

# NDT SCOOP

I N S P E C T I O N

M A G A Z I N E

by NDT CORNER

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Q3.2023

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EDITION 3 QUARTER III 2023

TECHNOLOGIES

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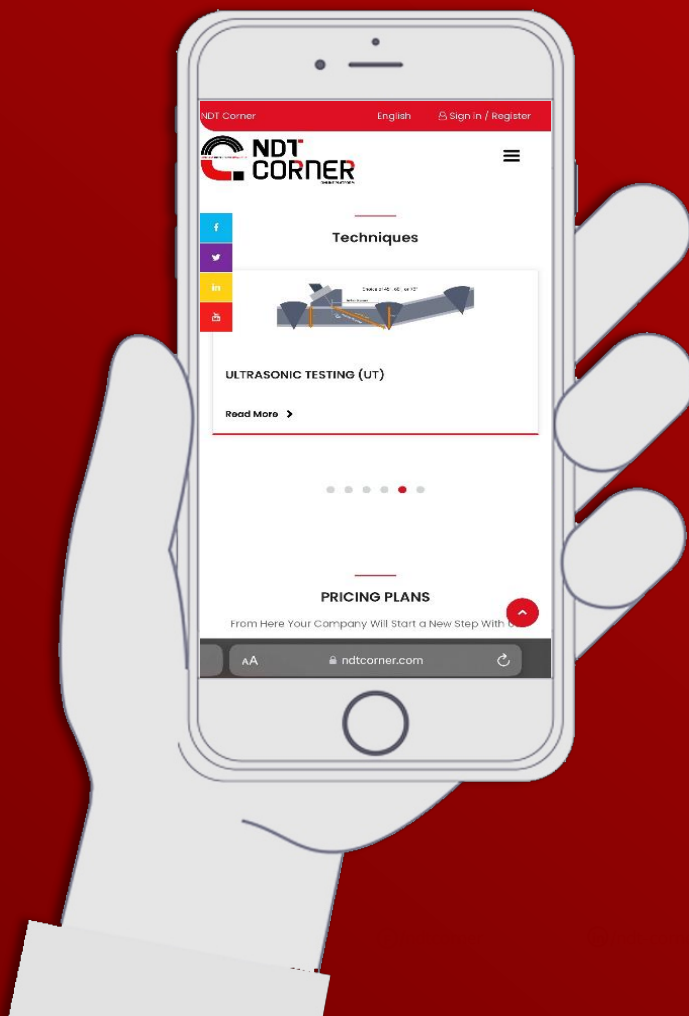
TRAINING

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**SCAN ME**



# NDT SCOOP

INSPECTION MAGAZINE

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**Q.3 EDITION**

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### ON THE COVER

MFE Inspection Solutions is your number one source for all things NDT, RVI, ENV and UAVs. We're dedicated to giving you the very best tool or solution for the job, focusing on dependability, customer service, and professionalism. Founded in 2009 by the Duke Family. [mfe-is.com](http://mfe-is.com)



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We are "ISO 45001: 2018" Accredited by LIYODS register.

We are "ISO 14001: 2015" certified, Environmental Management System - Accredited by LIYODS register.

We are Certified of full Membership, Lifting Equipment Engineers Association. Certificate No. 6455.

We are an IRATA International Membership for Rope Access (Operator & Trainer) Certificate No. 7108/OT.

We are formally recognized as a member of Drops, the industry wide initiative focused on preventing dropped objects in the workplace. DIPS is licensed from the Egyptian Nuclear & Radiological Regulatory Authority (ENRRA) for industrial Radiography.

We are Certified for ABS Certificate, for Hull Gauging for vessels NDT & Rope access.

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4. Lifting Equipment Inspection.
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6. Welding and Painting inspection.
7. Dropped Objects Survey.
8. Rope Access services.
9. Training Courses.



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- Special Ultrasonic Testing (AUT, PAUT, TOFD, CUPS, SRUT, HTHA detection).
- 2D,3D Laser scanning analysis and modeling.
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Introducing the ultimate solution for detecting hydrocarbon gas leaks:

## **MFE OGI Handheld Camera**

The Quad - O compliant MFE OGI Camera features Sierra Olympic's industry-leading, mid-wave infrared Ventus OGI camera core and is designed to detect and visualize hydrocarbon gases, including methane and propane. Operators can take the camera right to the source to determine the size, movement, and direction of the gas leak in order to quickly get people out of harm's way and repair the leak.

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- **CARRY BY HAND FOR FURTHER DIAGNOSIS**
- **DIGITAL NOISE REDUCTION**
- **ACHIEVE MORE ACCURATE RESULTS WITH SHUTTER & SCENE-BASED NUC**
- **HIGH 640 X 512 RESOLUTION**



**MFE OGI Camera**



**Other OGI Camera**





# FEATURED NDT METHOD

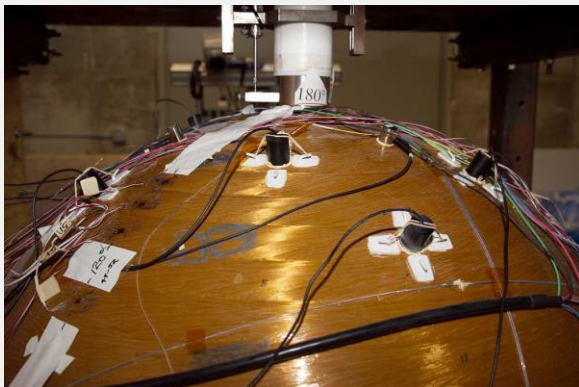
Inspection Knowledge

## Acoustic Emission Testing (AET)

### WHAT IS MEANT BY ACOUSTIC EMISSIONS?

Acoustic Emission (AE) refers to the generation of transient elastic waves produced by a sudden redistribution of stress in a material. When a structure is subject to an external stimulus (change in pressure, load, or temperature), localized sources trigger the release of energy, in the form of stress waves, which propagate to the surface and are recorded by sensors. With the right equipment and setup, motions on the order of picometers (10 – 12 m) can be identified. Sources of AE vary from natural events like earthquakes and rock bursts melting, twinning, and phase transformations in metals. In composites, matrix cracking and fiber breakage and debonding contribute to acoustic emissions. AEs have also been measured and recorded in polymers, wood, and concrete, among other materials.

**Detection and analysis** of AE signals can supply valuable information regarding the origin and importance of a discontinuity in a material. Because of the versatility of Acoustic Emission Testing (AE), it has many industrial applications (e.g. assessing structural integrity, detecting flaws, testing for leaks, or monitoring weld quality) and is used extensively as a research tool.

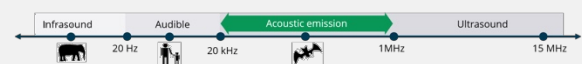


Acoustic Emission is unlike most other NDT techniques in two regards:

- 1st pertains to the origin of the signal. Instead of supplying energy to the object under examination, AET simply listens for the energy released by the object. AE tests are often performed on structures while in operation, as this provides adequate loading for propagating defects and triggering acoustic emissions.
- 2nd difference is that AET deals with dynamic processes, or changes, in a material. This is particularly meaningful because only active features (e.g., crack growth) are highlighted. The ability to discern between developing and stagnant defects is significant. However, it is possible for flaws to go undetected all together if loading is not high enough to cause an acoustic event. Furthermore, strength or risk of failure of a component. Other advantages of AET include fast and complete volumetric inspection using multiple sensors, permanent sensor mounting for process control, and no need to disassemble and clean a specimen.

### Principle of Acoustic Emission Testing

When a material with defects is subjected to mechanical stress or load, it releases energy. This energy travels in the shape of high-frequency stress waves. These waves or fluctuations are obtained with the utilization of sensors which in turn transforms the energy into voltage. This voltage is electronically overstated with the utilization of timing circuits and later refined as acoustic emission signal data.



### Applications of Acoustic Emission Testing

It's a known fact that acoustic emission testing is versatile and has numerous applications in various industries. It is also used as research equipment. Now, let's read about a few applications of acoustic emission testing that are listed below:

- Identification of active sources that includes crack propagation, fatigue, fiber delamination, yielding, fiber fracture, corrosion, and creep.
- Leak detection. Research & Development (R&D) studies.
- Weld quality monitoring.
- In-field examination.
- Structural integrity inspection.
- Production quality supervision.
- Monitoring chemical reactions and phase changes.
- Leak detection.

Industries categories that can use acoustic emission testing includes:

**Aerospace:** The aerospace field can employ acoustic emission testing to evaluate fuel storage tanks and motors.

**Alternative energy sources:** Acoustic emission testing is beneficial for assessing the structural integrity of alternative energy infrastructure, just like wind turbines.

**Automotive:** Automotive manufacturers can make use of acoustic emission testing to evaluate vehicle elements and factory equipment as well.

**Materials research & development:** Those who are working in materials research and development, can make use of the AET method to examine the integrity of brand-new materials as well as existing materials in numerous applications.

**Nuclear power:** To inspect nuclear components like valves, lift beams, and streamlines AET can be utilized.

**Offshore drilling:** This non-destructive method can give early detection of drawbacks in offshore drilling pipelines and platforms.

**Oil and gas:** AET can be used by oil and gas companies to assess processing equipment, vessels, and pipelines.

**Power distribution:** Acoustic emission testing can be utilized in power transformers for partial discharge inspection.

#### Advantages of Acoustic Emission Testing:

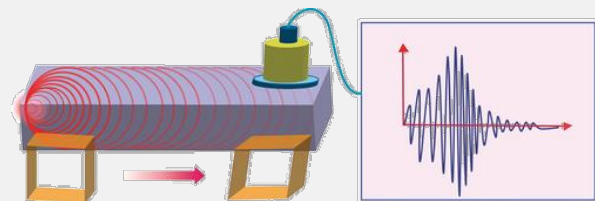
Acoustic emission testing can be utilized for the timely identification of any defects & real-time monitoring as well. It is a high-sensitivity test technique and delivers various advantages, as mentioned below.

1. **Timely damage detection** - As acoustic emission testing inspects the formation of cracks & defects, and as mentioned above that it is a highly sensitive test method, it can detect fairly small/micro defects in the initial stage. This early detection encourages you to fix up the flaws before they cause any crucial problems or threats.
2. **Global, simultaneous examination** - With the help of AET, you can analyze the whole unit or system simultaneously, comprising pressure vessels, piping, reactors, and any other extra elements. This leads to a more productive, cost-effective testing procedure and facilitates the assessment of even large systems somewhat instantly.
3. **No need for stopping the operation** - AET can often be executed on a unit while it is functioning, averting the necessity for shutting down a system. One can even conduct acoustic emission testing at the time of an in-service over-pressurization or scheduled cool-down. Preventing a shutdown of the machines can decrease costs considerably and will help you keep a consistent productivity level.
4. **Detection of only active flaws** - Acoustic emission testing only specifies active deformities means those defects that are thriving. This characteristic shows that only flaws that are liable to cause critical problems in the future are detected, whereas stable cracks and former fabrication flaws are not. This facilitates you to concentrate on the most important problems, conserving the time and money of your business.
5. **Immediate indication of threat** - When it comes to acoustic emission testing, you get a sudden indication of the stability & strength of a provided component and the risk of disappointment or failure, encouraging you to react promptly if required.
6. **Minimal disruption to insulation** - Usually, only minor holes in insulation are needed to mount sensors. You might also be eligible to park permanent sensors under the insulation.
7. **Compliance assistance**: Various standards recognize acoustic emission testing, and it can help you to ensure compliance with federal, state, and local regulations.
8. **Decreased expenses** - Utilizing acoustic emission testing can decrease costs significantly by preventing downtime, curtailing examination time, expecting the smallest disruption to insulation, and specifying only the deformities that may result in substantial problems soon if not amended.

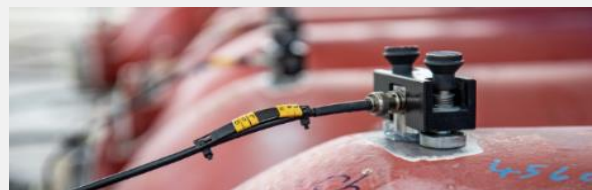
#### Limitations of Acoustic Emission Testing:

Like any other test method, acoustic emission testing also has some limitations, which indicates it might not be the perfect option for every application. In some circumstances, organizations can profit from supplementing acoustic emission testing with other examination methods. Some of the disadvantages/limitations of acoustic emission testing are as follows:

1. **Can only provide qualitative results** - Acoustic emission testing can only deliver qualitative outcomes and not quantitative results. It can actually detect that a flaw still exists, but specifying the size and depth of a crack, for instance, requires other examination methods, just like ultrasonic testing.
2. **Can only find active flaws** - The fact that acoustic emission testing only detects active flaws can actually be an advantage, but in some situations, you might also wish to identify stagnant imperfections. Acoustic emission testing would not help this objective. It is furthermore possible that AET may not observe very small active defects if the loading is not sufficient to result in an acoustic circumstance.
3. **Loud environments present challenges** - It can be extra challenging to obtain precise findings from acoustic emission testing when it is conducted in loud service atmosphere settings. In order to filter out surplus noise, signal discrimination and noise reduction methods and technologies are employed.
4. **Requires certain skills, knowledge, and proficiency** - Conducting AET needs a highly skilled, experienced, and knowledgeable operator. It also includes the utilization of relatively complicated and costly software and hardware.



**AE systems can only qualitatively gauge** how much damage is contained in a structure. In order to obtain quantitative results about the size, depth, and overall acceptability of a part, other NDT methods (often ultrasonic testing) are necessary. Another drawback of AE stems from load service environments which contribute extraneous noise to the signals. For successful applications, signal discrimination and noise reduction are crucial.







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UAIS has a large range of Advanced and conventional Non-Destructive Testing (NDT) capabilities that meet your project challenges and inspection needs. All of our NDT techniques and technologies are met the international standards. We employ state-of-the-art equipment and experienced professional personal in order to provide you with confidence and assurance.

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## One stop **NDT Solutions**

GNDT Heavy Equipment Trading LLC, established in 2018, is an ISO 9001:2015 accredited company specialising in the marketing, sales and support to the Non-Destructive Testing Industry.

GNDT UAE has expanded Middle East offices in Qatar (GNDT Qatar) & Kuwait (IBGTCC Kuwait) & Kingdom of Saudi Arabia.

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# MFE OGI CAMERA

*Unleash the power of mobility  
for gas leak detection with the*

## **MFE OGI Camera and Boston Dynamics Spot**



*DETECT METHANE  
LEAKS IN REAL TIME*

*CARRY THE MFE OGI CAMERA  
BY HAND FOR FURTHER DIAGNOSIS*

*SEAMLESS INTEGRATION,  
UNPARALLELED GAS LEAK DETECTION*

### **Introducing the ultimate solution for detecting hydrocarbon gas leaks: the MFE OGI Camera and Boston Dynamics' Spot.**

The Quad - O compliant MFE OGI Camera features Sierra Olympic's industry-leading, mid-wave infrared Ventus OGI camera core and is designed to detect and visualize hydrocarbon gases, including methane and propane.

When mounted on Boston Dynamics' Spot, operators may rely on Spot's unprecedented mobility to automate routine inspection tasks. When further inspection is required, the MFE OGI Camera can be used as a handheld device for precise, close-up detection.

A suite of advanced image processing functions, including automatic gain and dynamic contrast control, delivers visual acuity to operators for efficient leak detection and remediation.

Whether used as a handheld device or mounted on Spot, the MFE OGI Camera is an invaluable tool that saves time and money, increases efficiency, limits product loss, protects lives and reduces harm to the environment.



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# Guide to Codes

## A Comprehensive Guide to NDT NON-DESTRUCTIVE TESTING CODES & STANDARDS

### CODE

**Code** is a standard that has been adopted by one or more governmental bodies and has the force of law, or when it has been incorporated into a business contract.

- Codes are generally the governing documents, providing a set of rules that specify the minimum acceptable level of safety for manufactured, fabricated, or constructed objects.
- Most codes will provide acceptance and rejection criteria for the required inspections.
- ASME (American Society of Mechanical Engineers) Codes are legally enforceable in many US states. Whereas, in the other part of the world they are not legally enforceable, but such countries have their own similar codes.

### STANDARD

**Standards** are documents that establish engineering or technical requirements for products, practices, methods, or operations.

- Standards are the documents, prepared by professional societies or committee, which are believed to be efficient engineering practices and which contain mandatory requirements.
- An inspection standard may include information on how to apply multiple testing techniques.
- Standardization of certain items to prevent multiple versions to be used.
- Standards are usually created by individual companies, organizations, or countries. They are not legalized.

**Most countries have one or more organizations (“standards bodies”) that develop and publish technical industrial standards. Some do not, and those usually reference existing codes and standards for their manufacturing, fabrication, and construction projects. In the United States, these organizations are usually independent organizations from private industry, but in many countries, they are government.**



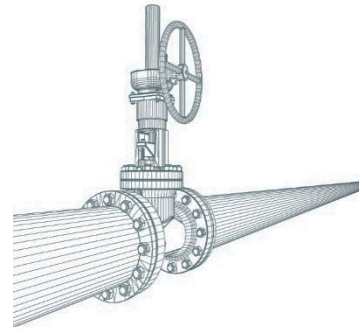


# Authorized Organizations

## To create **CODES & STANDARD**

### For Non-Destructive Testing

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



# Authorized Organizations

## To guide **TRAINING & CERTIFICATION**

### For Non-Destructive Testing

**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 it; **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.



## ASNT

### THE AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING.

is a member-based, non-profit professional society.

Provides NDT related reference materials, technical conferences, and certification documents. ASNT does not publish standards that describe how to perform NDT tasks.

Those are published by **ASTM International** and are discussed in that section,

## ASTM

### ASTM International

(Formerly the American Society for Testing and Materials) is one of the largest voluntary standards development organizations in the world, providing technical standards for materials, products, systems, and services. Over 180 ASTM NDT standards are published in the ASTM Annual Book of Standards, Volume 03.03, and Non-destructive Testing. ASTM defines three of their document categories as follows:

#### A “GUIDE”

is a compendium of information or series of options that does not recommend a specific course of action. A guide increases the awareness of information and approaches in each subject area.

#### A “PRACTICE”

is a definitive set of instructions for performing one or more specific operations or functions that does not produce a test result. Examples of practices include, but are not limited to application, assessment, cleaning, collection, decontamination, inspection, installation, preparation, sampling, screening and training.

#### A “TEST METHOD”

is a definitive procedure that produces a test result. Examples of test methods include, but are not limited to identification, measurement and evaluation of one or more qualities, characteristics or properties.

Here are **the most used ASTM NDT standards**. Additional standards could be sourced in the ASTM Annual Book of Standards, Volume 03.03.

<b>ASTM E709:</b>	Standard Guide for Magnetic Particle Testing
<b>ASTM E1444:</b>	Standard Practice for Magnetic Particle Testing for Aerospace
<b>ASTM E165:</b>	Standard Practice for Liquid PT for General Industry
<b>ASTM E1417:</b>	Standard Practice for Liquid Penetrant Testing
<b>ASTM E1208:</b>	Standard Practice for PT using the Lipophilic Post-Emulsifiable
<b>ASTM E1209:</b>	Standard Practice for PT using the Water-Washable Process
<b>ASTM E1210:</b>	Standard Practice for PT using the Hydrophilic Post-Emulsifiable
<b>ASTM E1219:</b>	Standard Practice for PT using the Solvent-Removable Process
<b>ASTM E114:</b>	Practice for UT Pulse-Echo Straight-Beam by the Contact Method
<b>ASTM E164:</b>	Standard Practice for Contact Ultrasonic Testing of Weldments
<b>ASTM E213:</b>	Standard Practice for Ultrasonic Testing of Metal Pipe and Tubing
<b>ASTM E2375:</b>	Standard Practice for Ultrasonic Testing of Wrought Products
<b>ASTM E94:</b>	Guide for Radiographic Examination
<b>ASTM E1742:</b>	Practice for Radiographic Examination
<b>ASTM E1000:</b>	Guide for Radioscopy
<b>ASTM E1255:</b>	Practice for Radioscopy
<b>ASTM E1030:</b>	Test Method for Radiographic Examination of Metallic Castings
<b>ASTM E1032:</b>	Test Method for Radiographic Examination of Weldments
<b>ASTM E999:</b>	Guide for Controlling the Quality of Industrial RT Film Processing
<b>ASTM E142:</b>	Method for Controlling Quality of Radiographic Testing
<b>ASTM E2007:</b>	Standard Guide for Computed Radiography
<b>ASTM E2738:</b>	Standard Practice for Digital Imaging for Computed RT (CR) Test
<b>ASTM E268:</b>	Electromagnetic testing
<b>ASTM E1962:</b>	Standard Practice for UT Surface Testing using (EMAT) Techniques
<b>ASTM E426:</b>	Practice for Electromagnetic (Eddy-Current) of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar.

**[www.astm.org](http://www.astm.org)**



## ASME

### AMERICAN SOCIETY OF MECHANICAL ENGINEERS

is a not-for-profit professional organization that enables collaboration, knowledge sharing and skill development across all engineering disciplines, while promoting the vital role of the engineer in society. ASME codes and standards, publications, conferences, continuing education, and professional development programs provide a foundation for advancing technical knowledge and a safer world. ASME publishes multiple codes and standards including (but not limited to) the following documents:

The “ASME Boiler & Pressure Vessel Code” (BPVC). The 2010 edition of the BPVC with 2011 addenda was made available in July 2011. This code is made up of 12 sections, or “books,” covering the following subjects:

The **BPVC** is now published biennially in odd-numbered years without addenda in the intervening year.

**ASME#** Section 1: Power Boilers

**ASME#** Section 2: Materials

**ASME#** Section 3: Rules for Construction of Nuclear Facility Components

**ASME#** Section 4: Heating Boilers

**ASME#** Section 5: Nondestructive Examination

**ASME#** Section 6: Recommended Rules for the Care and Operation of Heating Boilers

**ASME#** Section 7: Recommended Guidelines for the Care of Power Boilers

**ASME#** Section 8: Pressure Vessels

**ASME#** Section 9: Welding and Brazing Qualifications

**ASME#** Section 10: Fiber-Reinforced Plastic Pressure Vessels

**ASME#** Section 11: Rules for In-service Inspection of Nuclear Power Plant Components

**ASME#** Section 12: Rules for Construction and Continued Service of Transport Tanks

**ASME B31.1:** Power Piping. This code contains requirements for piping systems typically found in electric power-generating stations, industrial institutional plants, geothermal heating systems, and heating and cooling systems.

**ASME B31.3:** Process Piping. This Code contains requirements for piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing-plant terminals.

[www.asme.org](http://www.asme.org)

## API

### AMERICAN PETROLEUM INSTITUTE

is a national trade association that represents all aspects of America’s oil and natural gas industry, including producers, refiners, suppliers, pipeline operators, marine transporters and service and supply companies. Among the standards that API publishes are the following:

**API 510:** Pressure Vessel Inspection: In-Service Inspection, Rating, Repair and Alteration

**API 570:** Piping Inspection: In-service Inspection, Rating, Repair, and Alteration of Piping Systems

**API 650:** Welded Tanks for Oil Storage

**API 653:** Tank Inspection, Repair, Alteration, and Reconstruction

**API 1104:** Welding of Pipelines and Related Facilities

[www.api.org](http://www.api.org)

## AWS

### AMERICAN WELDING SOCIETY

is a nonprofit organization with the goal of advancing the science, technology, and application of welding and related joining disciplines. AWS provides certification programs for welding inspectors, supervisors, educators, etc., and publishes multiple standards, many of which contain procedures for the application of nondestructive testing methods and techniques above and beyond visual inspection. A few of their standards are listed here:

**AWS D1.1:** Structural Welding Code – Steel

**AWS D1.2:** Structural Welding Code – Aluminum

**AWS D1.3:** Structural Welding Code – Sheet Steel

**AWS D1.5:** Bridge Welding Code

**AWS D1.6:** Structural Welding Code – Stainless Steel

[www.aws.org](http://www.aws.org)

## ISO

### INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

the world's largest developer and publisher of International Standards, is a non-governmental organization located in Geneva, Switzerland. ISO is a network of the national standards institutes of 161 countries, one member per country. Many of the ISO member institutes are part of the governmental structure of their countries or are mandated by their government. Other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations. Three of the many ISO standards are listed below:

**ISO 9712**, Non-destructive testing – Qualification and certification of personnel. This International standard, which was revised in 2012, provides the requirements for the NDT certification of NDT personnel by an accredited third-party certification body that conforms to the requirements of ISO/IEC 17024, Conformity assessment – General requirements for bodies operating certification of persons.

**ISO/IEC 17024**, Conformity assessment – General requirements for bodies operating certification of persons. This international standard was developed with the objective of achieving and promoting a globally accepted benchmark for organizations operating certification of persons.

**ISO/IEC 17011**, Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies. This international standard specifies the general requirements for accreditation bodies. ANSI, the U.S. accreditation body that has accredited ASNT is accredited under ISO 17011 and is a member of the International Accreditation Forum (IAF), the world association of Conformity Assessment Accreditation Bodies in the fields of management systems, products, services, personnel, and other similar programs of conformity assessment.

[www.iso.org](http://www.iso.org)

## AIA

### AEROSPACE INDUSTRIES ASSOCIATION

is a trade association with more than 100 major aerospace and defense member companies. These companies embody every high-technology manufacturing segment of the U.S. aerospace and defense industry from commercial aviation and avionics to manned and unmanned defense systems, to space technologies and satellite communications. The AIA publishes multiple aviation & aerospace-related standards, two of them are shown:

**NAS 410**, NAS Certification & Qualification of Nondestructive Test Personnel. This employer-based certification standard establishes the minimum requirements for the qualification and certification of personnel performing nondestructive testing (NDT), nondestructive inspection (NDI), or nondestructive evaluation (NDE) in the aerospace manufacturing, service, maintenance, and overhaul industries. In 2002, NAS 410 was harmonized with European Norm 4179 (listed in the CEN section), so that the requirements in both documents are identical.

**NAS 999**, Nondestructive Inspection of Advanced Composite Structures. This specification establishes the requirements for non-destructive inspection (NDI), NDI standards, NDI methods, and NDI acceptance criteria.

[www.aia-aerospace.org](http://www.aia-aerospace.org)

## CEN

### EUROPEAN COMMITTEE FOR STANDARDIZATION

is a business facilitator in Europe, removing trade barriers for European industry and consumers. Its mission is to foster the European economy in global trading, the welfare of European citizens and the environment. CEN is a major provider of European Standards and technical specifications. It is the only recognized European organization according to Directive 98/34/EC for the planning, drafting and adoption of European Standards in all areas of economic activity except for electro-technology and telecommunication. CEN's 31 National Members work together to develop voluntary European Standards (ENs).

Standards (Norms) developed by CEN are considered "harmonized standards" that are required to be accepted by all member nations in the European Union. The following two ENs are NDT certification standards:

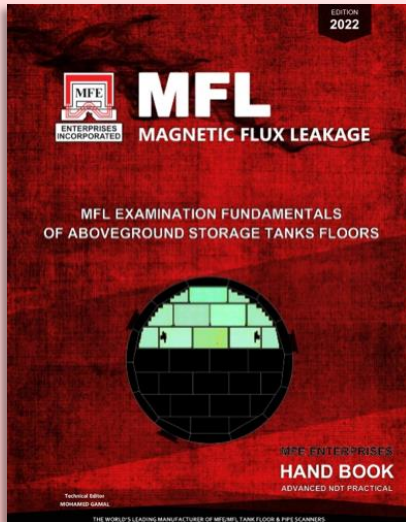
**EN 4179**, Aerospace series – Qualification and approval of personnel for non-destructive testing. This employer-based certification standard is the European version of NAS 410, which was described under the Aerospace Industries Association section on this web page.

**EN 473**, Non-destructive testing – Qualification and certification of NDT personnel – General principles. This European Standard established principles for the third-party ("central") qualification and certification of personnel who perform industrial non-destructive testing (NDT) by an accredited third-party certification body. Under EN 473, certification bodies had to administer procedures for certification according to the requirements of EN 473 and must fulfill the requirements of EN ISO/IEC 17024.

**EN ISO 9712**, which was approved in June 2012, replaced EN 473 as the European harmonized standard (Norm) for NDT central certification effective 1 January 2012. EN ISO 9712 permits the use of current EN 473 certifications until the certificate holders' next renewal period, at which time they must recertify in accordance with the EN ISO 9712 requirements. EN ISO 9712 and ISO 9712 are identical except that EN ISO 9712 has been approved as a harmonized standard for use under the European Pressure Equipment Directive 97/23/EC.

[www.cen.eu](http://www.cen.eu)





# A Comprehensive MFL Operational Handbook

## A Game Changer!

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MENA Director  
Editor v. 2019

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Review v. 2019

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### ABSTRACT

This Book is strongly providing a comprehensive guide to the MFL Tank Floor Examination.

Magnetic Flux Leakage (MFL) inspection is a method of non-destructive testing (NDT) 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 improve sizing accuracy, defect needs to be quantified and followed up by prove up using UT thickness with A scan features.

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 ASME Code and API 653. While MFL signals are often related to the volume of a defect, its depth is perhaps the most difficult to estimate and the most critical dimension since it indicates the closeness of a potential leak and if misinterpreted can lead to erroneous repair strategies with costly outcomes. Therefore, accurately determining the geometry of defects is pivotal if an optimum repair strategy is to be formulated.

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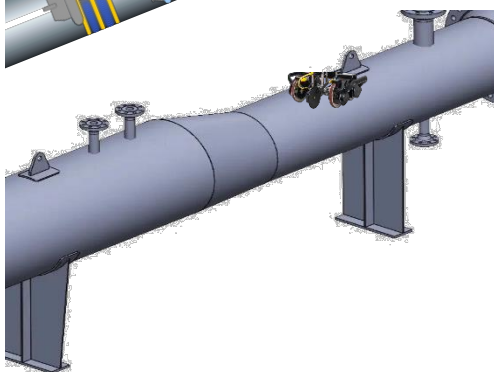
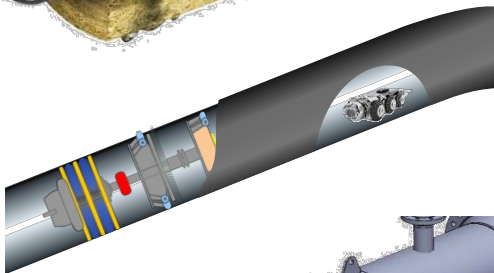
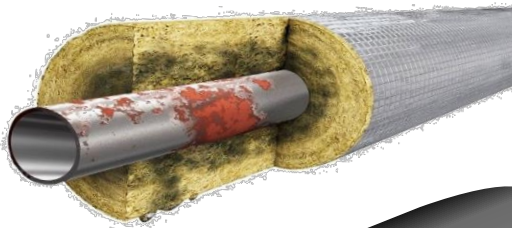
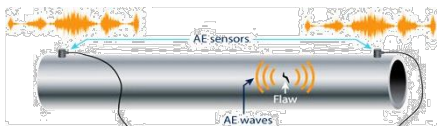
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## HOW TO INSPECT PIPELINES?

# PIPELINES Integrity

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### INSPECTION OVER INSULATION

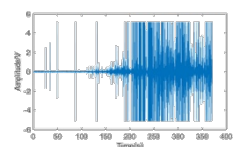
- Pulsed Eddy Current
- LRUT Guided Wave
- Digital RT
- Acoustic Emission

### INTERNAL INSPECTION

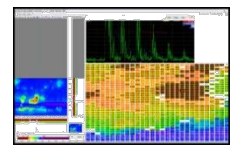
- Smart/Intelligent Pig
- Remote Visual Inspection (RVI)

### EXTERNAL INSPECTION

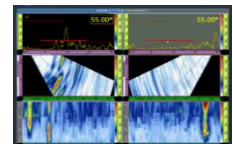
- Automatic UT Corrosion Mapping
- PAUT & Hydro-form Corrosion Mapping
- MFL Pipe Scan
- LRUT Guided wave
- EMAT (Surface & Subsurface)
- Thermal Imaging
- UT grid with A Scan feature.
- Acoustic Emission



Acoustic Emission



AUT Scan



PAUT Scan



UT Grid Scan



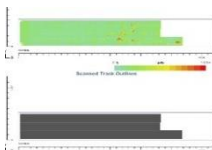
Digital RT



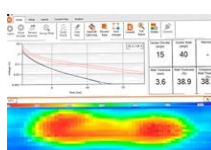
Thermal Imaging



Smart Pigging



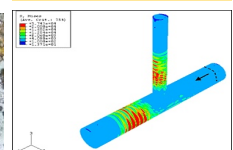
MFL Scan



ECT Scan



RVI Image



LRUT Test

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# Piping Classification

Three types of pipes are used in Oil, and Gas industry are **Seamless pipes, ERW Pipes, and LSAW Pipes**. All these types of Pipes are available in many materials and grades. A seamless pipe is manufactured without making any weld and by forming a hard steel billet on a shrill rod. Welded pipes are manufactured by applying processes like cutting, bending, and final welding of coils or plates.

## SEAMLESS PIPE

### Made without Welding

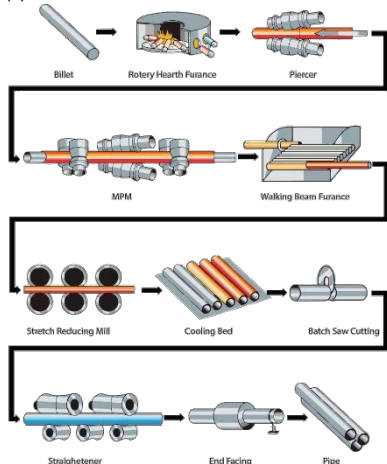
Seamless pipes are manufactured without seam welds. These pipes are manufactured from steel billets which are heated and drilled to generate the tubular section.

Seamless pipes are utilized for different purposes in the oil and gas industry such as upstream operations, and midstream operations like carrying and distribution of different fluids like oil, gas, slurries, steam, and acids. Also used in downstream operations like process piping to refine oil and gas in secondary produce. Seamless Pipes are suitable to use in general plumbing applications in this industry.

### Types of Seamless pipes used in the oil and gas industry are:

- Carbon Steel Seamless Pipes in grades such as ASTM A106, A333, A53, and API 5L.
- Chrome-moly alloy steel seamless pipes in grades like ASTM A335 Grades P5 to P91 for high temperature and pressure applications
- Stainless steel seamless pipes in ASTM A312 Series of 300 and 400 such as 304, 316, 321, and 347.
- Duplex and super duplex Seamless pipes in ASTM A790/ A928 with double ferritic and austenitic structure.
- Seamless Pipes are available in different nickel alloys such as Inconel, Hastelloy, Cupronickel, Monel, and Nickel.

**Applications of Seamless pipes:** widely used in nuclear devices, natural gas, petrochemical, shipbuilding and boiler industries, tubes for Pressure Applications, low and medium pressure service, heat exchange tubes, streaming tubes, low and medium pressure boiler water wall, economizer, re-heater, super-heater and steam pipeline.



## ERW PIPE

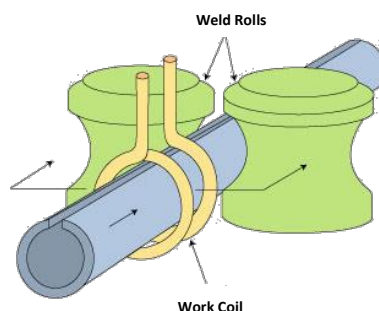
### Electric Resistance Welding

ERW pipes are produced by utilizing steel coils. These Pipes are formed by using coils, which are uncoiled, polished, cut, and then formed into the shape of the pipe by aligning its two edges electrically. The diameter of ERW pipe ranges from ½ inches (15mm) to 24 inches (21.34mm).

ERW Pipes are available in different materials such as carbon steel like ASTM A53 and stainless steel like ASTM A312. The ASME B36.10 and ASME B36.19 are the fundamental recommendations of these Pipes. By considering rate and performance, ERW Pipes are an adequate alternative to Seamless type of Pipes.

**Advantages of ERW pipes:** As only the edges are heated, the tube possesses a clean accurate surface. Electric resistance welding can make tubes in sizes up to 0.4 meter diameter. Tubes can also be made from steels having around 0.3% carbon. Major factor is economy in low pressure application.

**Applications of ERW pipes:** used in various engineering purposes, fencing, scaffolding, line pipes etc. for Oil & gas pipelines, Agricultural purposes, Drinking Water for housings, in collieries for extraction of Water, Thermal Powers, Transports, Hand pumps for deep boring wells, as a strong protection for cables by Telecom Department, Structural Purposes etc.



## LSAW PIPE

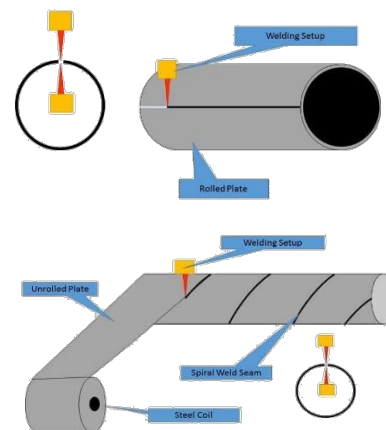
### Longitudinal Submerged Arc Welding

LSAW pipe made with submerged arc welding. The process is cutting, bending, and welding of steel plates. LSAW pipes are available in the maximum size range as compared to other Pipes.

These Pipes are available between 16 and 24 inches but they also suitable for pipelines beyond 24 inches.

**LSAW pipes are categorized** into two main types. One is the **longitudinal**, which includes a single or double straight seam weld, and another is the **spiral** type, which includes HSAW, SSAW, or SAWL. DSAW pipes have a joint weld on the interior side as well as the outer side of the pipe. However, LSAW pipes have only one seam weld on the outer cover of the pipe.

**Applications** API 5L large-diameter LSAW pipes are popularly used to convey hydrocarbons to lengthy distances in the oil and gas industry. HSAW or SSAW spiral weld pipes are not much used in the Oil and Gas industry.



## How to Order Steel Pipe for Your Project?

When ordering steel pipes, there are two key dimensions: the nominal pipe size (NPS) and the wall thickness (schedule). Pipe lengths can be single random (SRL) 5-7 meters for pipes below 4 inches or double random length (DRL) 11-13 meters above 4 inches. Custom lengths can be used for long pipelines. Pipe ends can be beveled (BE), plain (PE), threaded (THD) threaded and coupled (T&C) or grooved.

### Typical Order Details Summary:

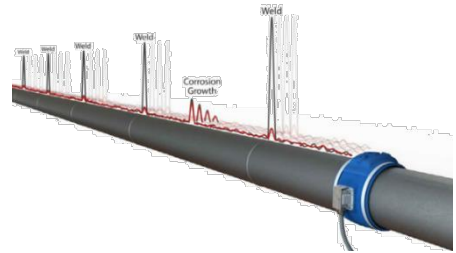
- Type (Seamless or welded)
- Nominal Pipe Size
- Schedule
- End types
- Material Grades
- Quantity in meters or feet.

# Detailed Piping Inspection Methods

## Long Range Ultrasonic Testing (LRUT)

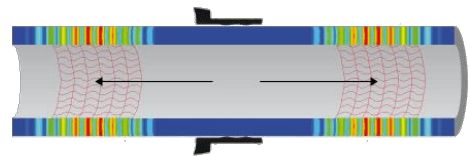
LRUT provides rapid screening for corrosion and erosion.

LRUT, also known as **guided wave ultrasonic testing**, is a fast and cost-effective method for inspecting long lengths of pipe. Hundreds of meters of pipe can be screened in one day from one single location and the technique can inspect 100% of the pipe wall. LRUT can be performed on piping that is in operation, insulated and buried, and in areas that are difficult to access such as those at high elevations. The method can therefore save time and money that would otherwise be spent on excavation, insulation removal and scaffolding. A ring of transducers is fitted around the pipeline and the transducers generate and receive low frequency ultrasonic guided waves along the pipe. The returning echoes indicate defects such as corrosion and other abnormalities.



### The benefits of long-range ultrasonic testing:

- Screening long lengths of pipe at one time
- Inspection of 100% of the pipe
- Detection of corrosion and erosion under insulation of pipes
- Analysis of pipes at difficult-access locations, such as wall penetrations, road crossings and buried sites
- Screening of on and offshore pipework, even in tightly packed racks
- Riser inspection



## Smart/Intelligent Pigging Testing

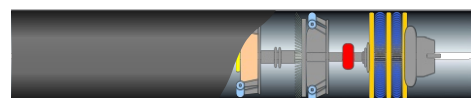
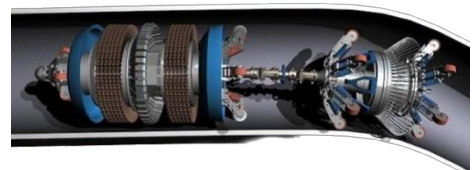
Pigging is an in-line inspection (ILI) technique.

PIG is inserted into pipelines to perform cleaning and inspection activities. Pigging can be conducted on a variety of pipelines sizes without having to stop the flow of material through the line. A pig is placed into the pipeline at a valve or pump station that has a special configuration of valves and pipes where the tool can be loaded into a receiver. Once the receiver is closed and sealed, the pig is then driven down the line, either being pulled through by a cable or being pushed through by the flow of product.

Traditionally, pigging was used purely to clean pipelines. The pig was simply placed in one end of a pipeline and pushed through the line by the product flow. It scrapes the sides of the pipe as it travels, removing dirt and debris as it goes.

For inspection, pigs can be fitted with various nondestructive examination technologies that can scan the pipe through which it travels. These are often referred to as "smart pigs." There are several different types of smart pigs utilized in ILI activities, each with its own set of advantages and disadvantages. Some are more effective at detecting certain types of corrosion or damage in different types of pipes, depending on their NDE capabilities. More recently though, some manufacturers are combining the various functions of these separate tools into one. This way a single tool can now be used to detect several different types of damage, making it more efficient and effective.

Smart pigs use nondestructive examination techniques such as ultrasonic testing and magnetic flux leakage testing to inspect for erosion corrosion, metal loss, pitting, weld anomalies, and hydrogen induced cracking, among others. They are also able to gather data on the pipeline's diameter, curvature, bends, and temperature. Smart pigging provides several advantages over traditional forms of pipeline inspection. It allows pipelines to be cleaned and inspected without having to stop the flow of product. It also allows the pipeline to be completely inspected without having to send inspectors down its entire length.





## Pulsed Eddy Current Testing (PEC)

**Inspection over Insulation to determine the condition of pipes and monitor corrosion.**

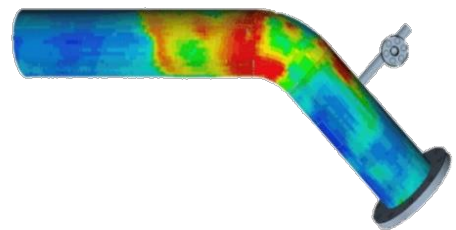
PEC technology does not require direct contact with a test object nor specific surface cleaning, making inspection fast and easy even at high temperatures and on offshore wells. Inspections can be conducted, and corrosion can be monitored during operation to allow for planned maintenance and repairs to be scheduled and carried out at times optimal for your business.

Pulsed Eddy Current readings conducted many times at the same location can be reliably reproduced regardless of casing, coatings or insulation. PEC technology provides results with a plus/minus 10% accuracy for corrosion detection and a plus/minus 0.2% accuracy rate for corrosion monitoring. Moreover, Pulsed Eddy Current inspections can be successfully and easily carried out at temperatures ranging from -100° C to 500° C (-150°F to 932°F).

Pulsed Eddy Current technology is based on electromagnetics and provides average wall thickness values over the probe footprint area. It measures and compares the percentage variation in average wall thickness throughout an object. Pulsed Eddy Current can be effectively applied for corrosion detection and monitoring on pipes and vessels made of carbon steel or low-alloy steel without contacting the steel surface itself. PEC technology allows measurements to be made through insulation, concrete or corrosion barriers.

### PEC testing conduct according to the following steps:

1. An instrument probe is placed on the weather sheeting insulation, coating or rusted surface of a pipe. Test objects should be of simple geometry such as a cylinder, elbow or plate.
2. A magnetic field is created by sending an electrical current through the transmitting coils of the probe. This field penetrates the weather sheeting and magnetizes the object wall.
3. The electric current in the transmission coil is then switched off, causing a sudden drop in the magnetic field. As a result of electromagnetic induction, Pulsed Eddy Currents are generated in the object wall.
4. The PEC probe monitors the rate of reduction in the induced Pulsed Eddy Current to determine the average wall thickness of the object in question. Although PEC average wall thickness readings are relative values showing variations in wall thickness, absolute readings can be obtained with wall thickness calibration at a specific point on the object.



## Remote Visual Inspection (RVI)

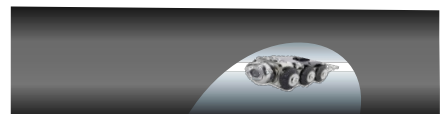
**Inspection thru a Powerful imaging acquiring.**

RVI is a non-destructive testing technique dating back to the 1970s that uses various types of video probes, video borescopes, remotely operated cameras, robotic crawlers, drones, and other specialized tools to remotely examine components for corrosion and damage. There are several different methods of RVI that can be used to inspect a variety of equipment.

In its most basic form, an RVI system is made up of a lens and an illuminating light source, both of which are connected to a light transmitting extension, at the end of which is attached a viewing eyepiece. Most modern designs though, are more complex. Several make use of fiber optics or distal LEDs as light sources. On-board computers can also be utilized to improve functionality of the systems.

### The three major methods of RVI:

- **Comparison Measurement**, based on a known reference dimension in the inspection image and measure other objects in the same view and plane.
- **Stereo Measurement**, uses a prism or dual lens to split images, allowing the camera to capture left & right views with a precise angle of separation.
- **Shadow Measurement** relies on a shadow triangulation of tip-to-target distance. A device known as a shadow measurement tip projects a shadow across the area being inspected.



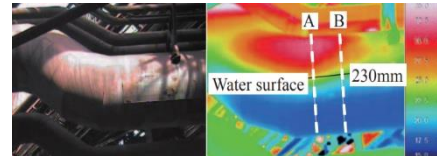
## Thermal Imaging Method

**A screening method for Pipes by Infrared Thermography.**

Thermal imaging is the technique of using the heat given off by an object to produce an image of it or to locate it. In essence, a thermal imaging camera measures variations in heat, or infrared radiation, and represents the heat as different colors in an image.

This style of imaging is used by many industries from medical, law enforcement, to plumbing and electrical. For instance, electricians use thermal imaging to detect hot spots in electrical systems which can indicate dangerous faults.

This method is based on triage techniques employed in the medical field and uses the test results obtained by an infrared thermographic camera and ultrasonic thickness gauge as determination criteria. Aiming at evaluating the wall thinning caused by aqueous corrosion due to sludge in pipes, an infrared thermographic camera was used to conduct studies to find a method for detecting sludge inside a pipe and a method for measuring the distribution of wall thinning. Testing conditions, signal processing, etc., were developed and adapted for actual pipes, and their validity was confirmed.



## Magnetic Flux Leakage Testing (MFL)

**MFL provides rapid screening for corrosion and erosion.**

The Magnetic Flux Leakage (MFL) is a Non-destructive testing (NDT) approach. It is used on ferromagnetic material if lined or unlined.

MFL is a rapid, reliable, and robust corrosion screening technique that detects the volume of missing magnetic material in a component under inspection.

MFL requires limited surface preparation and no couplant is needed. Users require minimal training, and with scanning speeds up to 1m/s (3.2 ft/s), MFL is the ideal solution for fast, cost-effective corrosion detection.



## Automatic UT Corrosion Mapping

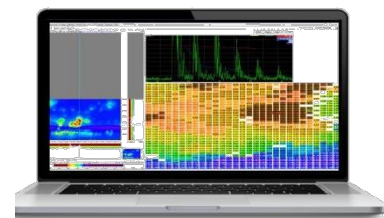
**Ultrasonic technique using powered scanners.**

AUT covers a range of ultrasonic inspection techniques using powered, mechanical scanners with magnetic wheels to only adhering purposes to locate inherent defects within a given material. AUT is the term used to describe corrosion mapping inspections, pulse-echo weld inspection, Phased Array and Time of Flight Diffraction.

Typical Automated Corrosion mapping systems can inspect 20-30 sq. meters per standard workday. The benefit of using the automated imaging systems allows a picture (C-Scan Image) quickly identifies any significant reduction in wall thickness. These automated corrosion mapping scans can then be superimposed into development drawings of equipment and accurately indicate location of problem regions. The images on this page show some significant problems detected from field inspections.

Automated Corrosion Mapping Ultrasonic scans of materials, uses a range of colors to represent the thickness range of part being inspected, typically blue colors are used to represent nominal wall thickness with orange and red colors used to indicate significant wall reduction.

Automated corrosion mapping of pipelines for follow up of Smart Pig surveys and Long-Range UT (LRUT) programs allows accurate assessment of localized areas of concern. Due to the speed of modern systems considerable coverage can be completed daily. If you have a critical system and you require 100% coverage for process reliability, then this is the solution you require.





## Digital Radiography Testing (DR)

A Computed Radiography to create an instant Image.

Digital Radiography (DR) is an advancement of traditional Film Radiography. This technique utilizes a DDA (Digital Detector Array) instead of Film or CR (Computed Radiography) to create an instant Image. Besides performing "standard" Radiography work, DR opens new opportunities such as fast and accurate wall thickness measurements and Corrosion monitoring.

The Radiation reaches the DDA, which has passed through the object, converted by a Scintillator into visible light and then translated into a digital Image. The physics (Angles, Penetration, technique etc.) remain similar and only mild changes are required to make the transition to Digital Radiography.

The DR standard for Pipe Radiography, the main one being the European ISO 17636-2, and the well-known ASME Section V (article 2) which permits the use of DR with mild modifications to the inspection technique.

**The DR Applications:** Corrosion monitoring • Weld quality (detect Cracks, Gas inclusions, Porosity, lack of penetration etc.) • Wall thickness (Wall thinning).



## Ultrasonic Thickness Measurement

UT Grid scan with spot digital reading & A-scan.

An ultrasonic thickness gauge works by precisely measuring how long it takes for a sound pulse that has been generated by a small probe called an ultrasonic transducer to travel through a test piece and reflect from the inside surface or far wall. From this measurement, the thickness of the test piece is calculated and displayed on a digital screen.

The portability of the testing equipment allows for on-site inspection and results are instant. If a problem has been detected by the technique, additional non-destructive testing methods can be used to further investigate the findings.

Manual point thickness measurements using conventional ultrasound (UT) is a widely used technique for monitoring corrosion in many infrastructure applications. Depending upon the nature of the corrosion (e.g., localized, versus generalized and pitting), an inspector typically records the minimum thickness reading within a small area (usually 1 in.<sup>2</sup>). This however can lead to inconclusive inspection data due to minimal coverage of large areas, operator variability, lack of pitting or localized corrosion detection, and inadequate data reporting and analysis.



## Phased Array UT SCANNING

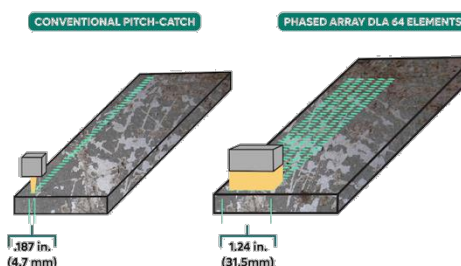
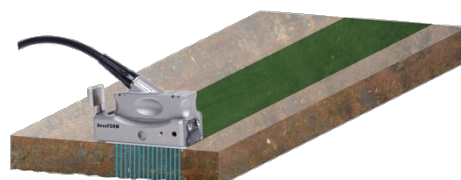
Inspect large surface areas quickly with high resolution.

The phased array instruments are now used to perform high-resolution corrosion inspections in accordance with today's demanding industry standards.

Ultrasonic phased array corrosion monitoring systems can be used to inspect large surface areas quickly with high resolution. Typically, a thickness reading is performed every 1 mm<sup>2</sup>, which represents 500 more sample points than conventional ultrasound. This high resolution makes it possible to detect small, localized indications, such as corrosion pits, and it enables the operator to profile the shape of the corroded area. This helps users to accurately evaluate the severity of corrosion detection and provides information for more accurate characterization of the damage.

Intuitive and affordable phased array instruments are now commercially available. These devices are easy to setup so users can record and archive data for further analysis. Easy-to-read images make interpreting acquisition data straightforward. The data can then be used to perform corrosion assessments according to ASME B31G and other applicable standards.

Multiplexing, sometimes called an electronic or linear scan, is used to perform corrosion monitoring. The sensor consists of a long-phased array probe, 25 –100 mm (1 – 4 in.) with between 32 and 128 elements. A small group of elements, defined as the active aperture, is activated to generate an ultrasonic beam propagating normal to the interface. This group of elements is then indexed using electronic multiplexing, creating a true physical movement of the ultrasonic beam under the array with an index as small as 1 mm (0.040"). The electronic indexing is performed so fast that a 4-inch (100 mm) line length is covered by the ultrasonic beams in milliseconds. The travel time of these beams is used to determine the component's thickness at each acquisition point.



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A photograph of a classroom or training room. A man in a light-colored shirt is standing at a whiteboard, writing. Four other people, wearing hard hats, are seated in the foreground, facing the whiteboard. The room has large windows on the left and right sides.

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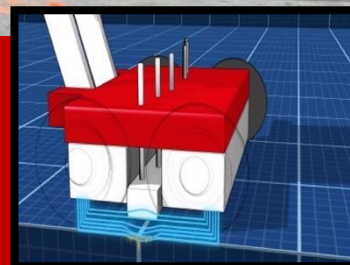
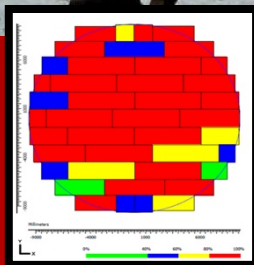
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## MFL TANK FLOOR INSPECTION COURSE

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- ▶ One Final Exam and a Practical Test.



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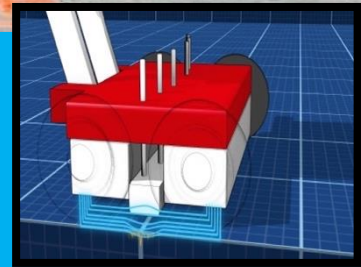
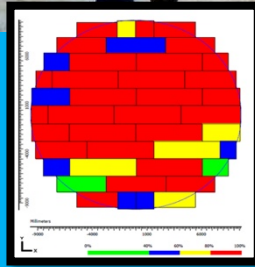
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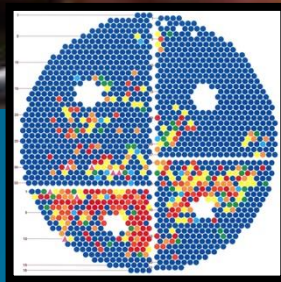
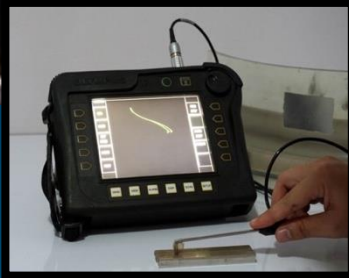
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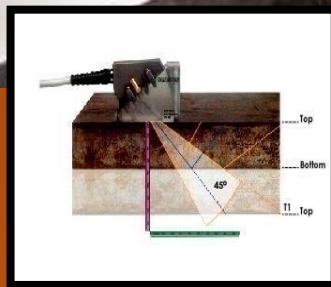
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# NEWS

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# City of the Future North Pole Project

**Saudi Arabia** unveils solar-powered plans with the world's tallest tower!



## Saudi Arabia's megaproject places sustainability at the core

The project places a strong emphasis on connectivity and sustainability through the implementation of pedestrian-friendly streets, bike lanes and pathways and the use of solar energy and other renewable sources. Public spaces have been designed according to climate responsiveness and to allow residents and visitors greater access to nature.

**North Pole** sits outside of Riyadh, promising everything from air taxis to vertical living. Autonomous vehicles, high-speed underground transport and other advanced modes of transportation have also been cited in plans.

Imagery shows that residential neighborhoods, commercial areas and industrial zones would take the form of a series of clusters, with a priority to ensure easy access and seamless mobility between them.

Like many of KSA's new wave of super-projects, the North Pole is poised to raise the standard of living in the country, with a keen focus on job creation.

"The North Pole project seamlessly blends modernity with the beauty of nature, delivering a unique living experience," Al Qahtani said on LinkedIn. "The project is poised to usher in a remarkable transformation, redefining the region's economic and social landscape. Anticipated to generate new job opportunities, attract foreign investments, and elevate living standards, this visionary project aims to elevate Riyadh's global standing as a modern metropolis."

Saudi Arabia Holding Co. CEO Mohammed Al Qahtani has revealed urban plans of the ground breaking '**North Pole Project**' extending over 306 sq km in northern Riyadh. Described as a 'city of the future, the plans are centered on the Rise Tower, which would become the world's tallest tower, according to a report by Commercial Interior Design.

The precise height of the planned Rise Tower was not revealed, however it would need to outdo Dubai's Burj Khalifa, which reaches 828 meters.



The Kingdom Tower, estimated to cost \$1.23 billion, would have 200 floors and overlook the Red Sea. Building it will require about 5.7 million square feet of concrete and 80,000 tons of steel, according to the Saudi Gazette.

Building a structure that tall, particularly on the coast, where saltwater could potentially damage it, is no easy feat. The foundations, which will be 200 feet (60 meters) deep, need to be able to withstand the saltwater of the nearby ocean. As a result, Advanced Construction Technology Services will test the strength of different concretes.

Wind load is another issue for buildings of this magnitude. To counter this challenge, the tower will change shape regularly. "Because it changes shape every few floors, the wind loads go round the building and won't be as extreme as on a really solid block," Gordon Gill explained to Construction Weekly. Gill is a partner at Adrian Smith + Gordon Gill Architecture, the design architects for the project.

Delivering the concrete to higher floors will also be a challenge. Possibly, engineers could use similar methods to those employed when building the Burj Khalifa; 6 million cubic feet of concrete was pushed through a single pump, usually at night when temperatures were low enough to ensure that it would set.





## ADNOC awards \$3.6 billion contract for new gas processing facilities.

ADNOC Gas awarded a \$3.6 billion contract to expand its gas processing infrastructure in the UAE. The contract was given to a joint venture between Abu Dhabi's National Petroleum Construction Company Co (NPCC) and Spanish contractor Tecnicas Reunidas.

The scope of the contract includes commissioning of new gas processing facilities that will optimize supply to the Ruwais Industrial Complex in Abu Dhabi's western Al Dhafra region.

Contract aims to maximize feedstock from ADNOC Gas' plants to meet future demand from its customers.

Over 70% of the contract's value will flow back into the UAE's economy under ADNOC's successful In-Country Value program.



### ADNOC Gas boosting

ADNOC Gas Maximizing Ethane Recovery and Monetization project aims to boost ethane extraction by 35% to 40% from its onshore facilities in the Habshan complex by building new processing facilities, as well as "unlock further value" from existing feedstock, delivering it to Ruwais through a 120-km (75 miles) natural gas liquids pipeline, the firm added.

Ahmed Mohamed Alebri, CEO of ADNOC Gas, said: "This capital project represents ADNOC Gas' latest investment in its gas processing infrastructure and underscores our commitment to responsibly meeting our customers' current and future energy demand for natural gas and its feedstock."

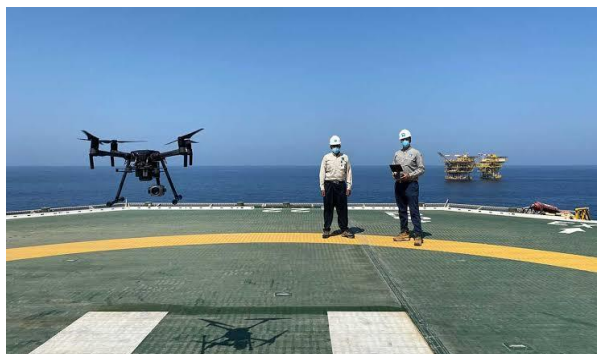
He added, "The expansion of our gas processing infrastructure will also provide additional energy to the country's growing industrial section, while stimulating economic growth and diversification through the significant ICV generated by the contract."

ADNOC Gas says it continues to leverage opportunities arising from ADNOC's integrated gas masterplan, which links every part of the gas value chain in the UAE, ensuring a sustainable and economic supply of natural gas to meet local and international demand. The plan includes new approaches and technologies to enable increased gas recovery from existing fields and develop untapped resources.

# DRONES set to transform oil & gas operations!

Related To: Saudi Aramco

Unmanned, remotely operated drones have become critical tools for inspection and maintenance at industrial sites.



Commercial drones, or unmanned aerial vehicles (UAVs), have undergone a technological revolution in the past five years. The development of high-quality sensors, intelligent motors, and low-cost navigation systems have expanded their use and affordability. Their potential continues to evolve, with companies investing \$3.8 billion in drone research and development in 2022.

At Aramco, UAVs have transformed many of the key tasks we perform at our facilities and across our infrastructure, and we are implementing a strategy over the next few years to increase their role across our operations including technology investment to localize and scale-up deployment.

## A new tool for the oil and gas sector!

Our industry is one of the fastest-growing sectors for drone use. Aramco uses UAVs to inspect and maintain a whole range of facilities, from onshore and offshore sites to power system infrastructure; as well as perform aerial mapping, emergency response and environmental monitoring.

UAVs are currently manufactured with three configurations fixed wing, multi-rotor, or a combination of the two, known as vertical takeoff and landing (VTOL) fixed-wing UAVs. Multi-rotor UAVs can take-off and land vertically, as well as hover with ultimate maneuverability, making them ideal for site-based, short range applications. Fixed-wing vehicles carry out tasks that require travelling longer distances, such as pipeline inspections, land surveys, and offshore exploration, and the VTOL fixed-wing UAVs eliminate the need for runways during takeoffs and landings.

Drones are making a significant difference because they can get to remote and hazardous locations more quickly and safely than any human can. They can also be equipped with IR and thermal sensors, optical gas imaging and cameras to collect data about key assets, such as rigs, platforms, pipelines, tanks, and vessels.

When a drone is used to inspect a tank, we do not need to erect scaffolding as maintenance staff are not required to work at high or in confined spaces.

Another benefit is that facilities, such as flare stack tips, do not have to be shut down for inspections. Instead, a UAV can collect high-resolution and thermal images while it is operating, checking for deformations, cracks, corrosion, and physical deterioration.

## Safety and security

In addition to routine inspections, UAVs play a key role in critical situations by providing real-time information. With optical and thermal data able to be streamed live to a command center, it is much easier to assess and respond appropriately. Drones are also increasingly important to Aramco's efforts to cut methane emissions. They are fitted with optical gas imaging to detect methane leaks, and can also be equipped with laser absorption spectrometry a technology that can ascertain the scale of a leak and determine the concentration of specific gases.

## Unlocking further potential uses

Recent advances include using UAVs for non-destructive testing, which allows inspectors to collect data about a specific material without damaging it. For example, Aramco's inspection department has deployed ultrasonic testing drones that use high-frequency soundwaves to detect flaws — and which could pave the way for measuring the thickness of an object using an integrated probe. In addition, 'caged drones' have also been designed to better access confined spaces.

At Aramco we take security seriously, and have prioritized encryption, authentication, and cybersecurity to ensure that drones are not hacked or damaged. We are also improving training for drone operators, as industry regulations become more standardized and structured.

But the autonomy of drone technology is also progressing rapidly. A new kind of UAV, known as a 'drone in a box,' is already being developed and can be launched automatically from a docking station or self-contained landing box. Powered by artificial intelligence and used for operations such as remote inspection, surveillance and deliveries, it will be capable of 'beyond visual line of sight' flight, using flight-planning software powered by unmanned aircraft system traffic management.

While the full potential of drones has yet to be unlocked, as we continue to embrace digitalization and expand its footprint at Aramco, it is increasingly apparent that they will be key to deploying the latest cutting-edge and disruptive technologies. In the process, they will likely continue to transform the way we operate.

The author Motaz Mashouk is Senior Vice-President of Engineering Services, Saudi Aramco.



# Fugro completes first Middle East ROV subsea inspection using USV.



Having commissioned the region's first-ever government-licensed USV in early 2023, Fugro has successfully completed its first USV operation for a client in the Middle East. The Fugro Pegasus USV (part of the Blue Essence fleet) was mobilized for Chinese operator Atlantis in early June to perform a subsea survey and inspection of the UAQ3 platform within the Umm Al Quwain gas field.

This pioneering operation was executed from Fugro's onshore remote operations centre (ROC) in Dubai using a specialist team of mariners and surveyors. The Fugro Pegasus USV was equipped with a Blue Volta® electric remotely operated vehicle (eROV), which was used to inspect the integrity of the platform's structure and generate a detailed map of the surrounding seabed. The data collected was streamed to the ROC, allowing Atlantis to review the data in real-time during the operation. This enabled the team to quickly identify and investigate areas of further interest to develop a comprehensive risk assessment for the client's upcoming decommissioning program.

The Blue Essence USV fleet forms part of Fugro's remote and autonomous operations program to deliver market-leading Geo-data insights to its clients with improved efficiency, safety and sustainability. Thanks to their economical design and optimized fuel system, the USVs eliminate carbon emissions by 95% versus conventional vessels and can spend up to two weeks at sea without refueling. Furthermore, the ability to remove personnel from the offshore environment significantly reduces health and safety risks and creates the opportunity to build a more localized and diversified workforce onshore.

Patrick Boyce, Drilling Manager at Atlantis (UAQ) Ltd, said: "Fugro's remote survey technology aligned seamlessly with our projects HSEQ, technical goals and was the most attractive commercial choice. The Fugro Pegasus was able to mobilize on time and despite difficult sea conditions, it completed the full scope of work in 40% of the allotted time frame. The USV operation was managed by the technical team at the very impressive Fugro ROC. Communications with the USV were strong throughout and provided excellent imaging results. Of particular note was the evident expertise and professionalism of the Fugro team, who have obviously dedicated many months to honing their execution procedures."

Hannes Swiegers, Fugro's Director of IRM Services & Remote Operations for the Middle East and India, said: "This is a significant milestone for our Middle East business and demonstrates how novel technologies can play a key part in delivering our clients' long-term safety, sustainability and in-country value (ICV) ambitions. Together with our clients, we are setting a new standard in Geo-data acquisition and analysis through continuous innovation, reducing unnecessary time, risk and carbon emissions. This new era of remote and autonomous technology will define the future of offshore operations in the energy sector and contribute towards a safer and more sustainable world."

(World pipelines)



## Senegal to receive €50 million from Africa Finance Corporation to **boost** oil & gas industry!

**Africa Finance Corporation (AFC), the leading infrastructure solutions provider on the continent, is collaborating with the Government of Senegal to fund the development of the landmark Sangomar oilfield.**

Through this strategic collaboration, AFC will invest €50 million in the oil field to help boost the country's emerging oil and gas industry and improve energy access and security in Senegal. Located 100 km southwest of the capital, Dakar, the Sangomar oil field spans 7490 km<sup>2</sup> and is estimated to hold around 500 million bbls of crude.

The Corporation's investment in the Sangomar oilfield will be used to drive the first phase of development towards achieving first oil, a key milestone in the advancement of the country's hydrocarbons sector. The facility will provide a significant boost to Senegal's economy, supporting the country's ambitions to become a regional hub for the oil and gas industry. It will also generate significant revenues for the government through taxes and royalties, create employment opportunities for local workers, and contribute to energy security by reducing dependence on imported oil and gas.

(World pipelines)

"We are pleased to support the development of the Sangomar field which we expect to have a transformative impact on the Republic of Senegal and its people through the reduction of import reliance, the generation of increased government revenues, the creation of local jobs and an overall contribution to accelerated industrialisation and economic development," said Mr. Samaila Zubairu, President and CEO of the Africa Finance Corporation.

Since the Republic of Senegal acceded to membership of the Corporation in 2019, AFC has helped to finance several critical sectors of the country's economy. These include: the 300MW combined-cycle gas power project in Cap des Biches, the country's largest Independent Power Project (IPP); the construction and rehabilitation of road networks in Senegal through Fonds d'Entretien Routier Autonome (FERA); and the provision of funding to the Ministry of Economy and Finance for projects such as the 128MW Sambangalou Hydro Power Dam in the Kedougou region and the procurement of petroleum products for power generation.





## Vibrant: Non-Destructive Testing Technology Company Secures \$ 3.35 Million!

Advantage Capital a leading impact-investing firm recently announced a \$3.35 million investment in Vibrant Corporation, a non-destructive testing (NDT) technology company. And Advantage Capital led the round, with several pre-existing Vibrant shareholders also participating. The company will leverage this funding to expand its workforce and increase production. Launched in 2006 in Albuquerque, New Mexico, Vibrant is a leader in the NDT space, developing the most commercially viable approach for Process Compensated Resonance Testing (PCRT) – a method of vibrating objects to test their integrity, which was initially developed at Los Alamos Laboratory. In late 2021, Vibrant gained traction with Collins Aerospace in applying PCRT to replace an environmentally unfriendly and labor-intensive NDT process on commercial aircraft wheels for most Boeing and Airbus commercial aircraft.

The company will use the funding to fund the construction and deployment of additional testing machines for commercial aircraft wheels. And much of this funding will go directly to the company's efforts in building advanced PCRT systems to support its rapidly growing service business in the Aerospace, Power, and Automotive. Vibrant is focused on investing in the local community. The manufacturing team prioritizes suppliers whenever available, often choosing contract manufacturers & distributors within the local area. The funding was made in connection with the Federal New Market Tax Credit Program, which aims to attract investment in low-income communities. And by encouraging private investment, the program helps fill the financing gap that exists for many businesses in distressed areas helping to drive job growth and economic development in the places that need.

## Bahrain's Tatweer Petroleum invites EPC bids for gas dehydration facilities!



Bahrain's Tatweer Petroleum, a wholly-owned unit of Bapco Energies, has issued an engineering, procurement and construction (EPC) tender for development of non-associated gas well hook-ups, associated pipelines and tie-ins in its gas dehydration facilities at Awali region in Bahrain.

Tatweer Petroleum is currently undertaking a phased field development project to install non-associated gas (NAG) compressor facilities (NCF's) stations and remote gas dehydration units (GDU) to maintain gas deliverability from the Awali field, Trade Arabia reported.

The scope of work for the contractor includes provision of EPC services of NAG well hook-ups, associated pipelines at compression and GDUs assisting with the operability enhancement of Tatweer Petroleum facilities.

The last date for submitting the bids has been set at September 3. The entire project will be completed within a five-year period.



# TECHNICAL Articles

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# GREEN HYDROGEN



**An alternative to replace the fossil fuels to reduce emissions and cares for our planet!**

Decarbonizing the planet is one of the goals that countries around the world have set for 2050. To achieve this, decarbonizing the production of an element like hydrogen, giving rise to green hydrogen, is one of the keys as this is currently responsible for more than 2 % of total global CO2 emissions. Find out how this is achieved and what its impact will be in the coming decades.



## Learn How Green Hydrogen is extracted!

### How is the HYDROGEN obtained?

#### 1. Molecular transformation:

These are different techniques in which a series of **chemical reactions to obtain hydrogen are performed**. The most widely used technique involves reforming natural gas from oil fields whereby high temperature water vapor is used to separate the carbon from the hydrogen that makes up the natural gas. Two successive reactions produce dihydrogen and carbon dioxide. This is the most widely used of all the methods today.

#### 2. Gasification:

Gasification with water vapor and pure oxygen is performed using coal or biomass. A reactor burns the coal or biomass at very high temperatures. In the combustion, gases are released which give rise to dihydrogen and carbon monoxide.

#### 3. Water electrolysis:

This process involves breaking down the water molecule (H<sub>2</sub>O) into oxygen (O<sub>2</sub>) and hydrogen (H<sub>2</sub>) by a direct electrical current that is connected by electrodes to the water. When electrolysis is performed with renewable energy, this is the most sustainable method of production.

### Benefits of using green hydrogen as a fuel:

Green hydrogen will be one of the protagonists in the upcoming energy transition that global economies are obligated to lead to achieve carbon neutrality and combat climate change.

To this end, it will be of vital importance to eliminate emissions in those uses that are currently difficult to electrify, which is where green hydrogen claims its potential due to all its inherent benefits:

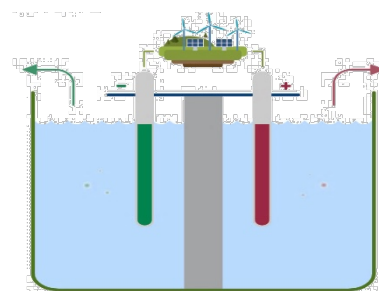
- Clean energy: The only waste it generates is water.
- Renewable energy: Use natural resources that are not exhausted.
- Storable: Can be compressed and stored in ad hoc tanks for a long time.
- Transportable: Very light element, compressed hydrogen tanks allow easier handling than lithium batteries.

### What is GREEN/RENEWABLE hydrogen?

As such, **green hydrogen** is that obtained using **renewable energies in its production**, which makes it a **clean, sustainable** fuel with a zero-pollution index that can be key not only as an energy vector, but as a raw material.

Its great value in the fight against climate change lies in its ability to replace fossil fuels in those sectors and uses that until now were more difficult to decarbonize, in addition to its potential as an energy storage system.

**Green hydrogen is achieved** through a process of electrolysis powered by renewable energies such as **wind or solar**. Electrolysis involves using an electrical current to **break down the water** molecule into **oxygen** and **hydrogen** by electrodes.



# STEAM HAZARDS & ASSOCIATED CONTROLS



Using steam in the process industries presents a number of hazards!

## Thermal expansion

One of these must do directly with the properties of the steam itself, that is, heat - particularly, superheated steam. Introducing steam into a pipeline or vessel exposes the structure to high temperature, which results in the material expanding. Therefore, it is essential that pipelines and vessels be designed to take account of the expansion caused by the thermal heating effects of steam.

This is most usually achieved by building in flexibility using expansion joints or expanding sections that compensate for the thermal movement, as well as bellows and other design features to allow the material to expand without causing a rupture.

## Prevention of the formation of vacuums

When steam gives up its heat in certain conditions (subject to pressure regulation), the steam may produce condensate (wet steam). Steam as vapor or gas occupies a much larger volume than water at the same temperature so that, when the steam's volume is reduced, a natural vacuum will form unless provision is made to allow for the loss of volume. In practical situations, steam input is controlled by valves. When the valve closes (e.g. on a heating coil), a vacuum can very quickly develop unless the pressure is equalized. It is therefore usual to fit vacuum breakers in steam lines to allow for the equalization of pressure, preventing the vacuum. This is also important to ensure there is sufficient pressure within the system to allow the condensate to be discharged.

## Water in steam lines (water hammer)

Water hammer results from water in a pipeline striking a fixed object under high pressure. This may occur during start-up or during variable conditions. The water in a steam system is accelerated either by steam under pressure or because of a low-pressure void into which the water is 'sucked'. The water is abruptly stopped when it meets a mixture such as a valve, fitting, a bend or tee in the pipeline. The water then loses its kinetic energy as it strikes the object, setting up vibrations caused by the pressure shock that is imparted.

There are two basic mechanisms for creating water hammer.

One involves water entrained in steam being rapidly moved through the pipe (as condensate); the other is when the steam rapidly condenses, due to being surrounded by lower temperature condensate that causes the steam to rapidly condense to liquid. This causes a massive change in pressure due to the loss of volume, the result of which is that the cooler condensate rushes in to fill the void created.

The pressure changes in water hammer may lead to pipe fracture and, consequently, loss of contents. More mild cases of water hammer may be heard as knocking (hammer) or seen as movement of pipework. The pressure produced in the second type of water hammer, when the steam rapidly forms liquid, can (subject to pressure and temperature) result in massive damage to all pipeline components.

The first control for water hammer is good design of pipework and process controls. It also calls for the removal of condensate, improving the quality of the steam (minimize water), steam velocity and flow, ensuring that pipework insulation is maintained and removing the opportunity for cold areas to allow condensate to form (e.g. sagging in pipelines), controlling pressure and avoiding pressure drops, absolutely avoiding the risk of explosion by not mixing hot and cold (high pressure steam with 'cooled' condensate), ensuring steam pressure and temperature are reached before allowing steam flow, and maintaining steam traps and drainage.

Special care needs to be taken during start-up and shut-down, e.g. steam traps may not be functioning and water carry-over into the system is likely.



700 mm cast iron water pipe broken by water hammer

Ref. NEBOSH-PSM



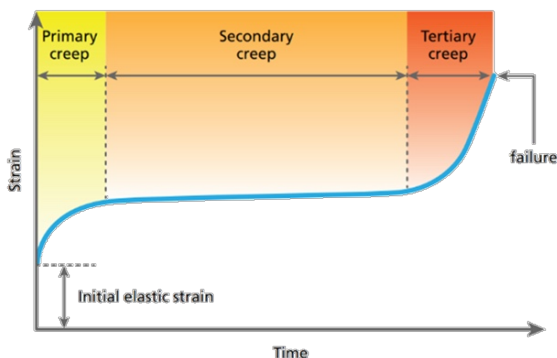
# FAILURE MODES FOR TANK SHELLS & ASSOCIATED PIPEWORK



The metals used for tanks and pipelines can be subject to a range of failure modes, e.g., creep, stress, thermal shock, and brittle fracture:

## CREEP

Creep describes the gradual extension of material under a steady tensile stress over a long period of time, particularly in high-temperature conditions. Tensile refers to the pulling apart of the metal in a single plane. Another aspect is elasticity, which refers to the degree to which the material will return to its former length after stretching. Tensile strength and elasticity decrease with increasing temperature, which means that creep is more likely to occur at higher temperatures. Exposed to creep, the metal of a tank or pipe may deform and eventually fracture.



## STRESS

Stress refers to the tensile or compressive loading placed on a material. Strain refers to the deformation that it will undergo when stress is applied to it. This gives rise to two broad categories of material; ductile, which will move under strain, and brittle, which simply breaks under strain. Steel is ductile and will yield before it breaks; cast iron is brittle and does not yield.

Stress failures occur as a result of the impact on a material of the conditions to which it is exposed. So, in tanks and pipework, the metal will be subject to stress because of the loading exerted by the contents, changes in temperature and variations in loading. For example, a tank being emptied and then refilled will be subject to movement as the structure responds to the variation in the load placed on it. In pipework at flanges, openings and connections, there will be greater loading and therefore more stress.

Stress corrosion is an example of failure that occurs when a metal corrodes as a result of exposure to a specific environment and is unable to take the load placed on it, e.g., mild steel exposed to nitrates. Similarly, in some situations, hydrogen atoms will invade steel and cause hydrogen embrittlement. At high temperature, hydrogen enters the steel and then reforms as hydrogen molecules, taking up space and putting pressure on the steel, which then cracks.

## THERMAL SHOCK

Thermal shock results from exposing materials to rapid and extreme temperature changes. This causes the different parts of the material to expand by differing amounts, which in turn gives rise to uneven expansion. As a result, cracking occurs when the stress applied by the expansion exceeds the strength of the material. The crack will continue until the object or material fails.

## BRITTLE FRACTURE

Brittle fractures occur suddenly when the material is put under excessive stress and has no, or limited, elasticity. This may happen because the material is intrinsically brittle or the loading on it has happened so fast that it has not had time to be elastic. This is usually referred to as impact or 'snatch' loading. In brittle fracture, small cracks rapidly spread through the material, which then suddenly fails under stress. As there is no elastic component, if the two ends of a brittle fracture are put back together, they join up perfectly, unlike ductile fractures that have become deformed. Low temperatures can increase the occurrence of brittle fracture, e.g., materials used for storing and conveying LPG.

## FATIGUE FAILURE

Fatigue is the formation of crack(s) as a result of repeated application of loads that individually do not create sufficient stress to cause failure. It may appear as thermal fatigue, contact fatigue, surface or pitting fatigue, subsurface cracking or subcase fatigue, and corrosion fatigue.

The fatigue fracture is caused by the simultaneous action of:

- Cyclic stress, i.e., repeated actions creating stress, filling/ emptying, loading/unloading.
- Tensile stress, i.e., putting a load on the material.
- Plastic strain, i.e., the material does not yield (exhibit elasticity).

For storage tanks, fatigue may also be induced by:

- Wind load/vibration.
- Pump-induced vibration.
- Pedestrians walking on/over components.

Although we have discussed a number of different types of failure above, there are many other types. For example, corrosion is a significant issue, especially when vessels and pipelines are located in or near the sea, when corrosion rates can be significantly higher.

Ref. NEBOSH-PSM



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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.



Nigeria Oil & Gas International  
09 – 13 July 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 **9 – 13 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.



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**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)  
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.



**3rd Asset Integrity Management Conference. Aug. 2023**

The 3rd Asset Integrity Management Conference where Asset Integrity Managers, Digital Transformation Heads, Corrosion Management Specialists, Maintenance Experts, Contractors, and Heads of Special Projects from the Oil and Gas Sector will gather to discuss the latest trends, innovations, and key technologies.



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.

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**RVI**

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**MFE Middle East** is part of MFE Family, Represent the entire MFE group and provide all service in the Middle East and Africa region.

**MANUFACTURING**

**MFE Enterprises** is the world's leading manufacturer of MFL Tank Floor Scanners Since 1994, a U.S. based firm with more than 25 years of solid presence in the market. **MFE manufactures** Non-Destructive Testing (NDT) and Magnetic Flux Leakage (MFL) inspection equipment. It's manufactures and sells specialized storage tank and pipeline MFL inspection tools to ensure fast and efficient identification of defects in facility assets. Using modern MFL detection technology, MFE Enterprises offers the very best in storage tank and pipeline inspection equipment. Our mission has never changed: We provide educational information to the NDT community about MFL technology and the advantages of deploying our MFL Scanners for FAST and ACCURATE inspection of your plant assets. We have sold scanners around the world to NDT service specialists



**Sales**

MFE manufactures Non-Destructive Testing (NDT) and Magnetic Flux Leakage (MFL) inspection equipment. It's manufactures and sells specialized storage tank and pipeline MFL inspection tools to ensure fast and efficient identification of defects in facility assets. Using modern MFL detection technology.

**Rental**

We serve a variety of industries with our NDT, RVI and Environmental inspection equipment. Our tools and accessories help ensure safety in the workplace while maintaining equipment integrity! and protecting our clients' bottom line. We offer a large inventory of equipment from top manufacturers.

**Calibration**

NDT Electronics provide our clients with outstanding calibration and repair services in the field on Nondestructive Testing at an affordable price with a turnaround time unmatched in this industry. In 2016, NDT Electronics has joined the MFE Family, a family company since 1994.

Read more about MFE group and our latest inspection systems!

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# 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 (lbs)	=	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 <sup>9</sup> ) BTUs (net)	
39.68	billion (10 <sup>9</sup> ) BTUs (net)		5.674	billion (10 <sup>9</sup> ) BTUs (net)				

## SPECIFIC GRAVITY: VOLUME PER TON

## SPECIFIC GRAVITY RANGES

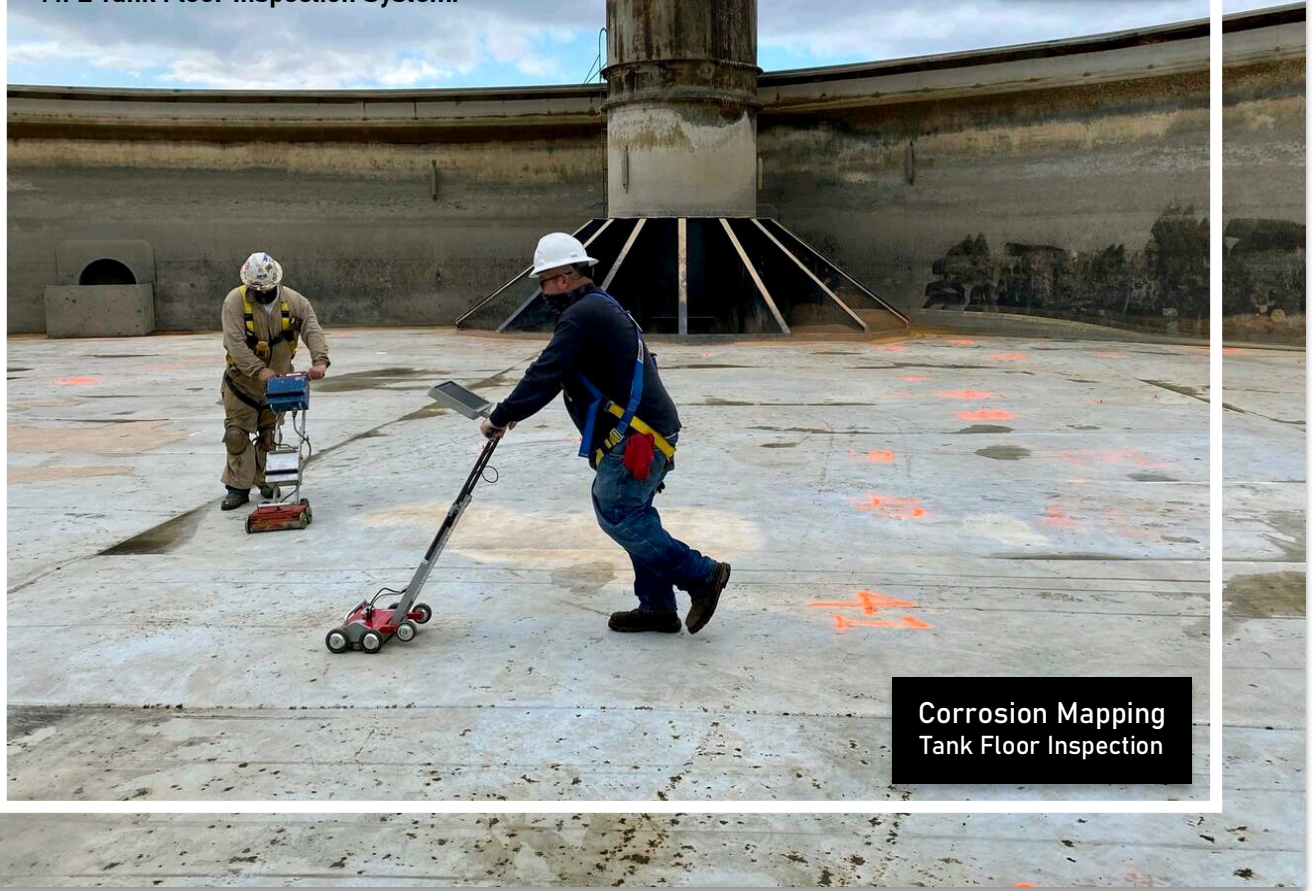
## CALORIFIC VALUE OF FUELS

Degrees API	Specific Gravity @ 60°F	Barrels per*			Specific Gravity	Barrels per metric ton	Rough Gross Values in Btu Per lb		
		Met. Ton	Long ton.						
25	0.904	6.98	7.09	Crude Oils	0.80 - 0.97	8.0 - 6.6	Crude Oils	18 300 - 19 500	
26	0.898	7.02	7.13	Aviation Gasolines	0.70 - 0.78	9.1 - 8.2	Gasolines	20 500	
27	0.893	7.06	7.18	Motor Gasolines	0.71 - 0.79	9.0 - 8.1	Kerosine's	19 800	
28	0.887	7.1	7.22	Kerosine's	0.78 - 0.84	8.2 - 7.6	Benzole	18 100	
29	0.882	7.15	7.27	Gas Oils	0.82 - 0.90	7.8 - 7.1	Ethyl Alcohol	11 600	
30	0.876	7.19	7.31	Diesel Oils	0.82 - 0.92	7.8 - 6.9	Gas Oils	19 200	
31	0.871	7.24	7.36	Lubricating Oils	0.85 - 0.95	7.5 - 6.7	Fuel Oil (Bunker)	18 300	
32	0.865	7.28	7.4	Fuel Oils	0.92 - 0.99	6.9 - 6.5	Coal (Bituminous)	10 200 - 14 600	
33	0.86	7.33	7.45	Asphaltic Bitumen's	1.00 - 1.10	6.4 - 5.8	LNG	22 300	
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	micro	= one millionth		hecto	=	one hundred
39	0.83	7.6	7.72	milli	= one thousandth		kilo	=	one thousand
40	0.825	7.64	7.76	centi	= one hundredth		mega	=	one million
41	0.82	7.69	7.81	dec	= one tenth		giga	=	one billion (10 <sup>9</sup> )
42	0.816	7.73	7.85	deca	= ten		tera	=	one trillion (10 <sup>12</sup> )



# The MFE MARK IV

MFL Tank Floor Inspection System.



Corrosion Mapping  
Tank Floor Inspection

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