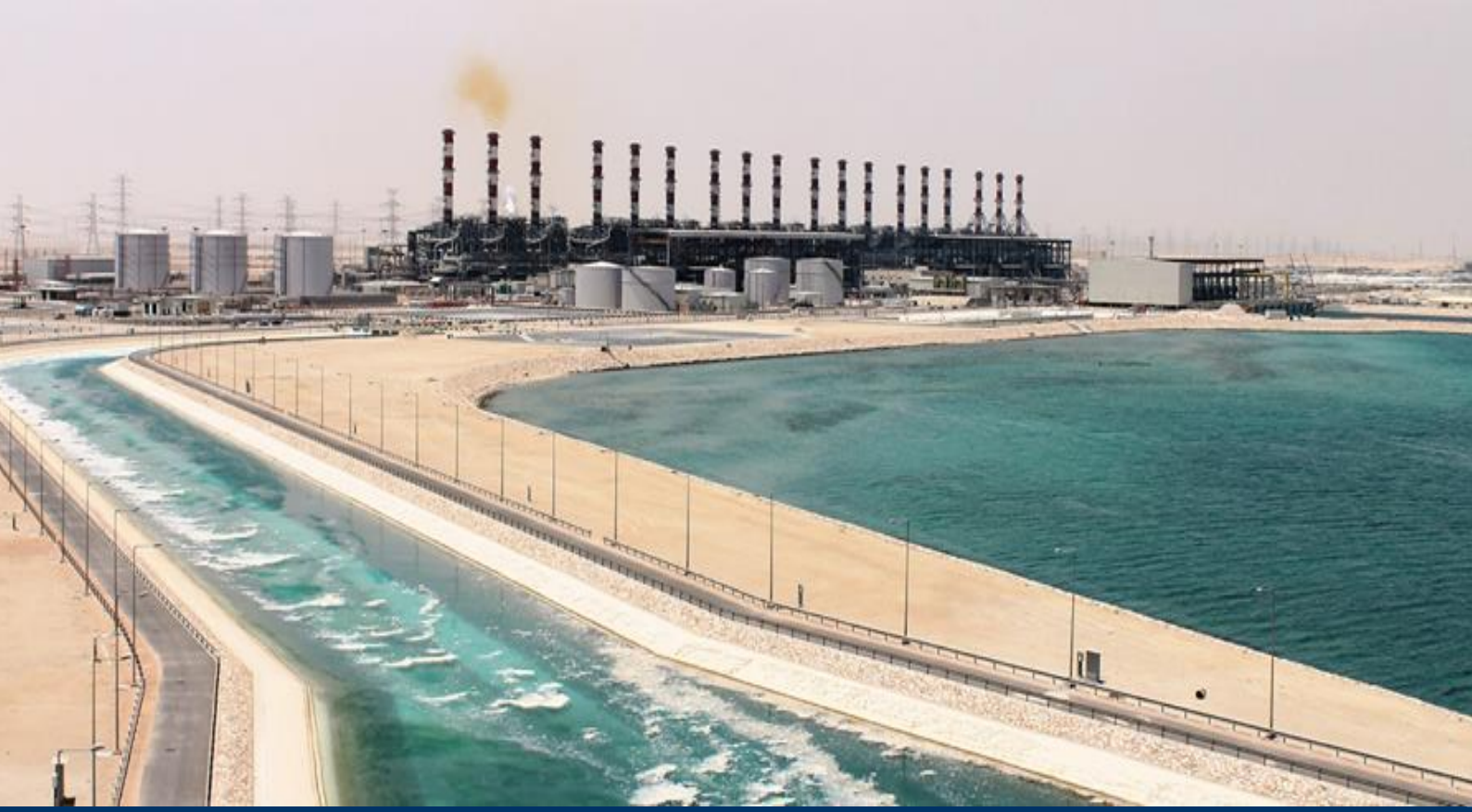

Boiler Component Lifing Services

THE BASICS OF CONDITION ASSESSMENT

One of key expert to boiler condition assessment is thorough pre-outage planning, which often includes reviewing operating and design data. When such information and data is reviewed, and an understanding of unit operation is applied. The process allows for optimized condition assessment efforts by pre-planning work scopes, tailoring testing and inspection methods to the plant's needs, and prioritizing inspection locations within the boiler.

Specific work scope activities associated with condition assessment often include:

Review of Operating Parameters

- Identifying Areas of Concern Based on Geometry.
- Identifying Areas of Higher Temperature Exposures.

Review of Historical Inspection Reports

- Identifying Locations of Prior Failures or Damage
- Identifying Patterns of Damage

Application of Advanced Nondestructive Examination (NDE)

- Matching NDE Methods with Damage Mechanisms Expected
- Sizing of Flaws in Boiler Components

Metallurgical Testing of Boiler Tube Samples

- Identification of Material Condition/Thermal Damage/Damage Mechanisms
- Deposit Loading of Water-touched Tubes
- Dimensional Analysis and Hardness Testing
- Remaining Life Analysis

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Life Assessment Steam Turbine Components

With the increasing competition in the power generation sector worldwide, high standards of reliability, availability and safety are becoming number one requirement for successful operation of a power plant. Steam turbine equipment operates under very complex thermal and mechanical loadings and hence plant operators are daily challenged to cost-effectively manage their safe and reliable operation.

AMCO Integrity offers comprehensive ***Asset Integrity Services*** that assist plant operators in making informed decisions on the operation and maintenance of the main steam turbine components. The benefits include:

- Improved safety and reliability
- Reduced downtime
- Scheduled repair or replacement
- Cost savings

FITNESS FOR SERVICE & REMAINING LIFE ASSESSMENT

A key activity of AMCO Asset Integrity Services is in the area of fitness-for-service (FFS) and remaining life assessment (RLA) of a range of plant, including steam turbine equipment. Assessment of this type may be performed on new components just entering service or on existing components where changes in service are planned as a result of degradation during service. For performing such an assessment, steam turbine equipment is generally split in two main categories:

Rotating parts

- High temperature Rotors & blades
- Lower temperature Rotors & blades
- Discs

Static parts

- Casing
- Valves / Steam Chests
- HT Fasteners
- Piping

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Life Assessment Steam Turbine Components

As is well known the rotors are complex components with many different designs (solid, bored, welded and disked). In terms of the steam turbine equipment assessment (FFS & RLA), the rotors, and particularly those operating at very high temperatures, are the most critical components, as they are not only highly stressed but ***brittle failure*** can be a significant threat to them. The rotor critical areas at which FSS and RLA should be focused include the bore, the 1st stage blade root fixing and geometrical stress raisers. Furthermore, for the solid forged impulse type rotor, two additional critical areas should be considered; the disc balance holes and disc to body fillet radii.

The current trend towards higher plant output leads to high operating stresses within the plant components including the steam turbine equipment. To accommodate these stresses, materials exhibiting higher strength and fracture toughness are used for steam turbine components. However, rotor steels particularly those of earlier manufacture, are susceptible to ***temper embrittlement***, which is a shift in the ***brittle to ductile transition*** that occurs when the material is cooled (heated) slowly through a temperature range of 350°C to 570°C. Hence, when evaluating the remaining life of a steam turbine component (e.g. rotor, casing), it is important to assess whether it has been operating within the temper embrittlement temperature range and if it has, any impact on the material fracture toughness has to be taken into account when making an integrity assessment of such components. . It is well known that for the steam turbine equipment, the key input to the FFS and remaining life assessment is not single valued but distributed:

- through spatial changes (e.g. thickness, temperature, stress, etc.) or temporal variability (e.g. operating conditions, ageing, etc.), or,
- through the imprecision of measurements and scatter in the data (e.g. inspection, on-line monitoring data, materials data, etc.)

The deterministic approach to life assessment is based on the “worst-case scenario” and conservative values/ bounds for the inputs are generally used in the analysis. However, this may provide an overly conservative and unrealistic result.

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Life Assessment Steam Turbine Components

Thus AMCO also offers the option to perform a ***probabilistic life assessment,*** which provides a more realistic estimate of the component remaining life by statistically quantifying the variation in the key inputs in terms of a nominal value and the scatter or drift around this value. AMCO has built up valuable experience in this area and made a number of publications.

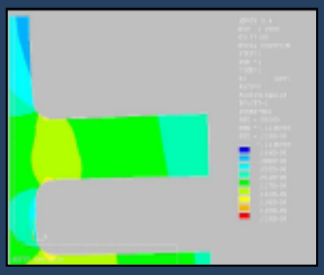
Stress Analysis

The integrity of the steam turbine equipment and hence RLA is closely linked to the stresses that key components experience during service and how these stresses compare with the design. AMCO has excellent experience in stress analysis using both traditional 'hand' calculation approach and, where necessary, advanced Finite Element (FE) methods. AMCO is well familiar with British, European and ASME standards and can provide assessment for:

- Temperature distributions
- Mechanical and thermal stress levels and distributions in structures subjected to transient and/or steady state loading
- Dynamic response of components, including natural frequencies and mode shapes
- Stress concentration factors, particularly used for assessing grind-out repair of small defects
- Life prediction under creep and/or fatigue conditions

FE Thermal and Structural Analysis of Steam turbine components

a/ Valve casing – Temperature distribution



b/ LP turbine rotor – Stress distribution in stage 1

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Life Assessment Steam Turbine Components

AMCO'S Approach to Life Assessment

AMCO adopts a staged approach to life assessment of steam turbine equipment as follows:

i Preliminary assessment (Level 1)
- Detailed assessment (FE stress analysis etc.) using average or minimum inputs
- Deterministic

ii Refined Assessment (Level 2)
- Improve operational inputs
- Probabilistic option

iii Detailed Assessment (Level 3)
- Improve material property inputs via sampling, testing and re –inspection
- Refined probabilistic option

AMCO has established expertise in performing a wide range of FFS analyses and remaining life assessment for steam turbine equipment, which includes (but not limited to):

HP/IP Rotors
- Brittle fracture,
- Bore high strain fatigue,
- Bore creep cracking due to strain exhaustion,
- Surface thermal fatigue damage, creep-fatigue interaction

LP Rotors & Discs
- Stress Corrosion Cracking
- Corrosion Fatigue

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Life Assessment Steam Turbine Components

LP Turbine Blades
- Stress Corrosion Cracking
- Corrosion Fatigue

High Temperature Casing
- Thermal fatigue
- Creep-fatigue

AMCO's Asset Integrity Services are internationally recognized in the field of ***defect assessment*** both at ambient and elevated temperatures. For assessing steam turbine components containing cracking (detected or assumed), particularly their fitness against brittle fracture.

AMCO uses a range of effective and robust in-house tools that incorporate the widely accepted fracture assessment procedures and its own practical field experience. These special purpose tools, which are based on both ***deterministic*** and ***probabilistic*** methods, enable the assessment of known defects and to determine maximum acceptable defect sizes to assist in identifying suitable inspection methods and inspection intervals. In the area of defect assessment AMCO provides expert services in:

- Crack growth under fatigue and/or creep conditions.
- Determination of necessary potential defect size to be detected by NDE.
- Defect tolerance including critical crack size or critical load.

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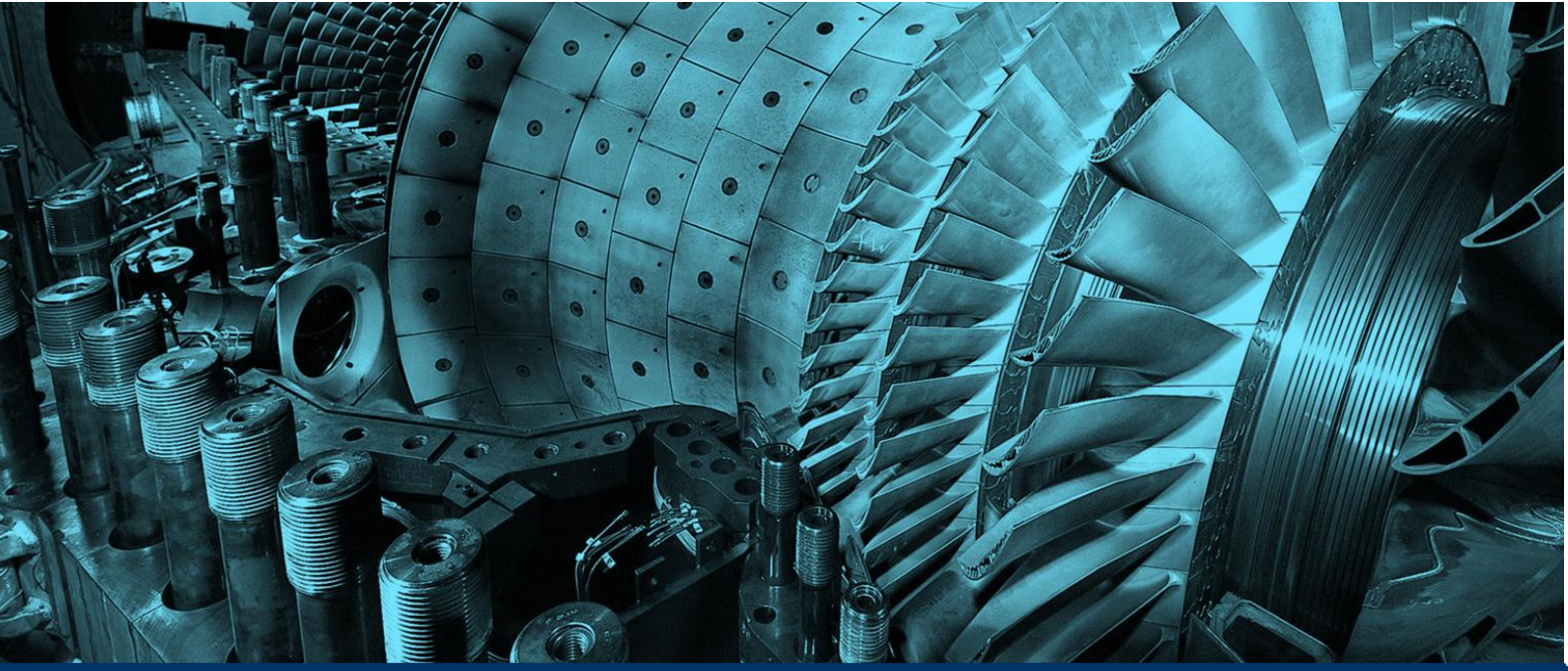


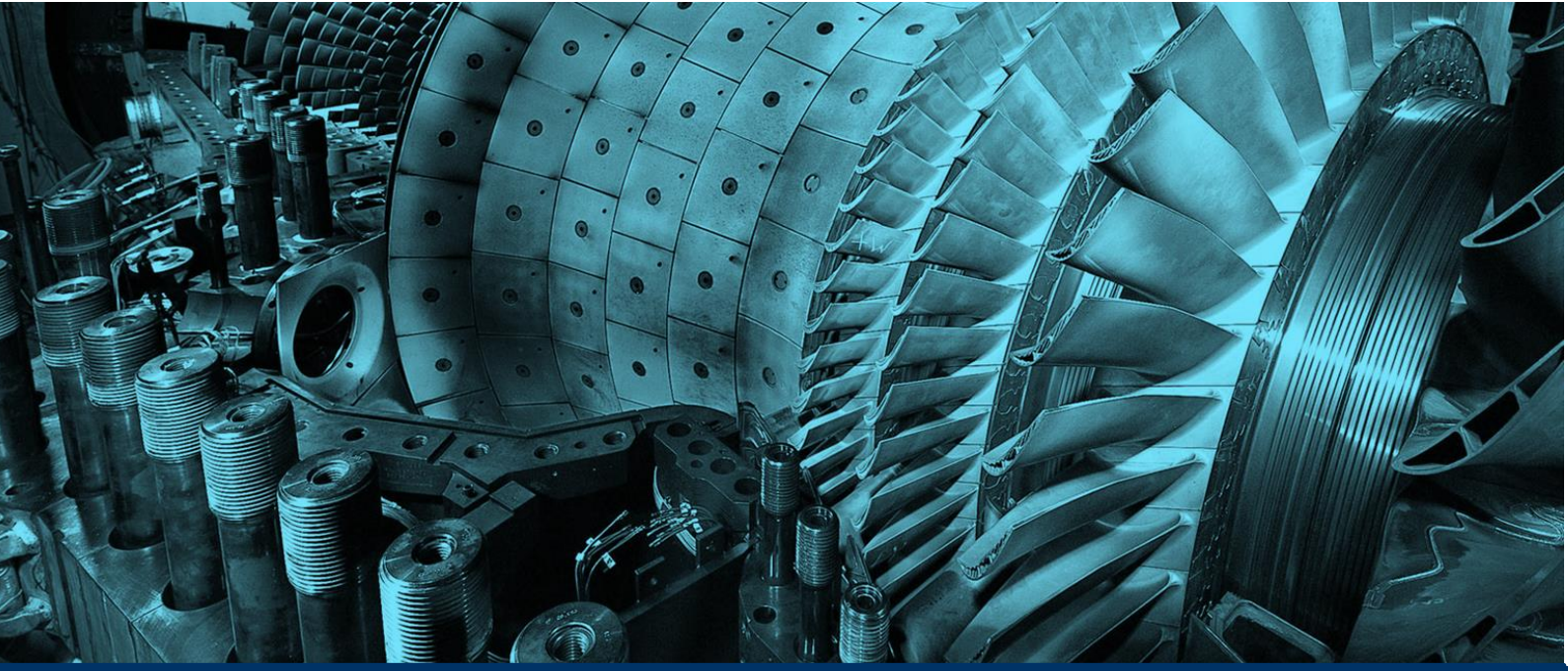
Turbine/ Generator Evaluation

Material degradation, corrosion, cracking, and particularly catastrophic failure are undesirable, but they are intolerable when it comes to turbine and generator components. AMCO's experienced technical staff from UK, USA & Japan is knowledgeable in all aspects of turbine/generator asset integrity management, including advanced NDE inspection, finite element analysis, reliability centered maintenance (RCM), component life assessment, metallurgical investigation of damaged and failed components and evaluation of turbine material properties by removing and testing small samples without the need for repair or replacement. We at AMCO, use our advance technology like Electric Discharge Sampling Equipment (EDSE) for removing the sample without heating or damaging the turbine component.

The engineers in our laboratory have the ability to conduct a full range of metallurgical assessments, whether as an individual service in support of a root cause analysis (RCA) team at the corporate level or plant site, or as part of a multidisciplinary approach to failure investigation that involves a range of engineering services from AMCO.

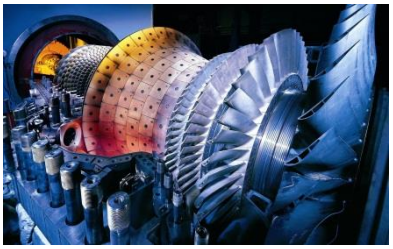
Evaluating Material Condition and Damage Mechanisms

The need for material evaluations can result from inadequate knowledge of the properties or details of the materials of construction, from identified conditions in which some level of material damage is suspected, from direct identification of damage, or from a component failure. Metallurgical and mechanical testing can be performed on large samples, or testing can be performed on small samples removed from the component(s) in question. For example, turbine wheels may be evaluated by removing small "scoop" samples, which allow for metallography, hardness testing, and estimates of strength and toughness properties without having to remove the wheel from service. Alternatively, components such as turbine blades (buckets), rotors or rotor sections, bolts, shims, etc. can be evaluated individually or in groups. In the case of material properties, testing can include chemical composition analyses and alloy verification, microstructural evaluation and associated hardness testing, and detailed mechanical testing to obtain tensile strength and fracture toughness properties. When material damage is suspected, or when damage or failure has occurred, testing can include property evaluations, as described above, in addition to fractography (optical and scanning electron microscopy), elemental analysis of contaminants that might be associated with material degradation such as stress corrosion cracking, metallography for evaluation of damage morphology, and identification of the damage mechanism. Metallurgical (destructive) testing is often performed as part of a formal Root Cause Analysis (RCA), with the testing results feeding into the RCA Team's information database.



Turbine/ Generator Evaluation

General categories of failure mode that are typically considered include overload, stress corrosion cracking, and fatigue failures. Since material properties can affect component behavior within each of these failure modes, evaluation of the component's material condition and comparison to appropriate material specifications is also important. Once the failure mode is identified, an RCA team can combine information regarding the machine's operating history, vibration data, cycle chemistry, and stress distribution to ultimately determine why the turbine failed. Our team of experts understand these goals, and can provide a full range of failure analysis testing and analysis methods to assist with causal analysis.



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High Temperature Hydrogen Attack

High-temperature hydrogen attack occurs in steels that operate above a certain pressure and temperature in a hydrogen environment.

High temperature hydrogen attack (HTHA) is a phenomenon which occurs within some industrial processes when the presence of hydrogen, subjected to high temperature and pressure, makes plants and systems prone to damage. This reaction can cause an industrial plant to suffer serious failure, which may lead to both expensive repairs and loss of production.

HTHA can be detected in a number of ways, but it is considered that with the complexity of HTHA a more structured approach is necessary. A series of procedures have been developed containing the latest advances in ultrasonic imaging and data processing techniques in order to achieve a greater level of confidence in both HTHA inspection results and inspection repeatability.

At AMCO with a full understanding of both the phenomena and the methods to assess it, we feel our HTHA service will help minimize your risk. Our experienced team and consultants are able to efficiently evaluate the presence of hydrogen damage to prevent failure of critical plant equipment. The information recorded can be later on analyzed allowing fitness for service calculations or condition assessment.

The Nelson curves are the set of graphs that have been widely used to delineate the safe operating conditions. Recent reports have found several incidents where HTHA occurred in the 'safe' region of the Nelson curves. In light of these findings, many companies are reexamining their approach to HTHA detection and analysis.

Need HTHA consultancy?

From a metallurgical point-of-view, high-temperature hydrogen attack (HTHA) is a incredible example of the mobility and power of tiny hydrogen particles in steel structures. HTHA can have serious consequences and has recently been cited in a number of dangerous failures, including several fatalities. The difficulty of HTHA is that it hides from most traditional inspection techniques until significant damage has occurred.

Our team includes hydrogen experts with skill at finding and evaluating the effects of HTHA.

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Structure Integrity Assessment

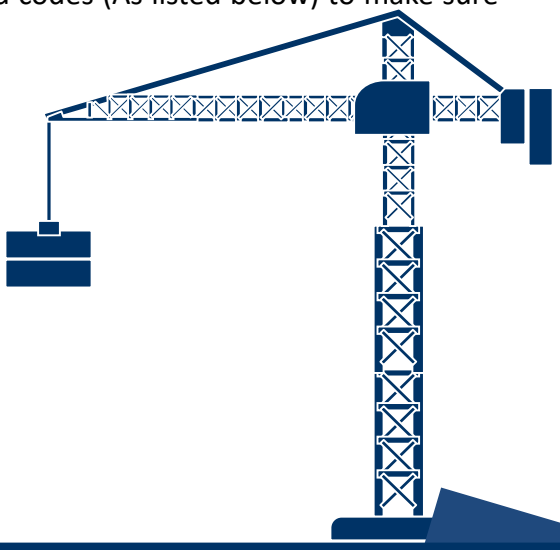
AMCO is having an experience in structural integrity, inspection and analysis. The current structural condition, assess the probability and requirements for extending the life of existing structures and develop integrity management strategies to meet business needs and legal requirements. Understanding the critical area for failure and develop continuous improvement strategies and reliability whilst reducing costs. We at AMCO help our clients Worldwide to assess the structure and help them to identify critical and high risk areas to avoid any failures, which have caused:

- Loss of Reputation
- Heavy Penalties,
- Loss of Life or Injuries
- Loss of Production
- Environmental damages
- Financial losses

Through the application of advanced structural integrity and analysis techniques, the reliability of equipment can be improved, replacement intervals for equipment components inspection and enhance the remaining life in aged equipment.

We use and have an experience with different structure standards and codes (As listed below) to make sure our customers are meeting their obligations. Standards include:

- ISO 13822
- ISO 13824
- ISO 2394
- ISO 31000
- AS 3990
- AS 1170
- AS 1657
- AS 2550
- AS 3600
- AS 1418
- AS 1554
- AS 5104
- AS 4324
- AS 4100
- AS 3990
- AS 3600



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Mechanical Improvement Services

AMCO Integrity help clients cost effectively and safely manage the integrity, performance and reliability of their assets at every stage of the lifecycle, from design to operating and maintenance through to late life and decommissioning. Improve safety, maximize operability, improve profitability process support, corrosion, metallurgy, risk analysis and increase the life expectancy of plant asset.

The goal of this programme is to effectively manage corporate assets in order to gain maximum value, profitability and returns while safeguarding personnel, the community, and the environment. A true Integrity Management program incorporates design, maintenance, inspection, process, operations, and management concepts, since all these disciplines impact the integrity of infrastructure and equipment.

Scope of Work:

- Inspection (advanced technologies including EDSE, SFM)
- Risk assessment and Risk Based Inspection (RBI)
- Maintenance (reliability, predictive and preventive strategies)
- Operational and process support (critical operating and process windows)
- Process safety and mechanical integrity services
- Management strategies
- HSE strategies
- Training in industry codes, standards and regulations
- Finalization of the report and submission.

Benefits:

- Maximizing Reliability, Availability, Maintainability (RAM) of equipment
- Enhancing plant performance and profit
- Improving safety and reduce risk
- Reduction in maintenance and inspection cost
- Improving personnel safety and performance
- Optimizing sparing

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Corrosion Management Services

Corrosion Control & Consulting Services

CORROSION-CONSULTING SERVICES OFFERED

- Corrosion Prevention and Control
- Root-Cause Failure Analysis
- Consulting and Expert-Witness Services
- Court Testimony and Depositions
- Materials Engineering
- Selection and Performance of Metals, Non-Metals, and Coatings
- Corrosion Data and Literature Searches, Reviews, and Reports

The best background for corrosion consulting is to have practical field experience in identifying and solving corrosion problems. No other company in Middle East has the breadth and depth of experience that AMCO offers in research, analysis and practical solutions for corrosion control.

AMCO Integrity has been providing corrosion consulting, corrosion prevention, and corrosion-control services for more than few years. Our objectives are:

- to provide a high quality of service at a reasonable price
- to develop practical solutions to clients' corrosion problems
- to work with our clients as a team.

Investigating thousands of failures across multiple industries

AMCO's experienced, professional staff along with its consultants has specialized expertise in corrosion technology and investigating corrosion-related failures.

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Corrosion Control & Consulting Services

AMCO Integrity have investigated thousands of failures due to corrosion and/or mechanical causes. The practical, experience-based backgrounds of our corrosion engineers qualify us to investigate a full range of corrosion problems across different industries. These include business, industry, insurance, legal, and government entities.

Our knowledge of corrosion spans both elevated-temperature and ambient temperature, aqueous-corrosion mechanisms. If something has failed due to corrosion, we have probably seen it – and solved it.

Providing extensive testing and resources

AMCO's professional staff is backed by the capabilities of a full-service chemical, mechanical, and corrosion-testing laboratory. Additional benefits include our extensive company technical library and on-line database search capabilities.

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Reliability Assessment

Reliability Centered Maintenance

What is RCM?

Reliability Centered Maintenance (RCM) is an engineering framework that enables engineers to empirically devise an optimum maintenance regime for plants. In recent years, maintenance and operation performance of plants has assumed far greater importance, resulting in the development of new maintenance philosophies and techniques. Reliability Centered Maintenance, often known as RCM, is an industrial improvement approach, focused on identifying and establishing the operational, maintenance and capital improvement strategies that will manage the risks of equipment failure most effectively. With the application of RCM principles, maintenance is evaluated and applied in a rational manner that provides the most value to a system's owner/ manager/ operator. The objective of RCM is to achieve reliability for all of the operating modes of a Plant Systems / Equipment / Components at an optimized cost.

AN OVERVIEW OF BASIC CONCEPTS

Reliability Centered Maintenance (RCM) analysis provides a structured framework for analyzing the functions and potential failures for a physical asset (such as an airplane, a manufacturing production line, etc.) with a focus on preserving system functions, rather than preserving equipment. RCM is used to develop scheduled maintenance plans that will provide an acceptable level of operability, with an acceptable level of risk, in an efficient and cost-effective manner. In recent years, maintenance and operation performance of plants has assumed far greater importance, resulting in the development of new maintenance philosophies and techniques.

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Reliability Centered Maintenance

With the application of RCM principles, maintenance is evaluated and applied in a rational manner that provides the most value to a system's owner/ manager/ operator. The objective of RCM is to achieve reliability for all of the operating modes of a Plant Systems / Equipment / Components at an optimised cost.

AMCO Integrity Pty Ltd offers a complete RCM Study and implementation guidelines of following categories of plant:

- ✓ Fossil power plants;
- ✓ Petrochemical plants; and
- ✓ Process plants.

In addition to the design of Maintenance and Reliability programmes, the following additional options are also available:

- ➢ Complete audits of existing programmes;
- ➢ Development and implementation strategies;
- ➢ LTSA reviews and the integration of the same with improved programmes.

BENEFITS

The main advantage of an RCM approach is that future Preventive Maintenance based tasks or RBIs (Risk Based Inspections and Maintenance) planning based on RBMS (Risk Based Maintenance Strategies) will be subject to objective and methodical review, which allows resources to be allocated to the highest risk areas first.

This approach avoids a lot of overspend on manpower and financial resources, resulting in more efficient utilization of the overall inspection and maintenance budgets, and enhancement of plant safety and reliability levels.

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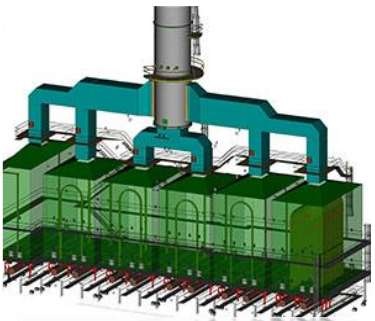
Reliability Centered Maintenance

RCM can be used to create a cost-effective maintenance strategy to address major causes of System/ Equipment/ Component failure. It is a systematic approach to defining a routine maintenance programme composed of cost-effective tasks that preserve important functions.

The result is a maintenance programme that focuses scarce economic resources on those items that would cause the most disruption if they were to fail.
RCM emphasizes the use of Predictive Maintenance techniques in addition to traditional Reactive or Preventive Maintenance measures.

AMCO's RCM study is intended to provide information and guidance for improved inspection and maintenance planning for the system studied. The reduction of System/ Equipment/ Component failures through applying mitigating measures will enhance the economics of fossil power plant operation. RCM develops a System driven plant maintenance strategy with optimized cost and improved reliability.



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Risk Based Inspection/Maintenance

AMCO Integrity provide Risk-Based Inspection/Maintenance services to refineries, oil & gas processing, petrochemical and power plants. Our RBI programme is designed to both qualitative and quantitative criteria and is based on the American Petroleum Institute RP 580/581 inspection methodologies.

Increasingly these days Maintenance Managers are finding that there is less time (and/or money) available to do the amount of maintenance that they would like to do. The key question that is often asked is "what outage tasks should I give priority to?" The answer is clearly to concentrate on the "value" Tasks, but how do you identify the critical tasks. There are a number of ways to assess the priority that should be given to maintenance or inspection tasks but increasingly a Risk Based approach is preferred. Although procedures are available for petrochemical and refining plant there was not one available for Power Plant. To address this need AMCO developed Risk Based Inspection and Maintenance Guidelines specifically aimed at generating equipment.

The main objective of Risk Based Maintenance is to allow a framework to identify and measure the risk areas and thereby allow optimized focusing of available resources.

It is important to recognize that identification of risks does not necessarily require a substantial financial or resource commitment rather, as the AMCO Guideline shows, a simplified system readily highlights and ranks risk areas for attention. The AMCO RBM process uses a "Risk Waterfall" Initially this involves examining how well the plant is managed in terms of technical and other programs and is carried out by comparison with good/best practice the attributes (or lack of attributes) of each program of each area. The output is a numerical indication of the level of risk in different plant areas. This is followed by a more detailed evaluation of the degree of risk by assessing how effectively the technical programmes are implemented and an estimate of the probable condition of specific components.

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Risk Based Inspection/Maintenance

Finally the maintenance activities to be performed on the component at the next shutdown are examined in terms of their (risk based) value and the cost of the activity to prioritize on a value cost basis. This allows elimination of the low value tasks and hence saving the costs associated with these tasks.

RISK BASED METHODS FOR OPTIMISING THE CONTENT AND TIMING OF OVERHAULS

In the current economic climate it is important to not only minimize risk levels but to do it at minimum cost. One of the main controllable costs is maintenance. The time it takes to carry out maintenance, the interval between outages, the quality and efficiency of the outage work and subsequent plant performance can all have a major impact on cost. AMCO has a suite of risk based methods for optimizing the maintenance and overhaul activities.

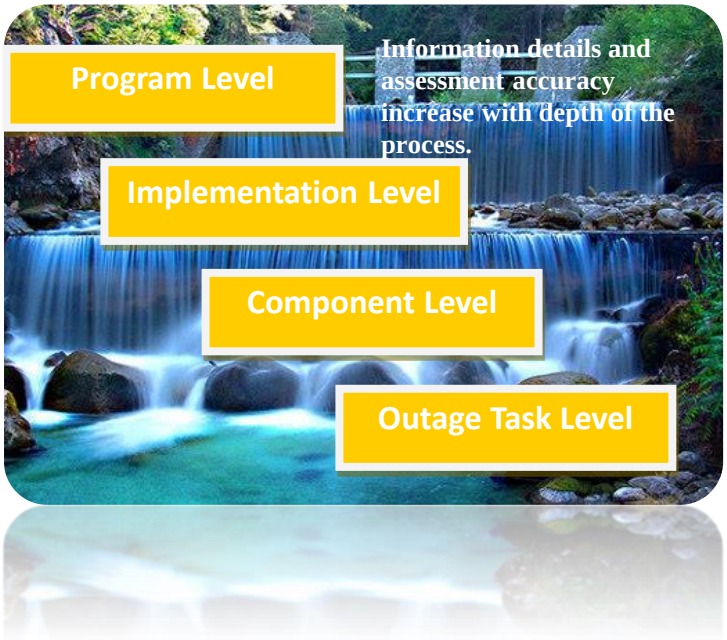
KEY AREAS ARE

- **Optimizing the outage content :**
  Risk can be used to define the value of all of the maintenance and inspection activities. When this is combined with the cost of the activity a cost/risk optimized outage program can be defined. As shown opposite the majority of the plant risk can be captured with a relatively small percentage of the original planned outage activities.

- **Optimizing the interval between outages:**
  By assessing the current condition of plant components and looking at how their risk levels increase with service it is possible to identify ways of moderating the risk thereby allowing longer run times between overhauls.

Risk Based Inspection/Maintenance

- **Optimizing Outage Productivity :**
  By using advanced project management skills, improved planning support and project risk identification and mitigation processes a productivity improvement of 10-20% can be achieved.



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Asset Criticality Analysis

There are so many decisions you have to make when striving to improve reliability that require prioritization. Which machines do I include in a condition monitoring programme? Which spares do I need to keep on hand? How do I prioritize work requests? Which projects identified in my "bad actor" list do I work on first? Which assets do I include in my detailed RCM analysis? And you can probably think of others.

Asset Criticality Analysis is a process by which assets are assigned a criticality rating based on their potential risk. Asset dependent organizations need to be continually educated and diligent about the importance of classifying assets in terms of the impact of asset failure on the organization. The aim is to identify the consequence and likelihood of failure of an asset to perform its function. The results of the asset critically analysis can be used to develop an appropriate and cost-effective maintenance strategy to manage organizational risk.

What is Asset Criticality Ranking?

The asset criticality ranking, is the combination of three important elements:

Consequences: The consequence of failure (including the impact on production, safety, environment, and quality, and the replacement/repair cost).
Reliability: The reliability of the asset (the likelihood that it will develop a fault condition that would lead to functional failure such that we would experience those consequences).
Detectability: The detectability of the fault condition (how likely it is that we will detect the onset of failure and thus avoid those consequences).

At one extreme we could have an asset that is unreliable, with no means of detecting imminent failure, with dire consequences if failure occurs.

Asset Criticality Analysis

That asset poses a serious risk. That asset will achieve a high asset criticality ranking. At the other extreme, if the consequence of failure is very low, and the reliability is high, and we will be warned when failure is imminent, then it poses almost no risk and there is no point in taking any preventative action. We can probably let that asset run to fail. Therefore, rather than having a criticality ranking scheme that simply declares that an asset is critical, essential, or nonessential (or some other categorization), it is important to develop a numerical scoring system that enables you to make important decisions.

Ranking the Consequence of Failure

You would then define five levels of severity in each of those areas. For example, for maintenance the five levels could be:

Insignificant: Minimal damage to equipment. No effect on other equipment. Spare held on site.
Minor: Moderate damage to equipment. Minimal damage to other equipment. Spare held in region.
Moderate: Major damage to equipment. Damage to other equipment. Spare available in less than one day.
Major: Destruction of equipment. Major damage to other equipment. Spare held in state but available in more than one day.
Extreme: Destruction of equipment. Destruction of other equipment. Spare not held in state.

When assessing the failure risks to determine equipment criticality, there are four key tips for achieving a robust, but streamlined process.

- Realise that risk relates to events – not equipment
- Select only one event – the event
- Assess only one risk dimension – the one with the highest level of risk
- Start at the top of the equipment hierarchy and work down

FMEA and FMECA Analysis

Failure Mode Effects Analysis (FMEA) is a structured analytical tool used by an organisation, business unit, or cross-functional team to identify and evaluate the potential failures of a process. This tool helps to establish the impact of the failure, identify and prioritise the action items with the goal of alleviating risk. It is a living document that should be initiated prior to process of production and maintained through the life cycle of the product.
For each component, the failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA worksheet or tools. AMCO Integrity is developing its own RCA and FMEA tools and will be available end of this year for the analysis.

Benefits:
FMEA and FMECA effort are as follows:

- It provides a documented method for selecting a design with a high probability of successful operation and safety.
- A documented uniform method of assessing potential failure mechanisms, failure modes and their impact on system operation, resulting in a list of failure modes ranked according to the seriousness of their system impact and likelihood of occurrence.
- Early identification of single failure points (SFPS) and system interface problems, which may be critical to mission success and/or safety. They also provide a method of verifying that switching between redundant elements is not jeopardised by postulated single failures.
- An effective method for evaluating the effect of proposed changes to the design and/or operational procedures on mission success and safety.
- A basis for in-flight troubleshooting procedures and for locating performance monitoring and fault-detection devices.
- Criteria for early planning of tests.

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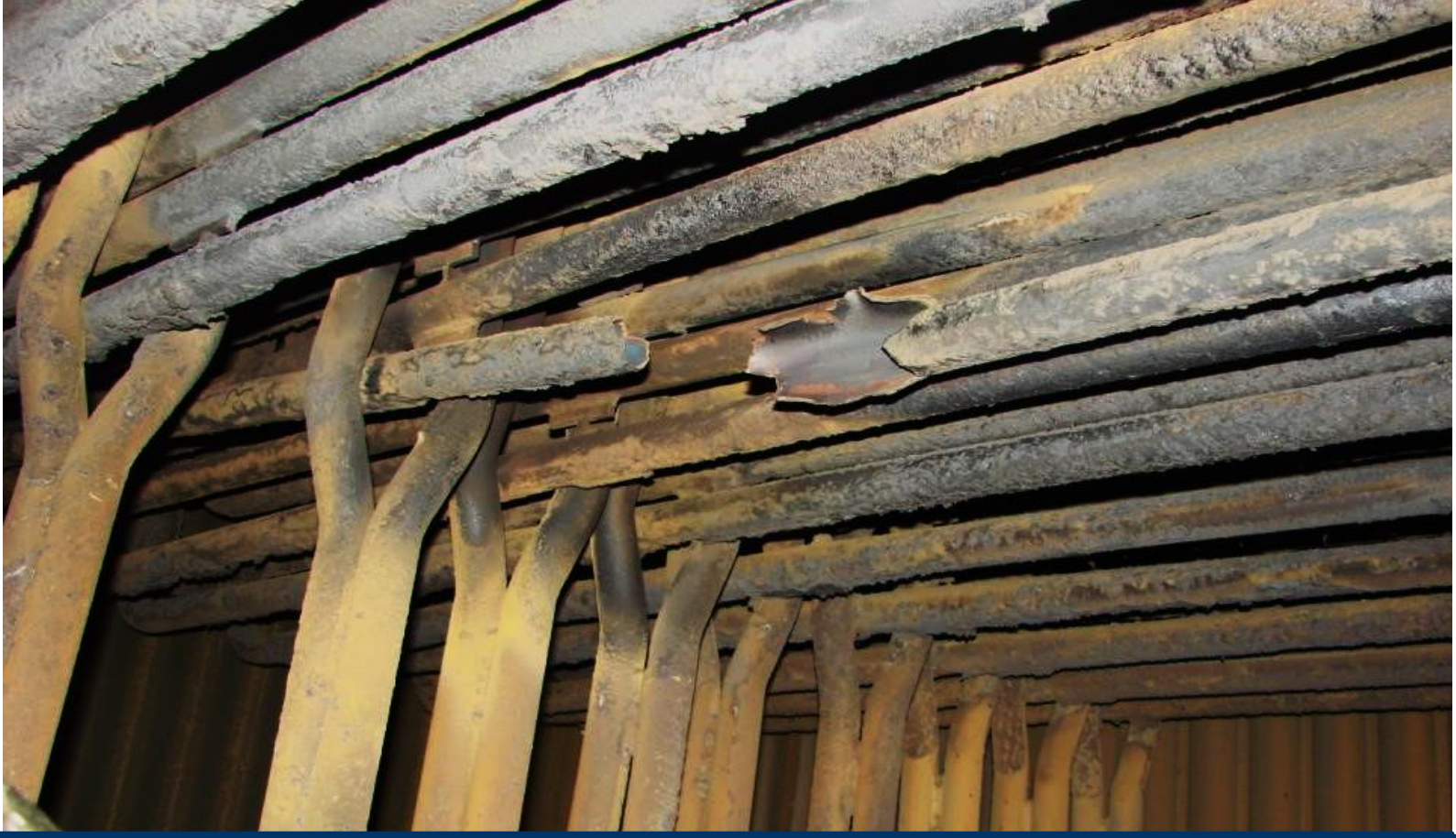
FMEA and FMECA Analysis

How to perform Failure Mode Effects Analysis (FMEA)

There are several times at which it makes sense to perform a Failure Mode and Effects Analysis:

- When you are designing a new product, process or service
- When you are planning on performing an existing process in a different way
- When you have a quality improvement goal for a specific process
- When you need to understand and improve the failures of a process

In addition, it is advisable to perform an FMEA occasionally throughout the lifetime of a process. Quality and reliability must be consistently examined and improved for optimal results.



Root Cause Analysis (RCA)

You can apply RCA to almost any situation. Determining how far to go in your investigation requires good judgment and common sense.

A factor in a problem-fault-sequence is considered a root cause if removing it prevents the final undesirable outcome from recurring. A causal factor, conversely, is one that affects an event's outcome, but is not the root cause. Although removing a causal factor can benefit an outcome, it does not prevent its recurrence with certainty.

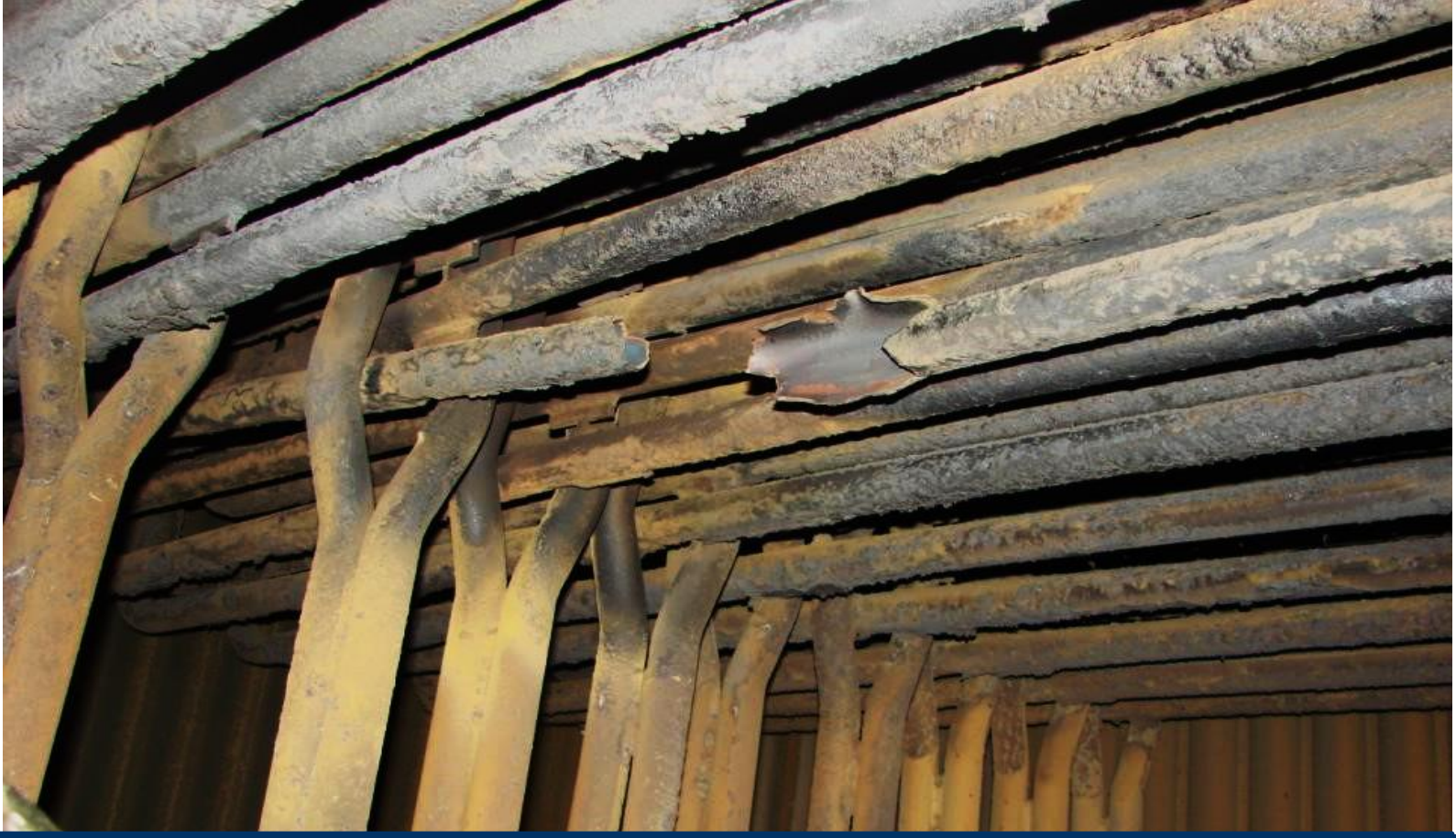
Root Cause Analysis (RCA) is a popular and often-used technique that helps people answer the question of why the problem occurred in the first place. It seeks to identify the origin of a problem using a specific set of steps, with associated tools, to find the primary cause of the problem, so that you can:

- Determine what happened.
- Determine why it happened.
- Figure out what to do to reduce the likelihood that it will happen again.

RCA assumes that systems and events are interrelated. An action in one area triggers an action in another, and another, and so on. By tracing back these actions, you can discover where the problem started and how it grew into the symptom you're now facing.

You'll usually find three basic types of causes:

Physical causes – Tangible, material items failed in some way (for example, a car's brakes stopped working).
Human causes – People did something wrong, or did not do something that was needed. Human causes typically lead to physical causes (for example, no one filled the brake fluid, which led to the brakes failing).



Root Cause Analysis (RCA)

You can apply RCA to almost any situation. Determining how far to go in your investigation requires good judgment and common sense.

Organisational causes – A system, process, or policy that people use to make decisions or do their work is faulty (for example, no one person was responsible for vehicle maintenance, and everyone assumed someone else had filled the brake fluid).

RCA looks at all three types of causes. It involves investigating the patterns of negative effects, finding hidden flaws in the system, and discovering specific actions that contributed to the problem. This often means that RCA reveals more than one root cause.

The Root Cause Analysis Process

- ✓ Step One: Define the Problem
- ✓ Step Two: Collect Data
- ✓ Step Three: Identify Possible Causal Factors
- ✓ Step Four: Identify the Root Cause(s)
- ✓ Step Five: Recommend and Implement Solutions

Analyse your cause-and-effect process, and identify the changes needed for various systems. It's also important that you plan ahead to predict the effects of your solution. This way, you can spot potential failures before they happen.

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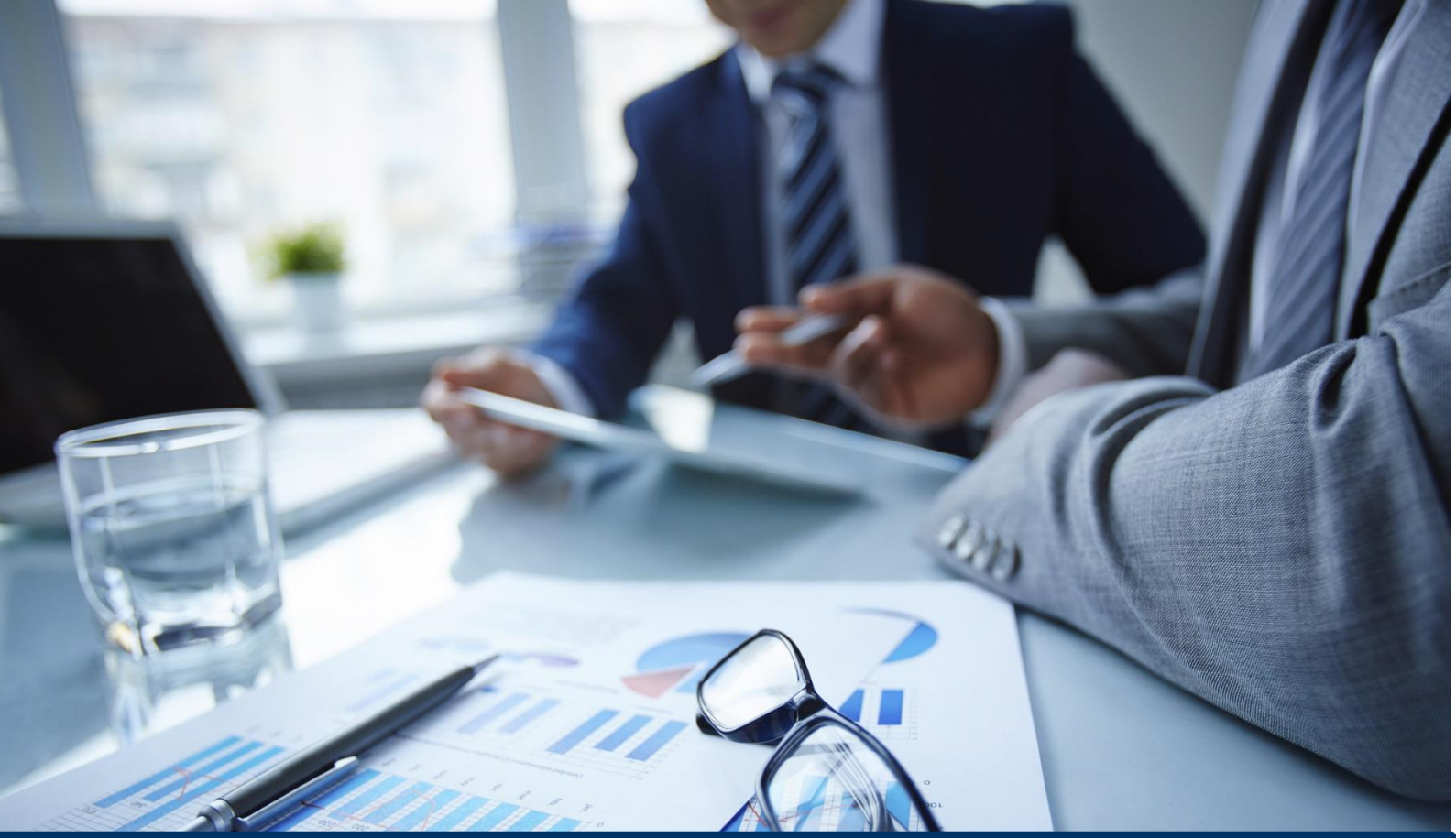

Asset Management Strategies

Develop maintenance strategy! What you want to gain with your equipment maintenance, why it is important for the equipment and how to do it to meet the stakeholder expectations. Then turn strategy into the plans to maintain production asset reliability with the equipment maintenance program.

Most maintenance improvement initiatives today are functional in nature. Managing assets strategically involves every function in the plant working towards the same goals. Operations and maintenance are rewarded for creating and utilizing the capacity of their units. Many companies have recently implemented reliability initiatives geared toward optimizing the maintenance function at their plants. Some are successful; however, most will admit they did not realize the expected benefits. The Five Step Process to Developing Asset Strategy

1. Define the Problem
2. Analysis and Process Mapping
3. Failure modes and effects analysis (FMEA
4. 4. Initial Asset Strategy
5. Institutionalize the continuous improvement process and make it visual

The key requirements of successful plant-wide reliability improvement are these:

• An analysis of the potential production available in the plant based on best demonstrated performance and operating characteristics of best performing plants
• Quantified current operating rates of each units, and goals for improving these rates
• A business case with a three-five year horizon which identifies expectations for costs and production based on improvement efforts.
• A multi-year plan that identifies the types of changes in practices and measurements needed to achieve the goals

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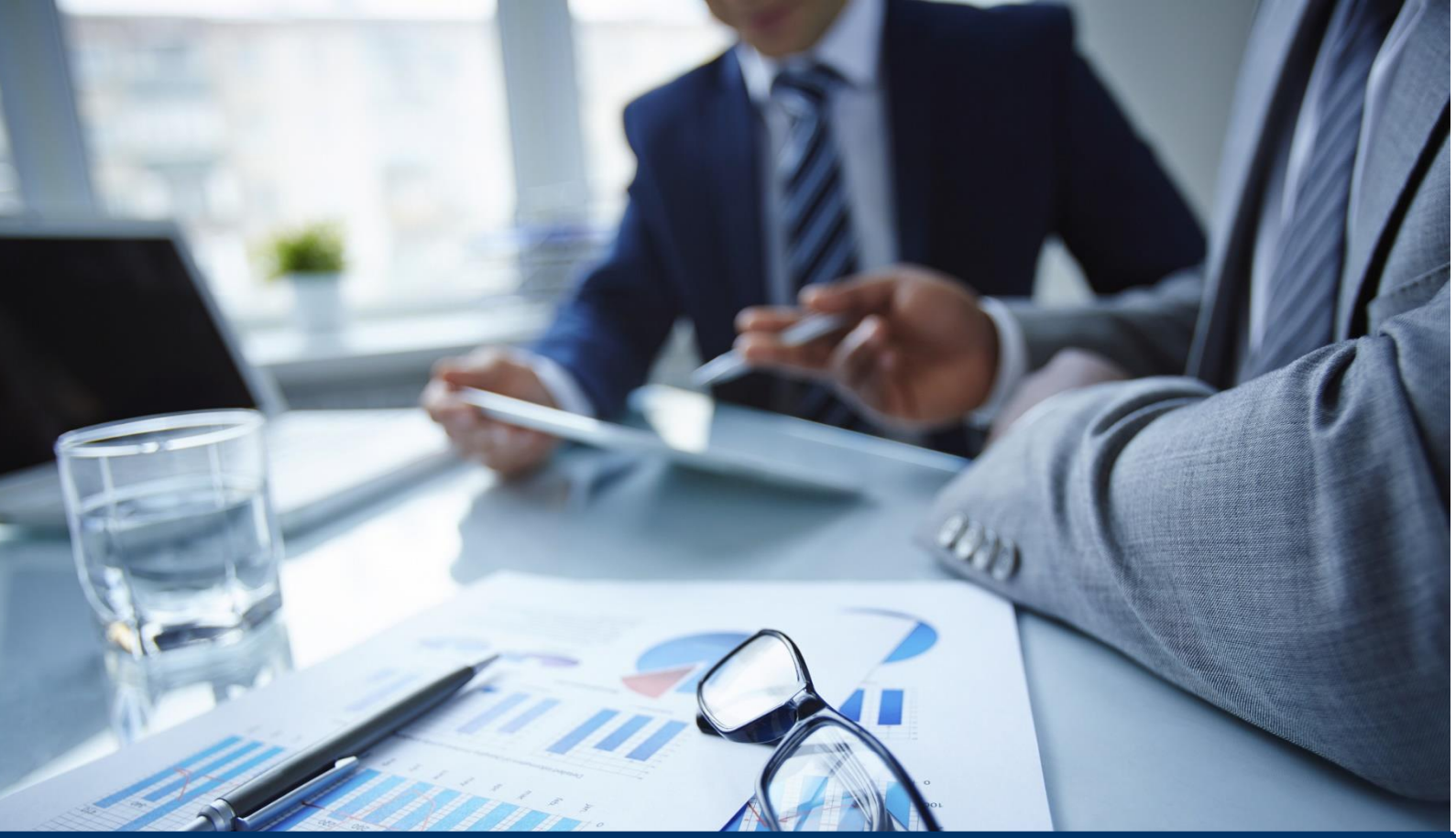

Asset Management Strategies

- A keen understanding that every function works interdependently to management equipment health
- Accountability for delivering these results, transcending annual budget cycles

We at AMCO Integrity take our clients through the development of a sound Maintenance Strategy meeting their business requirements, maintenance budget and proven methodologies.

Strategies may be developed from a detailed Failure Modes and Effects Analysis or Failure Modes Effects and Criticality Analysis where the equipment is analysed from a component or function standpoint. Both of these processes can define a maintenance strategy.

Today maintenance managers have huge pressure due to low production and increasing cost, AMCO Integrity Pty Ltd can assist. We provide a wide range of maintenance strategies and reliability management services. Our maintenance experts can support:

- Study current maintenance strategy and history to find the Most suitable maintenance improvement opportunities
- Preventive maintenance strategy development
- Predictive maintenance strategy development
- Enterprise Asset Management Strategy Development
  Maintenance Audit and/or Maintenance Management System Audit
- Equipment criticality analysis
- Operational risk assessment
- Conducting Failure Mode Effects Analysis (FMEA)
- Conducting Failure Mode, Effects and Criticality Analysis (FMECA)
- Performing Reliability Centred Maintenance (RCM) Analysis
- Doing Root Cause Failure Analysis (RCFA) of Equipment Failures

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Strategic Asset Management

The **Asset Strategy** is the top level strategic plan in the Total Asset Management (TAM) process. The Asset Strategy helps to demonstrate the relationship between the performance of their physical asset portfolio and the services they deliver. It also enables to determine whether the proposed services and resultant physical asset requirements are sustainable within realistically anticipated funding levels.

Managing assets strategically involves every function in the plant working towards the same goals. Operations and maintenance are rewarded for creating and utilizing the capacity of their units. Purchasing has its main goal as operating reliability, with cost as an important but secondary goal. Engineering is based on total lifecycle value created, including product characteristics, maintainability, operability, and total cost per output unit.

Strategic Asset Management represents a comprehensive, top-down approach to managing plant equipment and people for maximum profitability and reduce maintenance cost. It's single most important feature is in its fact-based management of the potential profitability of a plant, based on market conditions and variables within the control of management. The scope of Strategic Asset Management (SAM) begins with sales forecasting, through production planning, includes all facets of manufacturing, and ends with delivery of product to a customer.

As per Bradley, we start with a view of the original purpose of the plant.

- To provide employment?
- Yes, but only as a byproduct.
- To satisfy customers?
- Yes, but as a means to an end.

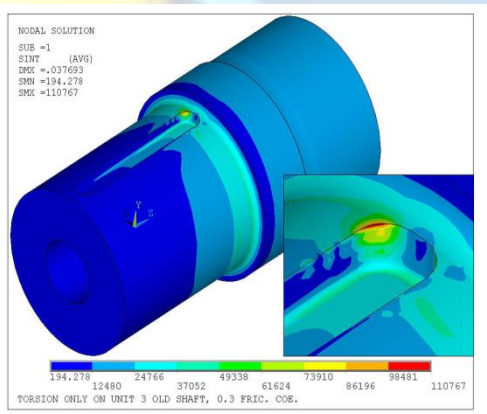
Engineering Design Analysis

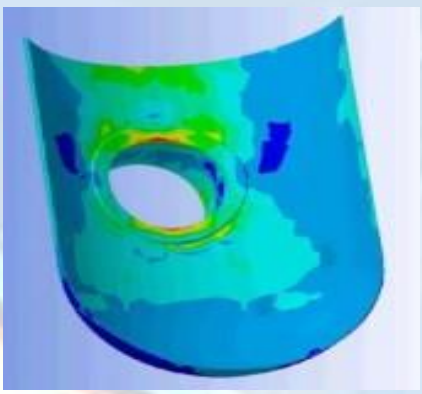
Critical components and systems can exhibit problems or issues at any time during their service lives. New systems can break down prematurely or fail to function as designed, older systems can incur long-term wear or damage or fail as a result of other unidentified causes, or changes to the design or operation of a system can result in a need to understand how the current condition of the component or system will affect performance.

AMCO Integrity offers in-house finite element (FE) modelling of plant components. FE modelling can help in a number of circumstances – at the design phase, when looking for stress concentrations and deciding the placement of welds; in remaining life assessment, when evaluating the effect of thinning on stress distribution; in maintenance planning, when locating areas for inspection etc. Our engineers have experience modelling complex components and interpreting the results to provide you with the best recommendations.

These tools can be applied to a wide variety of components and systems, including:

- Headers and Drums
- Welds/DMWs
- Nozzles
- Valves
- Piping
- Turbine Rotors/Disks
- Boiler Tube Assemblies
- Pressure Vessels
- Steam Chests
- Structural Components
- Fasteners/Bolts
- Fittings





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Engineering Design Analysis

Why Finite Element Modelling?

Finite element analysis (FEA) is a computer-based technique which can be used to analyze mechanical components or parts. FEA is also a popular numerical methodology that is widely used to solve engineering problems. Major applications for FEA include static, dynamic and thermal characterizations of mechanical components or parts.

The use of FEA in modelling the viscoelastic properties such as incompressibility, large strains and non-linearity. Even with the complex theory, shortcomings and difficulties, non-linear FEA is becoming more popular as a standard analysis tool for stress analysis, failure analysis, fluid mechanics, heat transfer etc.

Geometric discontinuities cause a large variation of stress locally and often produce a significant increase in stress. The high stress due to geometric discontinuity is called a 'Stress Concentration'. This can also appear when loads are applied over a small area or at a point. Geometric discontinuities are often called as 'Stress Risers'. Examples of stress risers include holes, notches, fillets and threads in a structural member.

Often, Stress Risers are at the starting point of material damage. This ultimately leads to material failure by fracture. For this reason, it is important to realize the existence of stress concentrations and understand the overall behavior of some typical geometrical configurations for critical applications. The ratio of the average or nominal stress to maximum stress is called Stress Concentration Factor and is denoted by K. These Stress Concentration Factors are significant in any mechanical component, as they gives rise to localized stress when any change in the design or surface, or abrupt change in the cross section, occurs. Almost all machine components and structural members contain some form of geometrical or micro-structural discontinuities. These discontinuities are very dangerous and lead to failure. So it is very much essential to analyze the stress concentration factors for critical applications like Turbine Rotors, Tee Joints, valves etc.

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Asset Management (ISO5500X)

What we Offer as an Asset Management Consultant?

AMCO Integrity is specializes in asset management and is providing services around the globe. AMCO Integrity is offering several Asset Management services and few of them are listed below:

- Asset management life cycle
- Asset management strategy and planning
- Asset management decision making
- Asset selection and criticality determination
- Quality management
- Equipment deficiencies management
- Asset management programs implementation
- Organisation, leaderships and people
- Risk and review
- Selection and Implementation of asset management information systems
- Preventive Maintenance Optimization

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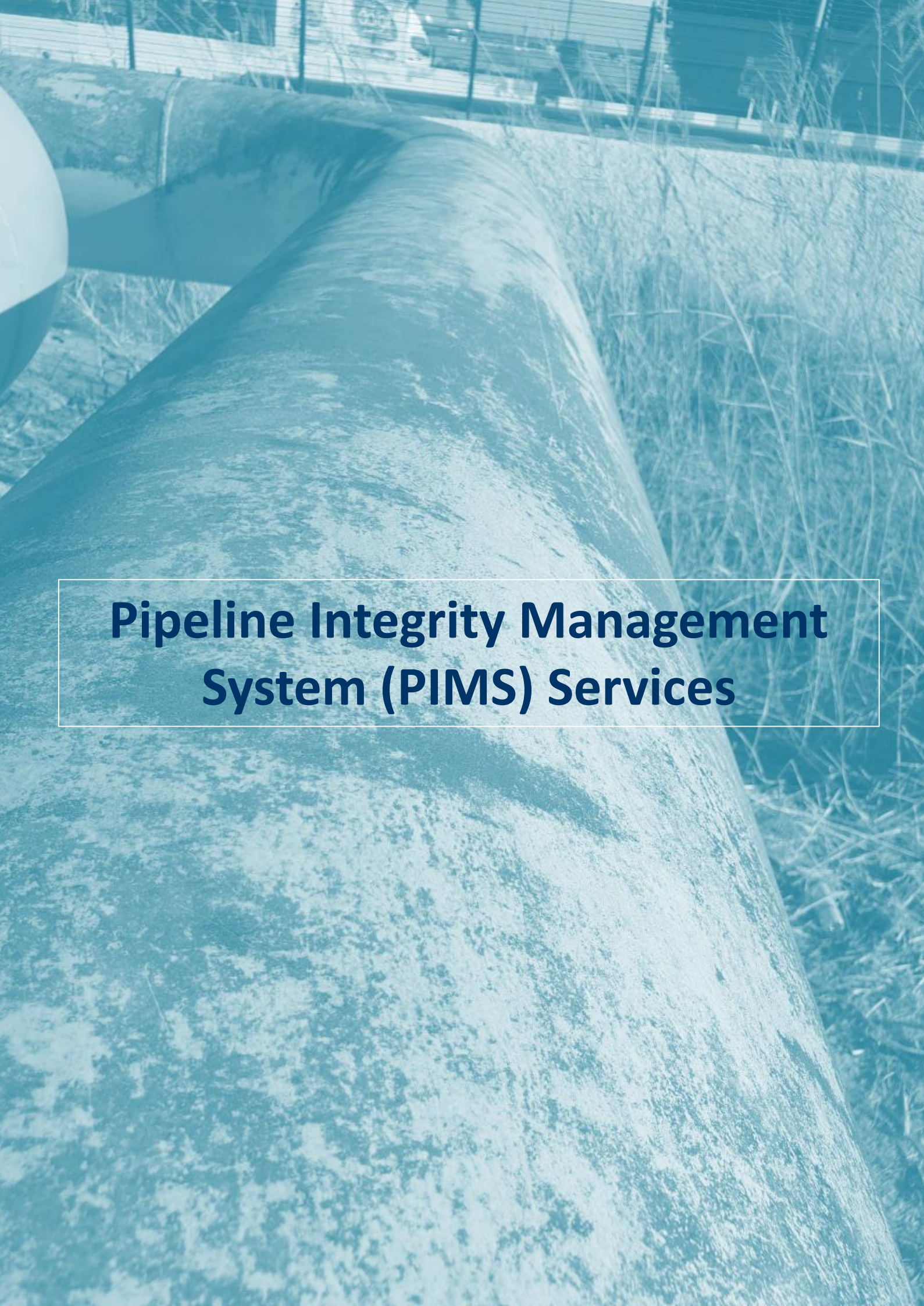

Pipeline Integrity Management System (PIMS) Services

Pipeline Integrity Management

AMCO Integrity offers a detailed, systematic, and integrated integrity management program, pertaining the means to improve the safety of pipeline systems. Such an integrity management program provides the information for plant operator to effectively allocate resources for appropriate prevention, detection, and remedial activities that will result in improved safety and a reduction in the number of incidents.

AMCO Integrity provide a process to assess and mitigate risks in order to reduce both the likelihood and consequences of incidents. It covers both a prescriptive-based and a performance-based integrity management program. The prescriptive process, when followed explicitly, will provide all the inspection, prevention, detection, and mitigation activities necessary to produce a satisfactory integrity management program.

AMCO Integrity have qualified staff to execute such projects.

Our Services Includes;

1. Asset Management Framework
2. Condition Assessment
3. Fitness for Purpose
4. Life Assessment
5. Failure Analysis
6. Big Data Analysis
7. Life Cycle and Costing Analysis
9. Life Prediction
10. Inspection Services

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