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SPECIAL RELEASE VOLUME 1 JANUARY

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CONTENTS

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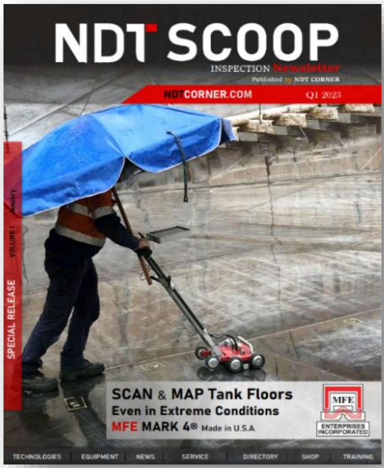

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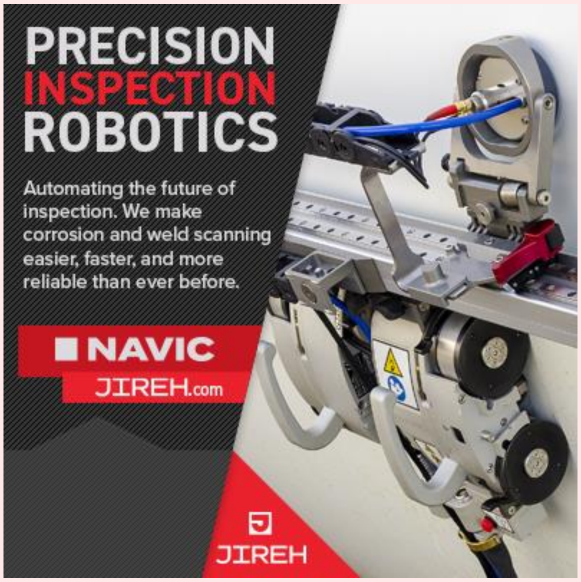
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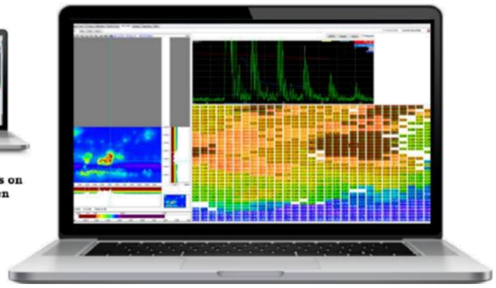

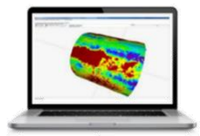

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MAGNETIC FLUX LEAKAGE EXAMINATION

WHAT is MFL?

Magnetic Flux Leakage (MFL) Examination is a method of non-destructive testing (NDT) for a ferromagnetic material; began to be widely used from the beginning of the 50s in the twentieth century and is the most popular methods of tank floor, pipeline, and tubular inspection. It is a qualitative test used to detect and assess corrosion, pitting and wall loss in lined and unlined metallic storage tanks and pipelines. A powerful magnet is used to magnetize the steel in areas where there is corrosion or missing metal, the magnetic field “leaks” from the steel. MFL tools use sensors placed between the poles of the magnet to pinpoint the leakage field. MFL is a rapid and robust approach that continues to be widely used to detect corrosion defects in Tank Floors as it considered a large area within short time scales. Once a defect has been detected, the main failing of the MFL approach is its inability to size and classify. To Verify and improve sizing accuracy, defect needs to be quantified and followed up by prove up using UT thickness with A scan features.

MEASURING METHODS & SENSORS:

1. Electromagnetic induction method. Based on Faraday's law of induction Coil, it is one of the most basic magnetic measurement methods.
2. Magnetic resistance effect method. This method utilizes the changing characteristics of material resistances under magnetic fields.
3. Hall Effect method. The electromotive force is generated by the electric current in the magnetic field. The change of the magnetic field intensity can be obtained by measuring the electromotive force.
4. Magnetic resonance imaging. By absorbing or radiating a certain frequency of electromagnetic wave in the magnetic field.
5. Magneto optical method. This approach utilizes the magneto-optical and magneto-stricture effects.

TANK BOTTOM DEFECTS & CORROSION:

In Oil & petrochemicals industries, corrosion is one of the main causes of catastrophes to structures and equipment. Atmospheric storage tanks, pressure vessels and pipelines are gradually corroded by chemical or electrochemical reactions within their environment.

The most common types of corrosion are pitting and uniform corrosion, especially pitting corrosion in low carbon steel. Low carbon steel is widely used as the main material for atmospheric storage tank floors, and the atmospheric storage tanks play an irreplaceable role in storage and transportation of crude oil and oil derivatives.

However, over 80% of the storage tanks shutdown, bottom perforation and leakage accidents are caused by tank bottom corrosion. This can cause very serious consequences on the environment, health and safety, producing a very wide range of hazards and disasters. Therefore, the storage tank bottom corrosion has attracted more and more attentions all over the world in recent decades.

UNDERNEATH PITTING CORROSION IN BOTTOM OF CRUDE STORAGE TANKS:

Soil-side corrosion of aboveground storage tank may be the main cause of tank failure, with thousands of Aboveground Storage Tanks (ASTs) installed, the MENA (Middle East & North Africa) region is not an exception. Ingress of chlorides and other corrosive species from the native soil and groundwater through the tank pad, along with the presence of bacteria such as SRB (sulfate-reducing bacteria), are believed to be the main causes for soil-side corrosion. Airborne chlorides and moisture can seep into the under-tank environment through the chime area, causing annular plates to corrode.

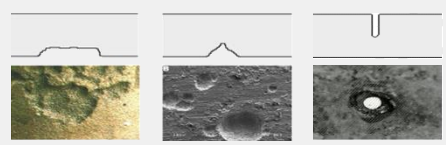
Underneath pitting corrosion is localized corrosion in bottom plates from soil side, this is most critical corrosion problem in tanks and it leads to bottom failure. Corrosion rate depends on the soil characteristics, moisture content in the padding and extent of water ingress between padding & bottom plates. Cause of pitting corrosion and embedded stone particle assisted crevice corrosion based on field & laboratory inspections and alternatives to mitigate the underneath corrosion effectively in future, are included in this paper broadly.

DEFECTS & CORROSION COMMON TYPES:

Corrosion comes in many different shapes and sizes grouped into three categories based on its geometrical shape:

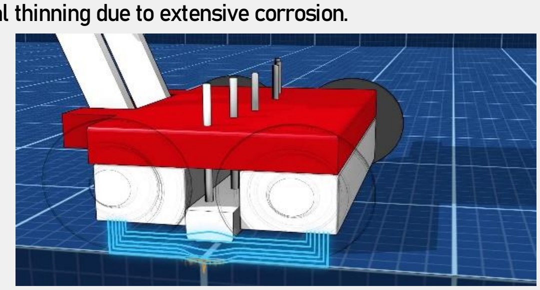
1) Lake (Dish shaped corrosion)
2) Pit (Conical shaped corrosion pits)
3) Pipes

Lake Type | Pit type | Pipe type



► Lake Type, have a large diameter compared to their actual depth.
► Pit / Conical Type, have some rounding at its deepest point.
► Pipe Type, have small diameter similar to the drilled hole.

As corrosion grows these basic shapes can join together, dish/lake shaped corrosion can be more difficult to detect due to the sloping edges. The MFL equipment will detect a change in plate thickness. Thus once the MFL inspection head is within a large area of corrosion the system can only detect further loss in plate thickness. It may be possible to detect the edges of such corrosion and with follow up ultrasonic thickness inspections determine that there is an area of general thinning due to extensive corrosion.



Continue MFL EXAMINATION

EQUIPMENT DESIGN CONSIDERATIONS:

EX. Tank Floor Scanner; the equipment shall consist of magnets, sensor or sensor array, and related electronic circuitry. A reference indicator, such as a ruled scale or linear array of illuminated light-emitting diodes, should be used to provide a means for identifying the approximate lateral position of indications. The equipment may be designed for manual scanning or may be motor driven. Software may be incorporated to assist in detection and characterization of discontinuities. ASME BPVC Section V, Article 16, T-1630

It is vital that MFL equipment produced for this particular application is designed to handle the environmental and practical problems which are always present. A piece of equipment designed in a laboratory and proved in ideal conditions invariably has significant short comings in the real world application. Some of the major considerations are discussed in the following paragraphs.

Some instruments can be disassembled for operation in and around obstructions or smaller surfaces. Alternatively there are some specific "hand scanning" devices for such requirements.

MFL scanning can be carried out in an automated manner, where information from a scan run is captured. This can be evaluated at this time or stored on a computer to build up an MFL picture of the whole tank floor. Subsequent analysis of the data can be performed out with the inspection environment. From these analysis areas for follow up UT inspections can be identified.

ADVANTAGES of MFL:

- Reliable results and ability to locate and estimate the size of defects over large areas in a quick and efficient manner.
- MFL covers a wide area not only random reading as conventional methods, which increase the (POD) possibility of detection of anomalies and reduce the remaining life assessment RLA.
- Saving time and cost due to the high inspection rate.
- Comprehensive reporting with statistical data, and color mapping.
- It can detect many types of defects. For example, surface defects, stomata, scars, shrinkage cavities, corrosion pitting
- Automated Corrosion Mapping Reporting & Data Analysis.
- Immediate result "Real time Display".

MFL in INTERNATIONAL CODES & STANDARDS:

- API 653 Standard - Tank Insp., Repair, Alteration and Reconstruct.-ANNEX G
- ASME BPVC Code - Section V – Nondestructive Examination - Article 16
- ASNT Volume 5 - Electromagnetic Testing
- The MFL Compendium – Published by API & ASNT

MFL APPLICATIONS:

► Storage Tank Floors (AST) (lined and unlined metallic bottom):
MFL is a widely used to detect corrosion in above ground storage tank floors (ASTs) within the oil industry where tank floors are inspected periodically, the AST to be taken out-of-service and emptied. This makes maintenance times that much more expensive and calls for techniques that are both reliable and fast. MFL is widely used in the context because of its inherent speed. MFL is accepted technology for locating defects on a tank floor. It is recommended by API 653 & ASME.

► Pipeline External Inspection (lined and unlined metallic):
MFL is a widely used to detect corrosion in pipelines externally within the oil industry where it inspected periodically, the pipe can be inspected while in service. MFL is widely used in the context because of its inherent speed.

► Pipeline Intelligent Pigging:
MFL Pig is a type of intelligent ILI pig used to measure pipe corrosion and metal loss.

► Tubular Inspection:
The MFL is used to detect circumferential cracks, wall losses, and pitting in ferromagnetic tubes such as carbon steel, nickel and ferrous stainless steel for Air cooler, Boilers & Heat Exchanger.

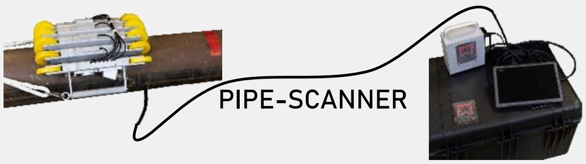
► Wire Rope Inspection:
The MFL measurement instrumentation supposed to be designed for detecting local faults (LF) & loss of metallic area (LMA) in external or internal layers of the wire rope.

SPOT ON SOME MFL EQUIPMENT:

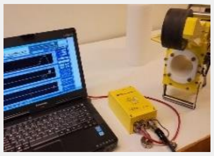
► Ex. 1: Storage Tank Floor Inspection.

MFL MARK IV
& EDGE SCAN

► Ex. 2: Pipeline External Inspection.



► Ex. 3: Wire Rope Inspection.



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2nd: Detecting and Defect Allocating Capabilities,

3rd: Scanner Structure & mobility,

4th: Power Requirements,

5th: Operation and Reporting Capabilities.

1st: SOFTWARE: MFESCAN V2.2.0 Alpha software including: Corrosion Mapping Mode: Guides the operator through an intuitive process that begins with quickly generating a sketch of the floor and ends with a comprehensive detail by the MFL map for the floor (editable report in the Word File), featured with no space for human error. Manual (Free Scan) Mode: Clearly illustrates where is the defect is relative to the magnetic bridge on the displaying to move and Locate defects even faster and display in A and C scan views.

2nd: DETECTING (POD): MFE sensing and detection techniques. A reliable detection technology using inductive coil sensors that features withstand harsh environmental conditions, work even when exposed to extreme changes in temperature, water presence, and exposure to high-friction conditions, and a longer lifespan along with reliable and accurate readings.

3rd: STRUCTURE & MOBILITY (TRANSPORTING): MK4 is designed for precision with elimination for the inconvenience of operating, shipping traditional, and large, cumbersome MFL equipment, ONLY 30 Kgs (just in two suitcases), unit width is 40 cm and adjustable from 70 cm to 130 cm in height, collapsible handle that Let you close as much as you can to edges, easy setting for the sensor bar to prevent damage and reduce dead zones that from floor curvature.

4th: POWER REQUIREMENTS: MK4 improvements, the whole unit is powered by onboard computer batteries. The system is supplied with 4 batteries, the table has a place for 2 batteries but only one is used and the other one is standby, you can remove the dead battery and re-insert the fresh one without shutting down the scanner, hot-swappable option.

5th: OPERATION & REPORTING: It is started by digital calibration & digital sensitivity adjustment controller then creating a tank on the MARK IV unit and scanning the tank bottom then export and print. The software automatically generating 3 reporting files once the inspection is completed: (1) Mapping report in Microsoft Word (All scans in C-scan view with tracks and corrosion Mapping features and also to enable operators to add notes and any additional data in an easy way). (2) Excel File (All Defects details (Loss Signals%, X&Y and cell for UT verifications input)). (3) Original TKD File (That file you can export to a USB Drive and import with any other MK4 device at a different site and open it or you can share it with us for further support on setting or scans evaluation if needed)

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An Introduction to NON-DESTRUCTIVE TESTING

A Comprehensive Guide to NDT

We are surrounded by large structures, dependent on complex machines. Lives are inextricably linked to the proper function of our infrastructure and machinery. For this to be safely possible, we must have absolute confidence in the technologies we rely on. Nondestructive testing provides that confidence.

Collecting data about different materials required testing methods that resulted in damage to the material under study. **Non-destructive testing** (NDT) gives inspectors a chance to learn about materials without damaging side effects.

You can learn more about these processes, the best ways to apply them, and the equipment used in NDT in this article. If you have any questions after you finish this article, feel free to contact our team at NDT Corner.

In many industries around the world, NDT is required by law. Where it is not, it remains a compelling and convincing best practice. Mastering this complex subject takes decades. It demands significant training and practical experience across a wide range of scenarios. Even after 30 years of testing, it's still possible to see something entirely new.

Company or government managers must often still make decisions regarding their nondestructive testing programs. To make smart choices, it's important to have a sound understanding of the purpose, applications, requirements, and different methods of nondestructive testing.

This overview is intended to serve as a guide to the subject, providing foundational information on each aspect of nondestructive testing.

Nondestructive testing (NDT), as it is commonly understood, refers to any means of determining the integrity of an object without destroying the object.

Other labels, such as nondestructive inspection (NDI), nondestructive evaluation (NDE), and nondestructive examination (NDE), are used interchangeably. Different labels are used more commonly in different geographical areas, or by different manufacturers.

Non-Destructive Testing (NDT) is the practice of looking for flaws or differences in a material, component without damaging the part's or system's capacity to function.

What is the Difference between **Destructive** & **Non-Destructive**?

These forms of testing both play a role in equipment maintenance. Testing allows professionals to fully assess the condition of mechanical components by focusing on their: Materials, Design and Structure

DESTRUCTIVE testing methods destroy or damage parts, where a component or product is bent, altered, stretch and de-forms its shape to test its strength and load-bearing capacity, where deformation of product is needed, known as Destructive testing.

Types of DESTRUCTIVE testing

- Corrosion Testing
- Facture and Mechanical Testing
- Fatigue Testing
- Hydrogen Testing
- Pressure Testing
- Residual Stress Measurement

Examples of Destructive Testing

- 3-Point Bend Testing: Assessing the flexibility of a material. The test requires technicians to bend the material at three distinct points.
- Macro Sectioning: Testing welded material. Extract a section of the material, often etching it during the examination process.
- Tensile Testing: Failure point or find out how the material would respond to certain conditions. In this situation, they may perform tensile testing using the application of controlled tension.

NON-DESTRUCTIVE **testing** does not cause damage to tested equipment.

Why Use NDT?

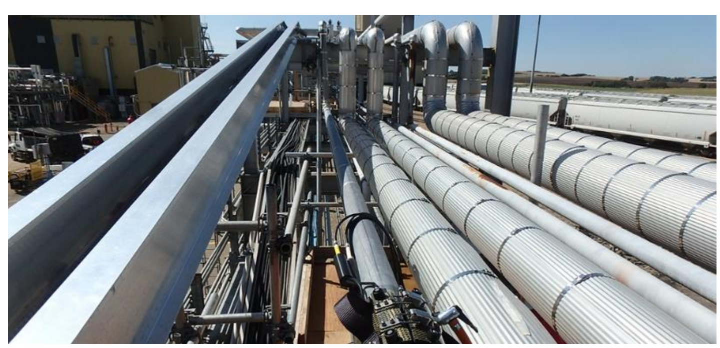
NDT has its various benefits in terms of uses, Here are some points to consider while thinking about why use NDT

- **ASSESS THE QUALITIES (REASSURANCE)**
  NDT gives reassurance on the product because when the product is inspected through the preferred NDT method, it gives clarity about Product quality and reliability. The underlying reason for doing that is risk management. While nondestructive testing does not eliminate risk, it can significantly reduce or mitigate it.

- **FAILURE PREVENTION**
  NDT reduces the chance of failure due to its process of Inspection, where you don't need to break the component or move anyway (if not possible to move), this gives flexibility and reduces the chances of any horrible condition to happen. Technicians perform nondestructive testing in the field to ascertain how close an object is to reaching those limits. If an object is too close to the limit, NDT allows it to be safely repaired or replaced before any harm is done.

- **ENHANCE PRODUCT RELIABILITY**
  While casting or manufacturing the product, various types of defects may come like Slag, porosity, and so on, which downgrade the quality of component and if gone without inspection, thus can cause some serious issues in the future, So Technician or Authorized person inspect the component to know, if there is any defects or discontinuity is present or not, this tells about product quality and if there is any discontinuity is present, then component or product is further sent to repair. This can increase product reliability and increase quality.

- **COST-EFFICIENT**
  NDT relies on Third-party inspection, so the organization doesn't need to be equipped with NDT equipment. They need to call an NDT company to inspect their products, which saves the various costs of equipment and manpower cost. Although, NDT tells you the quality and reliability of the product, hence its saves any further expenses in the long run.



Where Use NDT?

Nondestructive testing is widely used across many important global industries. Any industry with large physical equipment or infrastructure is likely to use some kind of nondestructive testing. Additionally, within each industry, several methods of NDT are commonly practiced.

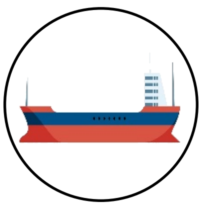
Aviation

Aerospace manufacturers, airlines, and repair services are all required by law to perform a variety of periodic NDT inspections. Nearly every aspect of an airplane or helicopter must be inspected at a specified interval. Many different NDT techniques are used in aviation and aerospace. Ex. use ultrasonic to examine turbine fan blades and eddy current to search for surface or subsurface flaws in multilayer structures.

Oil & Gas

All divisions of the oil and gas industry rely on NDT to prevent accidents based on thousands of miles and trillions of dollars of infrastructure and equipment to secure their investments. Drill sites, pipelines, and refineries employ NDT teams to constantly perform inspections of welds, pipes, risers, tanks, and large forgings. The sheer volume of the inspections performed by the oil and gas industry rewards efficient NDT tools

Marine

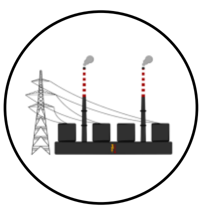


Large and small marine craft depend on NDT to prevent materials failure at sea. Metal and composite hulls are inspected by their manufacturers, and periodically while in service. Propeller blades, turbines, and internal equipment such as holding tanks or boilers must be routinely inspected as well. Nuclear powered ships must test their systems as carefully as with steam generator plants found on land. Due to the difficulties of maritime law, marine NDT regimes are often primarily the purview of ship owners and manufacturers, though informed by international standards

Manufacturing

Heavy manufacturing companies typically use NDT to ensure product quality prior to delivery. Pipe, steel, and tubing manufacturers inspect for material and weld integrity. Manufacturers of turbines, large vessels, and ships likewise trust NDT to determine whether their products meet appropriate specifications. Special composite can detect voids, delamination, density variations, porosity, stress, damage, and foreign materials present in their products. NDT in manufacturing not only guarantees product safety, but also a company's reputation.

Power



Large power plants have zero tolerance for failure and stringent testing requirements. Nuclear plants, in particular, trust their NDT solutions to ensure safe operation. But coal, oil, and gas plants all depend on NDT to detect flaws in their turbines, tubing, and related systems. Renewable power plants including hydropower and wind test their hardware and systems integrity as well

Automotive

While vehicle owners are not required to perform NDT, manufacturers are to prevent material failure on the road, manufacturers must inspect vehicle components for cracks and flaws, issues arising from improper heat treatment, and unacceptable material mixes.

Military

Militaries rely on aerospace, naval, and nuclear technologies, and must diligently inspect the equipment in their charge to ensure mission reliability. Military vehicles, munitions, and installations also commonly require NDT inspections.

Rail

Trains and their tracks require NDT, as does much related intermodal storage and logistics. Train car wheels, axles, brakes, and hydraulic systems must be inspected, as well as the rails and their frogs. Cranes, risers, and holding tanks require periodic safety inspections, particularly holding tanks storing hazardous materials.

Fertilizer, Cement, Mining, Medical and other industries.

All industries uses NDT to make certain their infrastructure remains safe and effective. Regardless of industry, the most common uses of NDT are to test the integrity of structural materials. These materials include metals of varying compositions and thicknesses, composite materials, fibers, and plastics. The need for NDT for a given application is derived from the likelihood and consequences of the application's failure.

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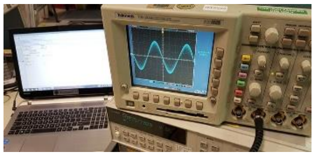

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G.E.S.

WHO WE ARE?

Global Engineering Solutions (GES) is a leading machinery and Equipment testing company in both mechanical and electrical fields. GES provides Predictive Maintenance & Condition Monitoring of rotating machinery, Electrical Machine and Equipment Testing, Instrumentation and Control Testing, Conventional and Advanced NDT (Non-Destructive Testing), Welding activities, maintenance and commissioning activities. Our services in the field of PdM and Condition monitoring include but are not limited to: Vibration Analysis, Operating Deflection Shape (ODS), Modal Analysis, Rotor Dynamic Analysis, In-situ Dynamic Balancing, Laser Alignment, and Machinery Fault Diagnostics, Thermography Surveys, Dynamic/Static Motor Current Analysis, Ultrasound, Flow Measurements and Machinery Performance Analysis.

Key industries include Oil& Gas, Petrochemicals, Power Generation, Pulp & Paper, Mining, Steel, Food, Cement and Chemical Industries. As a part of our business, GES provide Training Courses following **ISO 18436-2** Category I to III courses and certification. GES is utilizing the most advanced vibration analyzers and machine simulators in training Sessions such as CSI, Crystal Instruments, Bentley ADRE 16 channel, Spectra Quest Simulators and Bently Rotor Kit. **GES is certified ISO 9001 and ISO 45001.**

International Organization for Standardization ISO 45001

ISO 9001:2015

Global Engineering Solutions (G.E.S.)

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SHOULD ALL OBJECTS BE TESTED?

No, Non-destructive testing is worthwhile when the risk of an object failing outweighs the cost of testing it.

High-risk objects are those that endanger the lives of those around them upon failure, such as passenger jets or nuclear reactors. High-risk objects also include those which can cause severe financial or environmental harm, such as oil pipelines. The cost of testing is a function of equipment cost and employee time; employee time includes both training and actual testing.

Fortunately, companies don't have to guess which equipment or infrastructure to test, many nondestructive testing requirements are dictated by national governments.

Governments often base their legal requirements on information published by international standards bodies, such as ASTM or ISO. Thus, a derived, though nonetheless essential, purpose of NDT is ensuring regulatory compliance. Flaunting NDT requirements can quickly become more expensive in fines and penalties than simply following them

Requirements for NON-DESTRUCTIVE TESTING

Certain minimum standards for nondestructive testing are prescribed by law. Different nations or bodies follow different standards, so companies operating in multiple countries may have to meet different testing or reporting requirements for the same application. Companies subject to overlapping restrictions must follow the most stringent of them. Airlines, oil and gas companies, and manufacturers have the most exposure to complex and overlapping regulatory requirements. NDT programs should be developed in consultation with appropriate experts or specialist legal counsel to ensure full compliance. Most governmental standards for NDT are based on the recommendations of independent international organizations, including ISO and ASTM.

These organizations base their standards in part on the research of manufacturers and several national and international trade associations. These trade associations include the International Committee for Non-Destructive Testing, the American Society for Nondestructive Testing, and the Nondestructive Testing Management Association. Non-destructive testing regulations can specify parts to be tested, methods to be used, periodicity of testing, minimum acceptability values, and recordkeeping standards. NDT manufacturers use these standards as references when developing inspection equipment and solutions. Standards and equipment evolve together, with more effective solutions rising to meet more stringent requirements as they emerge. Manufacturers should be able to demonstrate how their products meet regulatory requirements for any application they market.

Training and Certification

for Non-destructive Testing

The successful operation of nondestructive testing technology requires adequate training and experience.

There are various training as well as certifications, which certified and trained a person to involve in NDT testing.

We all know that without proper training and required certification, the person is not allowed to operate equipment or involves in any kind of NDT testing.

While there is no one central, ultimate NDT training authority, training options remain nevertheless available. Training courses are provided by **equipment manufacturers, third-party inspection organizations, and employers themselves.** Employers enjoy final discretion in setting requirements for employee NDT training.

NDT training is typically divided into three levels, roughly corresponding to apprentice, journeyman, and master-level understanding. In the industry, these are known as Level I, Level II, and Level III certification.

NDT evaluations require both theoretical and applied knowledge. Experience, also, is an irreplaceable teacher. As part of their certification requirements, NDT technicians should prove proficiency in written and practical examinations, while minimum experience requirements ensure that important inspections are in proven hands.

Basic level, NDT technicians should demonstrate proficiency in one or more limited evaluation types, i.e., ultrasonic flaw detection in welds. They should be able to determine whether an application passes or fails evaluation, and document the results. Technicians should also be able to set up, calibrate, store, and observe safety measures for one or more types of NDT equipment. Level 1 technicians should be supervised by technicians of a higher level.

Intermediate NDT technicians should demonstrate an advanced understanding of the abilities and weaknesses of their NDT methods. They should be familiar with the relationship between test standards and methods as well as internal and external codes and regulations. Level II technicians can set up and calibrate equipment as well as interpret results. They can supervise a team of Level I technicians and compile reports for presentation.

NDT Expert develop the NDT strategies which Level I and II technicians implement. They convert external regulations into internal best practices. They designate test methods and standards and can be responsible for choosing or recommending equipment. In the absence of prescribed standards, Level III technicians should have the means to develop standards of their own. Level III technicians supervise and examine Level I and II technicians.

What to do, How to do, and what will be the criteria of inspection?

Authorized Organizations to create **Codes and Standard**

For ***Non-Destructive Testing***

ASTM (American Society for Testing & Materials)
ASNT (The American Society of Non-Destructive Testing)
ASME (American Society for Mechanical Engineers)
API (American Petroleum Institute)
AWS (American Welding Institute)
AIA (Aerospace Industries Association)
NBBI (National Board of Boiler and PV Inspectors)
ISO (International Organization for Standardization)
CEN (European Committee for Standardization)
PED (European Pressure Equipment Directive)

Authorized Organization to guide **Training and Certification**

For ***Non-Destructive Testing***

In certain cases, when certification of NDT personnel is required by standards, codes or regulations.

Many certify their personnel in accordance with the international standard ISO 9712. However, as NDT falls under the purview of different regulatory regimes.

Here are some organizations, which offer personnel, various training, and certification in various NDT methods.

American Society of Non-Destructive Testing (ASNT), a globally established organization, which offers NDT persons, a broad level of certification and training including all methods of NDT. ASNT offers, ASNT Level-II, ASNT Level-III.

British Institute of Non-destructive Testing (BINDT), an accredited certification organization that offers a Personnel Certification in Nondestructive Testing (PCN).

International Standards Organization (ISO), ISO 9712 (Non-destructive testing — Qualification and certification of NDT personnel) is a published standard that details the requirements for qualification and certification of personnel that perform NDT.

American Petroleum Institute (API), API offers numerous Individual Certification Programs (ICPs) specific to NDT personnel in the petroleum and petrochemical industries

Natural Resources Canada (NRCan), NRCan manages the Non-Destructive Testing Certification Body (NDTCB) which offers a Canadian General Standards Board (CGSB) certification.

Another organization that can do same; **French Committee for Non-destructive Testing Studies (COFREND)**, **Canadian Standards Association (CSA Group)**, **Canadian General Standards Board (CGSB)**

The exact regulations designed to handle NDT vary by country and industry.

Guide to Techniques & Equipment

For ***Non-Destructive Testing***

Explore **different** non-destructive inspection **techniques** right here. **Depending upon your industry**, you may use one or more of these testing methods.

Unique NDT Applications

NDT focuses on assessing issues with materials or equipment without causing any damage during the process. The unique applications associated with this form of testing provide several applications, including:

Detect External Flaws

Sometimes, equipment or materials have flaws in their exterior casing. However, these flaws may be microscopic, making them hard to identify with only a visual inspection. NDT testing allows technicians to identify these flaws before they become a problem.

Identifying Internal Flaws

Assessing the inside of a part or piece of equipment poses unique challenges, especially if you want the equipment to continue functioning afterward. NDT inspectors have various assessment tools at their disposal to handle these tests.

Testing Untouchable Objects

How do you test for defects on an object underwater or in a high-temperature environment? NDT provides a way to assess the condition of these parts without destroying them, without exposing technicians to dangerous situations in most cases.

Allows for Medical Assessments

We've primarily focused on the industrial uses of NDT. However, these tests play an essential role in most medical testing, as doctors do not want to damage their patients while carrying out tests to assess their health and well-being.

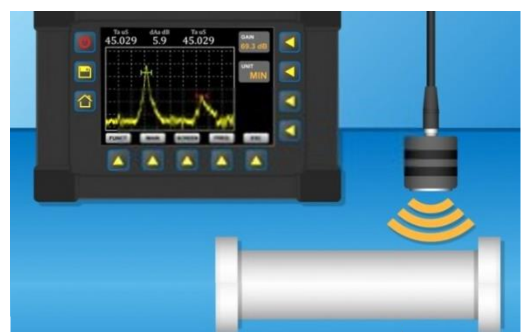
Going for a check-up at the doctor may involve a non-destructive inspection as medical professionals take your pulse, check your blood pressure, and assess your reflexes. In addition, doctors use other NDT technology when they take an X-ray to look at a broken bone or perform a CAT scan to look for other internal injuries.

Determines Machinery's Lifespan

Different machines wear down at different rates, and it can be difficult to tell when a machine is on its last legs. NDT inspections can help determine the rate at which a machine is degrading and how much longer it is likely to be useful before needing to be replaced.

A several Applications of the NDT can be identified,

Monitor, improve, and control manufacturing processes. Inspect for in-service damage. Inspect of raw products. Ensure product integrity and reliability. Maintain uniformity in quality level.



What is NDT equipment?

There are many types of NDT inspections performed in different industries. Therefore, there is no set list of tools used in non-destructive testing.

Inspectors may use everything from their eyes to high-tech machinery to detect defects in various pieces of equipment.

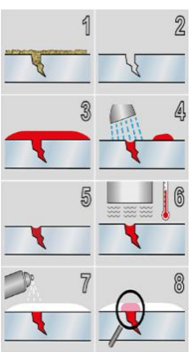
Now, learn more about different forms of testing to learn more about the possible equipment required for testing procedures.

Guide to Most Common Techniques
Of Non-Destructive Testing

Conventional NDT Techniques

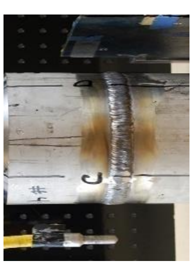
Visual Testing the most basic form of NDT testing. Technicians look at the equipment, material, or asset and notice flaws during visual inspections. They may also use a specialized device to handle a Remote Visual Inspection. Visual testing often provides an excellent place to start assessments, but you may require more in-depth assessments to get definitive results.

Magnetic Particle Testing looking for the flaws in ferromagnetic materials by assessing any disruptions in the flow of their magnetic field. Inspectors perform these tests by inducing a magnetic field and introducing iron particles to the material's surface. Inspectors observe the movement of the magnetic particles to look for imperfections. Assessing the magnetic field in this way allows technicians to check on the state of equipment without damaging the material. MT should not cause any health risks to inspectors.



Liquid Penetrant Testing indicate breaks or defects in the surface of pieces of equipment. Technicians perform liquid penetrant testing by applying a liquid that contains either a visible dye or a fluorescent dye to the surface of an object. The inspectors rub away excess liquid; any liquid that remains behind indicates a defect. Once crews notice the flaws, they examine them in greater detail with ultraviolet (UV) lights if they use a fluorescent dye. PT works very well to identify defects, and technicians can easily clean up after the process by washing away the dye.

Ultrasonic Testing use high-frequency sound waves during UT. They transmit the sound waves at the material or asset under inspection and look for any property changes. Many forms of UT use pulse echoes, which involve looking for surface imperfections based on the echoes reflected off of an item.

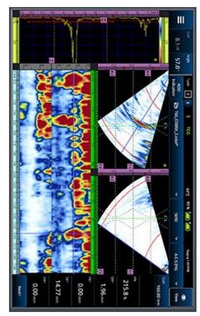


Radiographic Testing use radiation to complete RT. Often, crews use x-rays if they're dealing with thin materials. However, they may choose gamma radiation instead if they need to assess a dense or thick material, requiring a thickness measurement before beginning the assessment. Experts use a variety of processes to report the results of RT. For example, they may use computed tomography, computed radiography, digital.

Eddy Current Testing electromagnetic testing. This process allows crews to measure the magnetic field of a material based on its eddy currents (or electrical currents). Eddy current testing generally works best on non-ferrous materials. It used for surface and near surface cracks, used on metal, welds and tubes.

Advanced NDT Techniques

Magnetic flux leakage (MFL) testing utilizes a strong magnet, which creates a magnetic field that crews use when assessing structures made of steel. Use sensors to track any changes in the magnetic flux lines or density, which may indicate issues like: Pitting, Erosion, Corrosion. Monitoring the magnetic field allows crews to assess issues with large structures without causing any damage. Technicians often spend a significant amount of time studying magnetic field science and magnetic flux density before completing these tests.



Phased Array Ultrasonic Testing (PAUT) serves as a variation of traditional UT. This kind of test uses an array that can create independent pulses. Technicians control how each element fires, allowing them to steer or focus the sound beams. They can move the beam to various depths and angles, easily generating cross-section views of equipment or materials. Some examples of PAUT used a virtual probe to gather additional information in this NDT method.

Guided Wave Testing (GWT) Leak Testing use this NDT inspection to test pipes that stretch across long distances. The tests use ultrasonic waveforms to detect any issues in the walls of the line. Guided wave testing returns the results to a computer, allowing crews to look for possible problems. Companies can order either guided wave medium-range ultrasonic testing (GW MRUT) or guided wave long-range ultrasonic testing (GW LRUT). You may assess areas hundreds of feet away from the starting location with GW LRUT testing.

EC Tube Inspection is a key NDT practice in the Power Generation/Heat Exchanger sector and Eddy Current is one of the best methods of measuring wall thickness and circumferential cracks. Tubes may be inspected using ECT from the outer diameter (OD) at the time of manufacture and from the inner diameter (ID) for in-service inspection. Tube inspection equipment has a multi-channel to use different probes (ET, MFL, IRIS, RFT, NFT, and ECA). These all probes go inside the tube for Wall Loss, Corrosion, Cracks, etc. either (ID) or (OD) detection.

Acoustic Emission Testing use to look for defects and imperfections with this NDT testing method. First, they monitor acoustic energy bursts, focusing on the location of the burst, its intensity, and its arrival time. Acoustic emission testing works well for companies operating in many different industries.

MFE INSPECTION SOLUTIONS

OGI® Handheld Camera

Optical Gas Imaging

ANDROID BASED USER INTERFACE

Visualize HARMFUL GAS Leaks in Real-time

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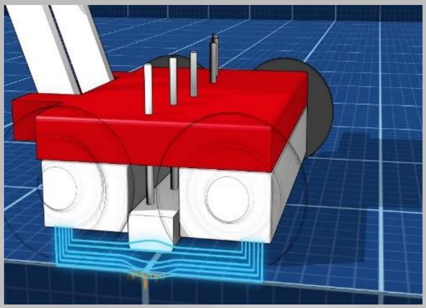
SOURCE NDT COURSES

NDT | Advanced NDT | API | ASME | QC/QA | NDT LIII | Welding | CWI | CSWIP | PAINTING



Invest in yourself

Better Future &

Strong Personnel Profile.

Build yourself

MFL Tank Inspection Training Course

Provided By MFE Middle East | OEM Training

FEATURED

Exclusive

MFE Hand Book

Magnetic Flux Leakage Training Course

Tank Floor Corrosion Mapping Inspection

According to the Standards set forth by API 653 Annex G, and SNT TC 1A

PROVIDED BY: MFE Enterprises / MFE Middle East
CERTIFICATIONS: OEM certificate Level II (Original Equipment Manufacturer)
LOCATIONS: USA - Egypt - UAE

- MFL Theory & Basics
- Factors of MFL testing
- Function testing
- Reporting analysis
- Scanning operations
- MFL limitations
- Manual & Mapping scanning
- Defects sizing
- Defects & Corrosion profile
- System setup & assembling
- Inspection process
- Exercises & Case study

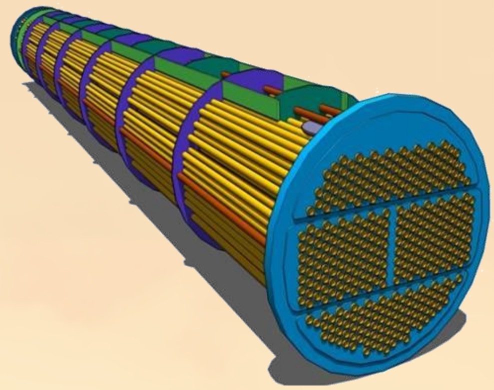
MFL COURSE OUT LINE:

- 40 hours, (5 days) Sunday - Thursday / (09:00 AM - 05:00 PM)
- Includes Original MFL HANDBOOK, Classroom, and Hands-on.
- Breakfast & Lunch Provided All Five Days
- One Final Exam and a Practical Test.

Eddy Current Testing Training Course

Provided By MFE Middle East

FEATURED



Exclusive
ECT Hand Book

ECT Training Course

Welding, Surface Cracks & Tube Inspection

According to the Standards set forth by ASME Code.

PROVIDED BY: MFE Middle East
CERTIFICATIONS: Level II certificate
LOCATIONS: Egypt - UAE

- ECT Theory & Basics
- Factors of ECT testing
- Calibration
- Reporting analysis
- ECT Applications
- ECT limitations
- Codes
- Defects
- Corrosion profile
- System setup & assembling
- Inspection process
- Exercises & Case study

ECT COURSE OUT LINE:

- 40 hours, Sunday - Thursday / (09:00 AM - 05:00 PM)
- Includes Original ECT HANDBOOK, Classroom, and Hands-on.
- Breakfast & Lunch Provided All Five Days
- One Final Exam and a Practical Test.

Phased Array UT Training Course

Provided By MFE Middle East

FEATURED

PAUT Training Course

Welding & Corrosion, Base metal Inspection

According to the Standards set forth by ASME Code.

PROVIDED BY: MFE Middle East
CERTIFICATIONS: Level II Certificate
LOCATIONS: Egypt - UAE

- UT Theory & Basics
- PAUT Parameters
- Calibration
- Reporting analysis
- Scanning operations
- PAUT limitations
- Manual & Mapping scanning
- Defects sizing
- Defects & Corrosion profile
- System setup & assembling
- Inspection process
- Exercises & Case study

PAUT COURSE OUT LINE:

- 40 hours, Sunday - Thursday / (09:00 AM - 05:00 PM)
- Includes PAUT HANDBOOK, Classroom, and Hands-on.
- Breakfast & Lunch Provided All Five Days
- One Final Exam and a Practical Test.

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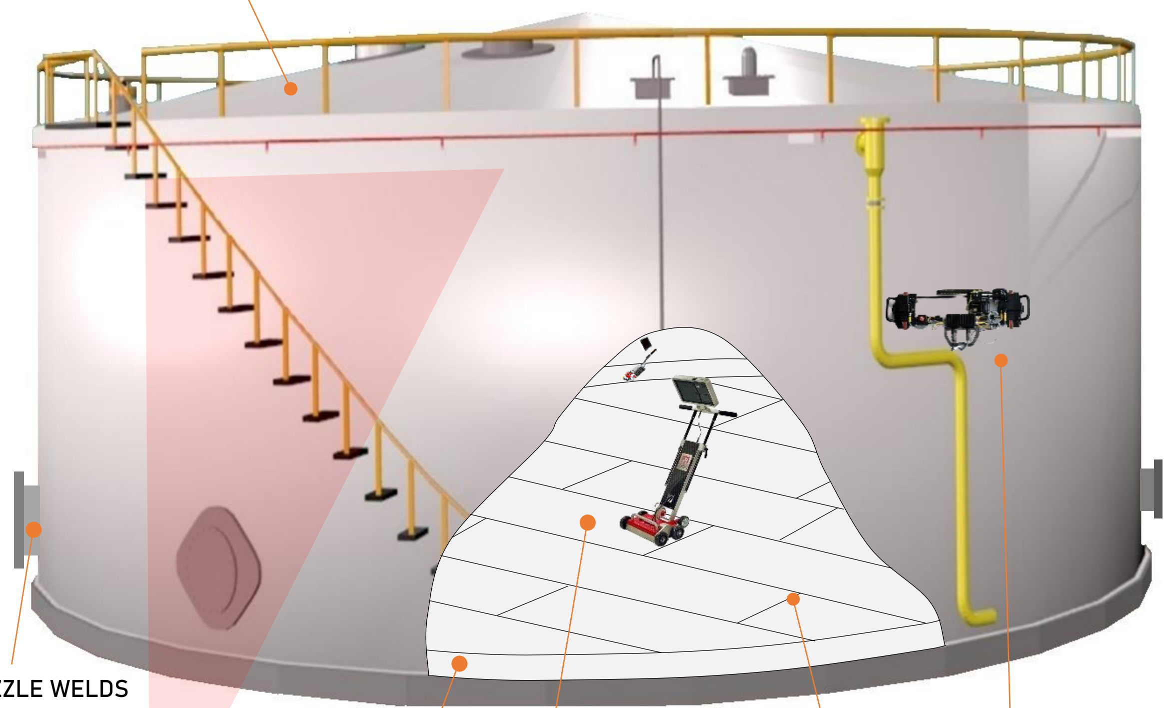
HOW TO INSPECT ABOVE GROUND STORAGE TANKS?

AST Tanks Integrity

ROOF PLATES
- AUT Corrosion Mapping
- UT with A SCAN

INTERNAL ROOF
- Drones if not access.
- UT with A-SCAN



NOZZLE WELDS
- MT
- UT FD
- Phased Array

FLOOR INNER PLATES
- MFL MARK IV Floor Inspection
- UT with A-SCAN
- Robotic UT (In-service)

SHELL PLATES
- HSR AUT Corrosion Mapping
- UT with A-SCAN

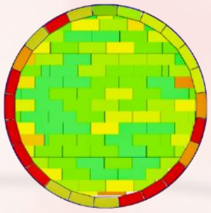
FLOOR ANNULAR PLATES
- MFL Edge Inspection
- UT with A-SCAN
- Robotic UT (In-service)
- Short Range-UT (In-service)

FLOOR WELDS
- UT FD / Shear Wave
- Phased Array
- Vacuum Box

TANK CALIBRATION
- 3D Laser Scan

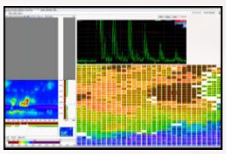
Detailed AST Inspection Methods & Reporting

MFL Report



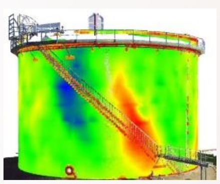
C-Scan corrosion mapping Layout produced by using Magnetic Flux Leakage Corrosion Mapping Inspection to detect corrosion in quick manner to provide the hot spots & corroded areas.

AUT Report



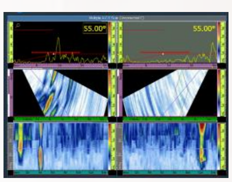
C-Scan corrosion mapping Layout produced by using Automatic Ultrasonic corrosion Mapping Inspection to detect corrosion in quick manner to provide the hot spots & corroded areas.

3D Laser Report



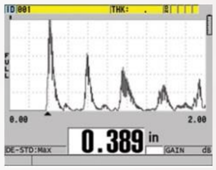
Tank Calibration, geometrical & structure analysis using 3D laser scanner, aimed to verify the compliance with API 650 & API 653.

PAUT Report



Advanced Welding Inspection Report using Phased Array UT equipment to detect weld defects in quick and accurate manner to provide permanent report with sizing and color code.

UT A-SCAN Report



Wall Thickness & Metal Loses measurements using UT Thickness Gauges includes A-scan feature to able to detect corrosion failure and display reading in Digital & A-scan view.

GLOBAL NEWS

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Egypt Green starts commissioning of Phase# 1 of green hydrogen plant.

Africa's first integrated green hydrogen plant is a joint venture between Fertiglobe, Scatec, Orascom Construction and The Sovereign Fund of Egypt.

On **November 8, 2022**, Egypt, President Sisi announced national strategy for green hydrogen production during the 2022 UN Climate Change Conference (COP27).

Egypt Green, a joint venture of Fertiglobe (an OCI-ADNOC joint venture), Scatec, Orascom Construction and The Sovereign Fund of Egypt, announced on Tuesday the start of commissioning of the first phase of the green hydrogen plant in Ain Sokhna.

Scatec said in a statement that the consortium is "currently testing the first and largest polymer electrolyte membrane (PEM) electrolyser in Africa for the first phase of the project."

The hydrogen tie-in for up to 100 MW of electrolysis have already been installed at Fertiglobe's two existing ammonia plants in Ain Sokhna.

The consortium is in the process of finalizing engineering and technology choices for the full-scale plant and aim to reach Final Investment Decision (FID) on the facility in 2023.

Scatec is majority owner of Egypt Green and will build and operate the facility.

As the first integrated green hydrogen plant in Africa, Egypt Green will eventually consist of 100 megawatts (MW) of electrolysers, powered by 260 MW of solar and wind.

The project would deliver up to approximately 15,000 tons of green hydrogen as feedstock for production of up to 90,000 tons of green ammonia per year in Fertiglobe's ammonia plants [owned by its subsidiary (EBIC) under an offtake agreement].

Saudi Arabia's TAQA to acquire 100% of Al Mansoori Petroleum Services

TAQA was advised by HSBC Saudi Arabia and White & Case whereas AMPS was advised by Goldman Sachs International and Clyde

The Industrialization & Energy Services Co., known as TAQA, which is backed by Saudi Arabia's Public Investment Fund, has entered a definitive agreement to acquire 100 percent of Abu Dhabi's AlMansoori Petroleum Services, according to a statement.

Expected to close in the fourth quarter of 2022, the transaction comes as part of expanding TAQA's Well Services business to the wider Middle East and North Africa region.

AMPS will add complementary products and services to TAQA's portfolio, including Early Production Facilities, Well Testing, Slick-line, Marine Stimulation Vessels, Multi-Purpose Service Vessels and Inspection Services.

"AMPS has a successful track record of 45 years in MENA, which will give TAQA an immediate entry in the region building on AMPS brand and reputation," Chairman, Abdulla Nasser Al-MANSOORI, said.

TAQA was advised by HSBC Saudi Arabia and White & Case, while AMPS was advised by Goldman Sachs International and Clyde & Co.

Saudi Arabia's PIF owns 45 percent of TAQA, while the remaining 55 percent is owned collectively by joint stock companies and several private and industrial investors.

The acquisition will enable TAQA's Well Services business expand from Saudi Arabia across the Middle East and North Africa (MENA) region.

TAQA's chairman of the board Eng Ahmed Al Zahrani added this step is "big" for the company as it aligns with the Kingdom's 2030 vision.

"This transaction marks a major milestone in the execution of our strategy. The combined capabilities of both businesses and the potential synergies will create a regional integrated well services business which will grow assertively and sustainably, delivering value to our three stakeholders – shareholders, customers and employees," TAQA chief executive officer Khalid M. Nouh said.

AMPS brings to TAQA a long-established, well-diversified MENA-based business with a track record of strong performance and longstanding relationships with large Oil and Gas companies in the region, the statement said.

"AMPS has a successful track record of 45 years in MENA, which will give TAQA an immediate entry in the region building on AMPS brand and reputation," AMPS chairman of the board Abdulla Nasser Al Mansoori said.

AMPS' products and services include Early Production Facilities, Well Testing, DST, Slickline, Marine Stimulation Vessels, Multi-Purpose Service Vessels, Inspection Services, H2S Monitoring and Logging and Perforation.

Spain to France New gas pipeline connection

Spain says gas pipeline to France could be operational within 8-9 months

After Russia's invasion of Ukraine, the European Union is trying to get off Russian natural gas. This has brought new interconnection projects into focus. Speech by Olaf Scholz, German Chancellor, pushed for the construction of a pipeline linking Portugal through Spain and France to central Europe.

Ribera stated that the new interconnection, the gas pipeline, could be operational in eight to nine months on the south side of the border. This is from the Pyrenees and Spain. To connect France and Spain, another section of the pipeline would be required to run from the Spanish grid to the French. Scholz stated that a pipeline linking the Iberian Peninsula and central Europe would "massively alleviate the supply situation now", adding that leaders from Spain, Portugal, France and the European Commission had already spoken about it. Antonio Costa, Portugal's Prime Minister, stated that Scholz's statement "reinforces pressure on the European Institutions to unblock this condition once and for all". He suggested that an alternative to the French link would be a sea-based pipe from Spain to Italy. Pedro Sanchez, the Spanish Prime Minister, stated that interconnections must be paid for by the European Union.

Arturo Gonzalo Aizpiri, CEO of Enagas, a Spanish gas grid operator, recently stated that the complete project between France-Spain, which was abandoned by regulators in 2019, could be completed around 700 million euros in two years.

Jordan hosted international renewable energy investment forum

AMMAN - Jordan hosted the Seventh International Investment Forum for Renewable Energy and Energy Efficiency in MENA, organized by the Arab Renewable Energy Commission (AREC), participation from the Arab world and beyond.

In a statement to the Jordan News Agency, Petra, AREC Secretary General Mohammed Taani said that the three-day forum covered many "important and vital" issues on the fields of renewable energy, energy efficiency, smart cities and grids, green hydrogen and sustainability.

Taani added that the forum covered innovative agricultural patterns, energy management, green hydrogen, carbon trading and green economy. Saudi Arabia, Qatar, Kuwait, Egypt, Sudan, Libya, Palestine, Syria, Mauritania, Morocco, the US, Switzerland, Germany, Czech Republic, the Netherlands, Romania, Italy, Greece, Turkey, Yemen, Britain and Chad participated in the forum.

TECHNICAL ARTICLES

Knowledge

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Knowledge is power

Damage Mechanisms

Damage Mechanisms (also referred to as degradation mechanisms) is a general term referring to any cause of problems or failures within process equipment. These can range from **corrosion**, to **cracking**, to **heat damage**, and everything in between.

When assessing damage mechanisms, one must take into account the current state of the equipment, as well as any potential damage the mechanism may cause later. Equipment's susceptibility to a particular damage mechanism is affected by a number of variables, including materials of construction, process fluids, operating conditions, external environment, etc. A good understanding of the variety of damage that exist is a must for any mechanical integrity program.

A thorough damage mechanisms review is essential for creating an **effective inspection strategy**. Once damage mechanisms and morphology are understood, inspection strategists can use this information to **select inspection methods with the highest probability of detecting (POD), characterizing, and measuring potential damage**.

Furthermore, inspection intervals can be established using industry codes and standards such as API 510, 570, 653, API RP 579 for fitness-for-service, and API 580 and 581 for risk-based inspection.

Damage mechanisms are detailed and covered at length in API RP 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry.

READ THE FULL ARTICLE
Techniques & Blogs Section

Some of the most common damage mechanisms in the refining and chemical processing industries are:

- ► **Corrosion under Insulation (CUI)**, which occurs when moisture builds up on the surface of insulated equipment.
- ► **Sulfidation Corrosion**, a type of corrosion that occurs at temperatures above 500 °F (260 °C) due to sulfur compounds in crude.
- ► **High Temperature Hydrogen Attack (HTHA)**, a mechanism that can affect equipment that is exposed to hydrogen at elevated temperatures (at least 400 °F or 204 °C).
- ► **Wet H2S Damage**, which can occur when atomic hydrogen from wet H2S corrosion reactions enters and weakens the steel.
- ► **CO2 Corrosion**, which is a form of degradation that occurs when dissolved CO2 in condensate forms carbonic acid, which corrodes steels.
- ► **Hydrogen Embrittlement**, which happens when atomic hydrogen infuses into certain higher strength steels and causes them to become brittle.
- ► **Brittle Fracture**, which is the sudden, very rapid fracture under stress where the material exhibits little or no evidence of ductility or plastic degradation before the fracture occurs.
- ► **Phosphoric Acid Corrosion** is an acidic environment "disease" largely associated with polymerization units using phosphoric acid as a catalyst. Dry phosphoric acid catalyst is not corrosive to carbon steel, but wet phosphoric acid can corrode carbon at thousands of mils per year. This type of corrosion can often be found in dead zones and crevices where wet acid can drop out. In places where water is present, upgrading to 304L, 316L, or Alloy 20 may be necessary to prevent this type of corrosion, depending on the temperature.

Degradation of Hi-Temperature Equipment by Creep & Creep Rupture

CREEP is time-dependent plastic deformation of materials/stressed components when they are subject to loads below yield strength at high temperatures. Creep life is significantly affected by metal temperature where 10-15°C change could half or double the life of a component. Therefore, good balance should be struck between integrity & production when an equipment is operated at creep conditions.

Operating variables that affect creep and stress rupture life are includes: material properties, operating temperatures and applied stress from internal pressure/mechanical loading. Stress rupture failures are typically short-term failures while creep failures are long-term failures.

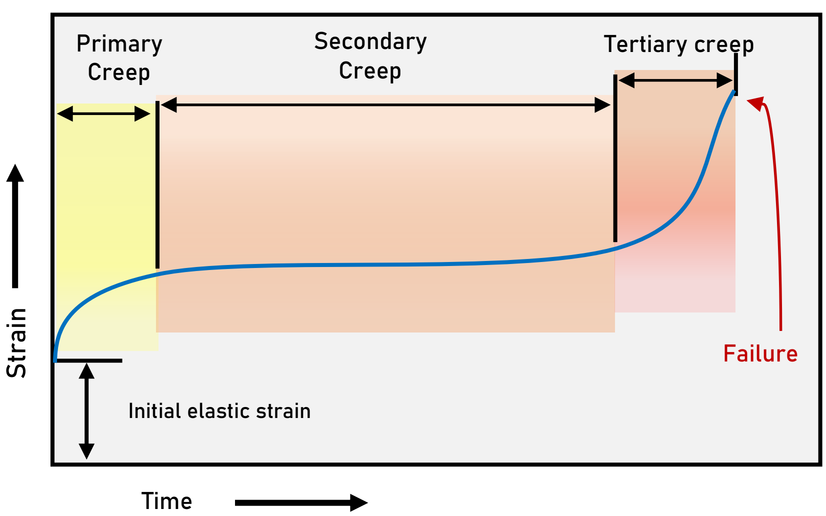
Creep deformation is the result of relative movement between individual grains or other discontinuities within the metal where micro-voids typically show up then they grow into micro fissures then cracks, which eventually grow through the wall resulting in failure.

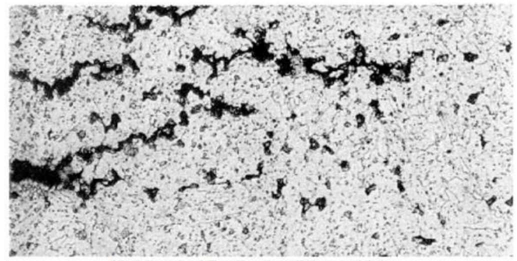
The most susceptible for creep rapture are heater tubes, tube supports as well as hi-pressure steam tubes in boilers that lead to sagging, bowing and bulging.

Creep time-to-failure strongly depends on stress, temperature, geometry & alloy. In addition, creep life is influenced by factors such as corrosion, fatigue or material defects.

Creep occurs in equipment operated above creep range, e.g. heater convection and radiant tubes, pigtails, supports, and hangers. Boiler components and superheated steam pipes are also susceptible to creep. Creep is an issue in dissimilar metal weld joints where stresses are generated by incurred differential thermal expansion.

Creep Deformation





Metallurgical Replication (Microvoids)

Tube Sagging

Bulged Tube

Creep Process Usually Involves **Three Typical Stages:**

Primary creep is the stage in which the material initially undergoes elastic strain under applied load. Still within the same region, increasing plastic strain at decreasing strain rate comes after the initial elastic strain.

Secondary creep, the creep rate is constant at a minimum rate. Indeed, design life of alloys is estimated based on the length of secondary creep as the material plastic deformation is accommodated by recovery processes.

Tertiary creep is the region in which the strain rate drastically increases with rapid extension to fracture. When material approaches this stage, rounded micro voids start nucleating through the microstructure. With time & stress, the cavities link up forming cracks, see attached micrographs. This process occurs by voids growth & shear strain on grain boundaries. Creep ruptures are typically characterized by multiplicity of creep voids adjacent to main fracture.

READ THE FULL ARTICLE
Techniques & Blogs Section

MONITORING

1. Establish baseline inspection of new components.

2. Adequate monitoring of metal temperature.

3. Inspect susceptible components for signs like dimensional changes, bulging, thickness loss, cracking, sagging, bowing, micro voids formation & fissuring.

4. Perform comprehensive condition/life assessment when component approaches its design life or experiences frequent failures/operational excursions.

5. Inspection (Non-Destructive Testing): The following NDT methods can help on monitoring and assessing (a) Visual inspections. (b) Infrared thermal scanning of tubes helps identify localized hot spots and tube operating temperatures in locations where there are no thermocouples. **(c)** Ultrasonic-based, intelligent pigs can also provide diametric growth measurements throughout the full coil length. **(d)** Hardness testing of heater tubes can indicate that the tubes severe overheats to insure adequate strength remains.

PREVENTION

1. Adequate materials selection (Alloys with improved creep resistance).

2. Keep metal temperature within design limits.

3. Mitigate process & fireside scaling.

4. Investigate deviations in critical process parameters on component's creep life.

5. Proper burner maintenance, and fouling control to minimize hot spots and overheating.

6. Visual check during routine operator rounds for burners flame pattern in heaters. Cleaning or replacement of burner tips.

7. Minimizing process-side fouling and fireside scaling which can necessitate over firing to maintain process temperatures.

8. Establishment and implementation of integrity operating windows (IOWs) for the process parameters.

9. Process variables associated with integrity operating windows should be monitored for unusual trends.

ASSESSMENT

A group of assessment levels is used to evaluate creep damage based on the data required for the analysis. FFS - fitness for service assessment procedures for pressurized components operating in the creep range are provided in API 579 Part 10 and to perform an evaluation to any of the assessment levels, the material properties for the temperature and stress conditions.

Detailed stress analysis is required to evaluate creep-fatigue damage, creep crack growth and creep buckling.

Primary assessment is screening criteria based on the original design of the component with the operating conditions based on a comparison with specified time-temperature-stress limits and a simplified creep damage calculation.

Secondary assessment is stress analysis that based on the stresses and strains at a point and through the wall thickness, and the associated operating time and temperature.

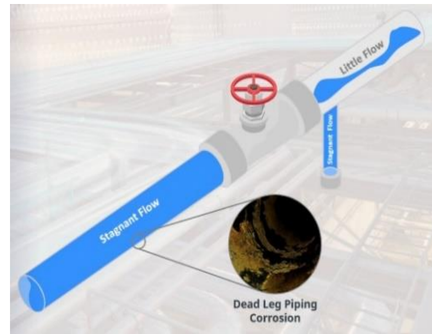
Tertiary assessment is advanced stress analysis to define the state of stress because of complicated geometry and/or loading conditions, when component is subject to cyclic operation and contains flaws.

REFERENCES CODES

API 571 **API 573** **API 579**

Dead Leg Definition & Management

DEADLEGS is a section of a production system (i.e. piping, tubing, etc.) that does not rarely or intermittently see process flow. The fluid in the system becomes stagnant and can cause contamination or accelerated corrosion.



Dead-legs remain a potential threat to safe production operations; they merit special attention because of the enhanced corrosion risk that these can often constitute.

Dead legs is defined as production segments continuously exposed to process fluids but without normal flow or provision for flow, including lines that are closed-off to flow by flanges, welded caps or other fittings.

Examples of typical dead legs in practice are summarized as follows:

1) Lines with one end blanked,
2) Pressurized dummy support legs,
3) Stagnant control valve bypass piping,
4) Spare pump piping,
5) Relief valve inlet and outlet header piping,
6) Pump trim bypass lines,
7) High point vents,
8) Sample points, Bleeders,
9) Instrument connections.
10) A section of pipework that is not part of the normal flow, but cannot be isolated from the normal flow (e.g., obsolete lines).
11) Pipework sections that are used intermittently (e.g., bypass lines and non-operating sections of spared equipment).
12) Pipework sections either upstream or downstream of a normally closed valve.
13) Drains pipework at the base of vessels.
14) Bridle pipework associated with a vessel.

There are three main types of dead legs:

1 PERMENENT OR PHYSICAL DEADLEGS — Normally no flow dead leas where areas are subject to long-term stagnation which are often inherent in original design or are due to modifications over the course of the life of the facility.

2 OPERATIONAL DEADLEGS — On/Off flow dead legs where partial flow or on/off flow conditions in such as spare pump piping, bypass lines, SRV in/out, lines normally closed and lines only used for start up or shut down operations.

3 TEMPRARY DEADLEGS — Equipment temporarily removed from service are particularly susceptible to dead leg corrosion, especially in the absence of an appropriate corrosion/damage mitigation practice or strategy.

Why are dead legs a concern?
Fluid is stagnant in dead legs; therefore, bacteria can establish colonies and proliferate resulting in an environment that is conducive to microbial influenced corrosion. Deposits can also form in dead legs leading to under deposit corrosion.

Corrosion rates at dead legs can be substantially higher than in the adjacent piping where the process fluid flow normally.

In addition, dead legs pose a challenge due to their potentially large number that can exist within a production system.

How dead legs can be managed?

Due to the difference in corrosion rates in dead legs relative to adjacent piping where fluid flow normally, a specific dead leg integrity management program is necessary.

Dead leg management is required in numerous industries such as Oil and Gas, Nuclear and Power Generation. A systematic approach to dead leg management is necessary, where based upon the assessed risk, inspection and mitigation strategies can be developed, planned, prioritized and implemented.

STAGES of Systematic Management of Dead Legs:

1

Identification of the Dead Legs

This is achieved via desktop corrosion assessment, communication with operations teams and thorough review of piping and instrumentation diagrams, isometrics, fabrication drawings and line walk downs.

2

Creating a dead leg register

The register should record all dead legs according to their type. The dead legs need to be risk assessed and then prioritized based upon their risk.

3

Assessment of prioritized dead legs

Prioritized dead legs are identified for removal or isolation. Often removal or permanent isolation of dead legs is not an option; therefore, they can be intermittently operated and/or flushed with a chemical to reduce the corrosion threat. Biocides are usually used to limit microbial growth

4

Targeted inspection

Dead legs need to be inspected to determine their physical condition and to determine the type, rate and causes of deterioration.

The inspection should be targeted at locations where water and deposits can collect allowing microbial activity to develop.

The fluids contained within dead legs are often stagnant; this leads to a number of potential problems over the longer-term:

- Aqueous hydrocarbon production fluids constitute a viable source of nutrients for microbiological entities; the stagnant conditions in dead legs are also conducive to the formation of sessile colonies of bacteria that may otherwise be less likely to form under flowing conditions. The accumulation and proliferation of sessile colonies of bacteria constitutes a credible threat from microbial induced corrosion (MIC). Local wall thinning leading to eventual perforation of the pipe wall because of MIC is a key threat to the integrity of dead legs.

- Aqueous hydrocarbon fluids contain acid gas fractions (CO2 and/or H2S) which are corrosive. When the corrosion process commences, the products that form dissolve in the process fluids, however as dead legs have no flow, the confined fluids volume is constrained such that saturation with corrosion products will occur relatively promptly. This leads to the accumulation of corrosion products and the eventual formation of debris and/or lose scale, and to the onset of under-deposit corrosion; local wall thinning leading to eventual perforation of the pipe wall because of under-deposit corrosion is a key threat to the integrity of dead legs.

It should be recognized also that once internal corrosion within dead legs commences it is often considerably more difficult to prevent its progression via chemical treatments alone using biocides and/or corrosion inhibitors. This is because well-established sessile colonies of bacteria are highly tenacious and will likely persist even where aggressive biocide treatments are employed; and the lack of flow and presence of debris substantially reduces the effectiveness of corrosion inhibitors.

The optimal approach to the management of dead leg integrity is as follows:

1. Dead leg Elimination: using the logic that prevention is better than cure, the elimination of dead legs is the most effective strategy, by virtue that it will remove all associated risks. Dead legs should therefore be identified and reviewed regularly to determine whether removal is possible. Removal of dead legs however, should be conducted in accordance with the management of change process.
2. Dead leg Strategy: in the event that dead legs cannot be removed, a strategy for managing the integrity of dead legs should be developed, involving the following:
   - I. Dead leg Integrity Risk Status (based on the following considerations):
     - a) Material of construction.
     - b) Nominal diameter and wall thickness.
     - c) Flow status (whether flow conditions are ever established).
     - d) Pressure and temperature
     - e) Process fluid chemistry
     - f) Consequence of failure of each dead leg.
     - g) Location of the dead leg (potential for escalation).
   - II. Consideration of whether the pipework can be drained and left empty.
   - III. Development of a risk-based scheme backed by data analytics to drive the dead leg inspection program.
   - IV. Development of an appropriate program for flushing of dead legs (including treatments using biocides or corrosion inhibitors as appropriate).

Non-Destructive Testing (NDT) for Dead Leg Inspection. The type of inspection technique selected will depend upon the specific type of dead leg and its dimensions:

- Visual inspection.
- Infrared Thermography may be useful for locating liquid interfaces.
- Profile RT on small diameter dead legs, Such as Vents & Drains.
- Scanning UT or RT on Larger Diameter dead Legs.
- EMAT and Pulses Eddy Current (PEC).

DEAD LEGS is detailed and covered at length in the following Codes

API 570	A considerable guidance for the inspection frequency of dead leg.
API 574	Defines dead legs, as components of a piping system that normally have no significant flow.
API 581	Defines dead legs as a section of piping or piping circuit that is used only during intermittent services such as start-ups, shutdowns rather than continuous Service.

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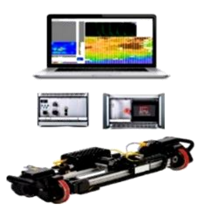
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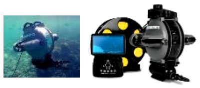
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UPCOMING EVENTS

EGYPS Exhibition 2023
13 – 15 February 2023

The EGYPS Technical Conference brings together global oil, gas and energy professionals to showcase the latest technical opportunities and challenges, breakthrough research findings, innovative technologies and industry solutions, creating an excellent learning and networking hub for the industry's technical experts. In 2023, the Technical Conference will showcase the technologies being used today and those transforming the industry of the future. Our international technical expert speakers will share their wealth of experience and knowledge. With 19 technical categories to select from, we look forward to receiving your abstract submissions.

Nigeria Oil & Gas International
13 – 15 February 2023

The **NOG International Exhibition** in Abuja, is Nigeria's most important **oil, gas, LNG and energy exhibition**, where energy professionals convene to exchange in dialogue, showcase technological advancements, identify innovative solutions and forge business partnerships. The NOG International Exhibition will take place from **2 – 6 July 2023 in Abuja** at the **International Conference Centre** with an expanded exhibition space of **5,000 sqm** attracting **5,000+ attendees** from Africa, Middle East, Europe, Asia and the USA to create and unparalleled business opportunity for exhibiting companies to tap into this vital market.

Fujairah Bunkering & Fuel Oil Forum (FUJCON)
13 March 2023

Along with our hosts, the Government of Fujairah & Port of Fujairah, we are pleased to hold the 13th International Fujairah Bunkering & Fuel Oil Forum (FUJCON 2023) from 13-15 March 2023 in Fujairah, UAE, under the Patronage of H.H. Sheikh Hamad bin Mohammed Al Sharqi, and the support of the Fujairah Oil Industry Zone.

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SPRINT Robotics
March 2023

Submit your abstract to speak at the SPRINT Robotics Asia-Pacific Summit 2023, a key event for Inspection, Maintenance & Cleaning robotics professionals. We are welcoming abstracts about use cases or new technologies for robotics for Inspection & Maintenance in capital-intensive industries. The SPRINT Robotics Asia-Pacific Summit will take place at the end of March 2023 in Singapore. The event features a dynamic program of technical presentations, an exposition, and demonstration day and dedicated networking events. The planning for the I&M Robotics week will be announced at the beginning of November.

PETROCHEMICAL & REFINING CONGRESS: EUROPE 2023

Petrochemical and Refining Congress is an annual downstream oil and gas B2B networking platform which is gathering more than 350 industry leaders from major companies including BP, Shell, Eni, McDermott, Fluor, Wood, BASF, Borealis, SABIC, and many others. The PRC Europe 2023 edition raises such hot questions as industry de-carbonization, petrochemicals and alternative fuels production, recycling technologies and plant improvements.

World Petrochemical Conference (WPC)
20 March 2023

The World Petrochemical Conference (WPC) is the premier gathering for the petrochemical industry, bringing together more than 1,000 senior chemical industry decision-makers from more than 40 countries for networking, unparalleled insight, and critical analysis from IHS Markit, your trusted partner in decision-making.

Hydrogen Technology Conference & Expo
28 June 2023

Hydrogen Technology Conference & Expo is North America's must-attend exhibition and conference that is exclusively dedicated to discussing advanced technologies for the hydrogen and fuel cell industry. The event brings together the entire hydrogen value chain to focus on developing solutions and innovations for low-carbon hydrogen production, efficient storage, and distribution as well as applications in a variety of stationary and mobile applications.

CONVERSATION FACTORS

LENGTH

1	Centimeter	=	0.3937	Inches	1	Inch	=	2.54	Cms
1	Meter	=	3.2808	Feet	1	Foot	=	0.3048	Meters
1	Kilometer	=	0.62137	Miles	1	Mile	=	1.60934	Kilometers
1	Kilometer	=	0.53996	Naut. Miles	1	Naut. Mile	=	1.852	Kilometers

AREA

1	Sq. meter	=	10.7639	Sq. Feet	1	Sq. Feet	=	0.092903	Sq. meters
1	Hectare	=	2.47105	Acres	1	Acre	=	0.404686	Hectares
1	Sq. Km	=	0.3861	Sq. Miles	1	Sq. Miles	=	2.58999	Sq. Kms
1	Sq. Km	=	247.105	Acres	1	Acre	=	0.004047	Sq. Kms

WEIGHT

1	Kilogram	=	2.20462	Pounds (lbs)	1	Pounds (lb)	=	0.45359	Kilogram
1	Metric Ton	=	0.98421	Long Tons	1	Long Ton	=	1.01605	Metric Tons
1	Metric Ton	=	1.10231	Short Tons	1	Short Ton	=	0.907185	Metric Tons

VOLUME

1	Liter	=	0.2642	U.S. Gallons	1	U.S. Gallon	=	3.785	Liters
1	Liter	=	0.21997	U.K. Gallons	1	U.K. Gallon	=	4.546.9	Liters
1	Cu. Meter	=	6.2898	Barrels	1	Barrel	=	0.159	Cu. Meters
1	Barrel	=	42	U.S. Gallons	1	Barrel	=	158.97	Liters

STANDARD ENERGY EQUIVALENTS

1000 metric tons of oil equiv. (TOE)		1000 barrels of oil Equivalent (BOE)		1000 metric tons of coal equiv. (TCE)	
10	Tera calories (net)	1.43	Tera calories (net)	7	Tera calories (net)
41.9	Tera joules (net)	6	Tera joules (net)	29.3	Tera joules (net)
1.43	thousand metric tons of coal equiv.	0.204	thousand metric tons of coal equiv.	0.84	million cubic meters of natural gas
1.2	million cubic meters of natural gas	0.172	million cubic meters of natural gas	8.14	gigawatt hours of electricity
11.63	gigawatt hours of electricity	1.661	gigawatt hours of electricity	0.7	thousand barrels of oil equiv.
7	thousand barrels of oil equiv	0.143	thousand barrels of oil equiv.	27.78	billion (10^9) BTUs (net)
39.68	billion (10^9) BTUs (net)	5.674	billion (10^9) BTUs (net)		

SPECIFIC GRAVITY: VOLUME PER TON

Degrees API	Specific Gravity @ 60°F	Barrels per* Met. Ton	Barrels per* Long ton.
25	0.904	6.98	7.09
26	0.898	7.02	7.13
27	0.893	7.06	7.18
28	0.887	7.1	7.22
29	0.882	7.15	7.27
30	0.876	7.19	7.31
31	0.871	7.24	7.36
32	0.865	7.28	7.4
33	0.86	7.33	7.45
34	0.855	7.37	7.49
35	0.85	7.42	7.54
36	0.845	7.46	7.58
37	0.84	7.51	7.63
38	0.835	7.55	7.67
39	0.83	7.6	7.72
40	0.825	7.64	7.76
41	0.82	7.69	7.81
42	0.816	7.73	7.85

SPECIFIC GRAVITY RANGES

	Specific Gravity	Barrels per metric ton
Crude Oils	0.80 - 0.97	8.0 - 6.6
Aviation Gasolines	0.70 - 0.78	9.1 - 8.2
Motor Gasolines	0.71 - 0.79	9.0 - 8.1
Kerosine's	0.78 - 0.84	8.2 - 7.6
Gas Oils	0.82 - 0.90	7.8 - 7.1
Diesel Oils	0.82 - 0.92	7.8 - 6.9
Lubricating Oils	0.85 - 0.95	7.5 - 6.7
Fuel Oils	0.92 - 0.99	6.9 - 6.5
Asphaltic Bitumen's	1.00 - 1.10	6.4 - 5.8

CALORIFIC VALUE OF FUELS

Rough Gross Values in Btu Per lb	
Crude Oils	18 300 - 19 500
Gasolines	20 500
Kerosine's	19 800
Benzole	18 100
Ethyl Alcohol	11 600
Gas Oils	19 200
Fuel Oil (Bunker)	18 300
Coal (Bituminous)	10 200 - 14 600
LNG	22 300

Multiples

micro	=	one millionth	hecto	=	one hundred
milli	=	one thousandth	kilo	=	one thousand
centi	=	one hundredth	mega	=	one million
dec	=	one tenth	giga	=	one billion (10^9)
deca	=	ten	tera	=	one trillion (10^{12})

Ref. Petroleum Magazine