

# Corrosion & Erosion

Inspection solutions for detection, sizing & monitoring



DATA ➤ INFORMATION ➤ KNOWLEDGE ➤ DECISION



# Overview

**GE Inspection Technologies** is a leading innovator for inspection solutions that deliver accuracy, productivity and safety to customers in a wide range of industries, including oil & gas, power generation, aerospace, transportation and government infrastructure.

Our advanced nondestructive testing and imaging technologies utilize the electromagnetic, radiographic, ultrasonic or visible energy spectrum to test and inspect a wide range of components. We have enormous depth and breadth of know-how which can be applied to your needs.

## Corrosion & Erosion

The negative effects of corrosion and erosion cost the oil & gas and power generation industries billions of dollars every year in unscheduled plant or pipeline shutdowns, inefficient or lost production, high maintenance repair costs or imposed fines. Experts believe that 20% to 25% of corrosion-related costs could be avoided. Corrosion and erosion detection, sizing and monitoring technologies are important elements toward realizing those savings.

## Multi-Modal Offering

GE Inspection Technologies offers the most comprehensive selection of testing and inspection capabilities and other products for industrial applications. Our strength lies in the use of field experience and customer feedback to build the most productive inspection products in the market. With the industry's broadest complement of nondestructive test methods to ensure our customers can be confident they are getting the optimal solution to meet their needs.

## DATA ➤ INFORMATION ➤ KNOWLEDGE ➤ DECISION

Our NDT technologies help you collect important data and convert it into useful information. Coupled with historical plant data, intelligent software, image enhancement, databasing, applicable codes and additional knowledge, asset owners can make better-informed decisions regarding treatment, mitigation, remaining life, component replacement or plant operating parameters.

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## On the cover



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| 1. Remote visual inspection of pitted boiler tubes        | 4. Real-time, on-stream monitoring of pipe wall thickness* |
| 2. Ultrasonic phased array profile of boiler tube ID pit* | 5. Computed Tomography of hydrogen-attacked boiler tube    |
| 3. Digital X-ray image of insulated pipe elbow*           | 6. Eddy current map of wall thinning*                      |

\*These images were captured and/or stored using Rhythm Software.



# Oil & Gas Application Solutions

GE Inspection Technologies addresses all major inspection needs for our oil and gas customers. We strive to deliver high-quality products & services that detect, size and monitor corrosion and inspect welds in a variety of situations and field conditions. Our leading-edge inspection solutions boost productivity, help you improve safety and solve your toughest oil and gas inspection challenges.

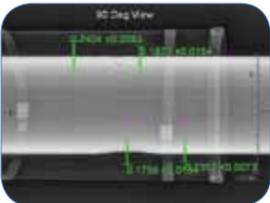
No other supplier can match GE's breadth of capability and depth of experience in the field of corrosion detection, sizing and monitoring of fixed and rotating equipment.

## Upstream

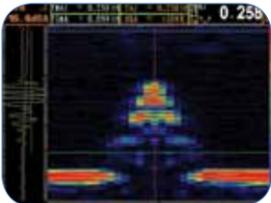


Rightrax™ installed-sensor system continuously monitors wall loss due to sand erosion at critical elbows on production platforms.

## Midstream



Digital radiography detects and measures corrosion under insulation (CUI) without removing the insulation.



Ultrasonic phased-array inspection assists in quickly scanning, detecting, profiling and sizing of isolated pitting in pipes.



Remote visual inspection of compressor blades can help identify erosion and thinning.

## Downstream



Phasor XS is a proven tool for characterizing safety-critical flange faces at refineries for corrosion and cracking.



Apollo is a multi-channel, multi-frequency eddy current instrument used to locate and size corrosion, erosion and cracking in heat exchanger tubes.



# Power Generation Application Solutions

We provide nondestructive testing and inspection solutions for key power generation corrosion applications, including those for fossil, nuclear, renewable generation as well as transmission and distribution. Our reliable, advanced technology and support services enable power generation customers to help maximize efficiency, minimize downtime and enhance productivity with unyielding integrity.

In addition to a broad product and service offering, GE has vast experience and expertise in BWR, PWR and Candu nuclear power applications, gas, coal and oil-fired fossil stations, gas turbines and hydro-electric assets.

## Fossil Power



## Gas Turbine & Combined Cycle



## Nuclear Power



Remote Visual Inspection with Menu Directed Inspection™ for turbine blade viewing.



USM Go is an ultra-portable, light-weight pulse-echo flaw detector for general purpose testing.



Rotating equipment inspection with computed radiography.



Apollo™ eddy current test instrument performs volumetric interrogation of heat exchanger tube bundle for corrosion and erosion.



Remote visual inspection of service water piping systems for MIC using robotic crawlers and high-resolution video cameras.



Phased array ultrasonic testing of reactor vessel and piping systems.

# Remote Visual Inspection (RVI)

RVI is a cost-effective inspection technique used to capture real-time views and images from inside voids such as tubes, pipes, rotating machinery, engines, heat-exchangers, tray towers, refractory-lined vessels and enclosed structures. RVI can be a perfect complementary technique to other NDT disciplines and is frequently used as the primary or initial inspection screening method to find localized corrosion and erosion.

## Video Borescopes

We offer an array of technologically advanced video borescopes, from the most portable to the most capable, all designed for ease-of-use while delivering video images of unsurpassed quality.



Our XLG3 VideoProbe is commonly used to diagnose operational problems with heat exchangers and other fixed and rotating refinery assets.

## On-site Remote Visual Inspection Service

Our staff of experienced remote imaging specialists, equipped with the latest remote visual inspection equipment, is available around the clock. We can assist during planned and unplanned outages, preventive maintenance, emergency services or with state or federal compliance issues.



Nuclear plant containment building steel liner is visually inspected with a custom 5-megapixel imaging system to meet ASME's IWE code requirements.

## Pan-Tilt-Zoom (PTZ) Cameras

GE has a full range of rugged industrial PTZ cameras for remote viewing in large areas. Three interchangeable zoom camera head diameters with high-intensity lighting, pan-and-tilt mechanisms and industrial waterproof packaging for protection from extreme environments.



A PTZ camera system is used to inspect the integrity of glass- and refractory-lined vessels.

## NDT Equipment Rental

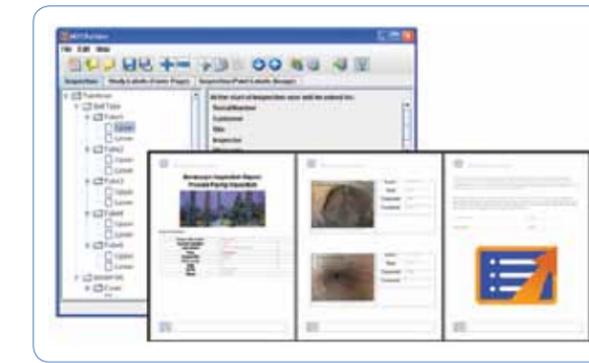
Access to GE's vast selection of nondestructive testing and remote visual inspection equipment is a phone call away. Regional field offices provide application expertise, equipment selection assistance and timely deliveries to your facility. Daily, weekly and monthly rates are available.



Flexible NDT equipment rental structure program – daily, weekly, monthly, or annually – to suit your needs. We also have lease-to-own arrangements available.

## Menu Directed Inspection™ (MDI)

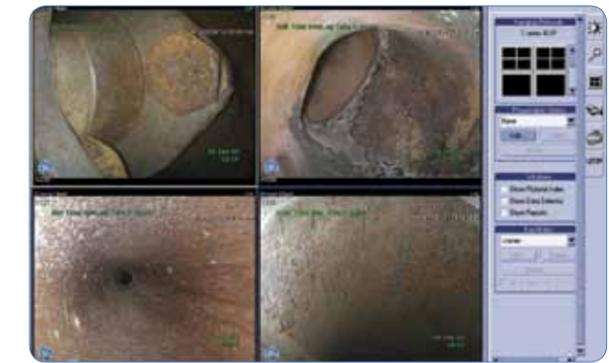
MDI is the first software tool in the NDT industry to standardize the inspection process. A GE video bore-scope operating MDI software helps guide inspectors through the inspection process and intelligently auto-generates a report, saving time, improving quality and increasing productivity.



MDI can be customized to guide inspectors through any remote visual inspection process.

## Rhythm® Software

Rhythm Visual software combines advanced image acquisition, review and data management tools for remote visual inspection. Its advanced data sharing capabilities allow significant improvements in productivity and enable faster identification of quality problems, leading to reduced production defects or better in-service asset management.



Rhythm provides a solution to analyze assets over time to increase asset lifetime. Rhythm utilizes ASTM standard image-file format: DICOM

# Ultrasonic Testing (UT)

Ultrasound technique has been used in non-destructive testing for almost 50 years and is used to find a variety of defects or non-conformities within almost any kind of solid material. The Krautkramer name has been synonymous with excellence in ultrasound during this period and is now part of our heritage at GE Inspection Technologies.

## Conventional Flaw Detectors

Flaw detection is a fast and accurate inspection method to evaluate internal product integrity. Ultrasound penetrates deeply into materials searching for metal loss and material degradation associated with corrosion and erosion.



USM Go is an ultra-portable ultrasonic flaw detector weighing only 850 g (1.87 lb). This product has gained wide-spread acceptance for rope-access applications.

## Corrosion Flaw Detector

Ultrasonic phased array instruments dedicated to locating and sizing pits can significantly improve inspection productivity.



The Phasor CV/DM ultrasonic flaw detector is optimized with software and special dual-element phased array transducers for increased coverage and probability of detection on tank walls, pipes, bolts and flanges.

## Phased Array Flaw Detectors

Ultrasonic phased array inspection continues to evolve rapidly and can be applied to many corrosion and erosion applications for upstream, midstream and downstream plant assets.



Phasor XS can be applied to the important challenge of detecting and sizing corrosion on flange faces at HF Alky units at oil refinery units.

## Corrosion Thickness Gages

These useful and productive tools are designed to help improve safety and ensure reliability of equipment and materials subject to corrosion or erosion. Data can be imported and exported from these devices for mapping and trending.



The DMS Go corrosion thickness gage is a simple, easy-to-use instrument for measuring remaining wall thickness of corroded tubes, pipes, tanks and vessels.

## Transducers

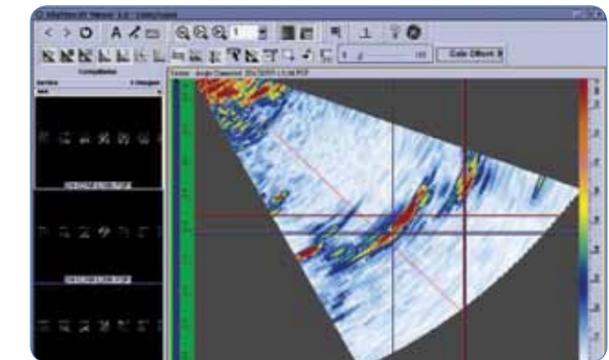
GE manufactures a wide range of standard and custom ultrasonic testing transducers including conventional, phased array and permanently installed for corrosion and erosion applications.



Phased-array and dual-element transducers are optimized for performance extended wear-and-tear, elevated temperatures and detection of isolated pitting.

## Rhythm® Software

Rhythm UT offers the same advanced viewing and measurement tools as the Phasor XS so you can work offline without sacrificing capabilities. Rhythm UT is a DICOM image management platform with additional tools to enhance reporting and analysis of corrosion/erosion data to assist in better decision-making.



Phasor XS phased array sector scans post-processed on Rhythm UT.

# Radiographic Testing (RT)

Radiography is one of the oldest, most reliable and proven nondestructive testing methods and offers unique benefits, such as revealing changes in thickness, internal and surface defects, large-area coverage and more. We offer conventional film radiography, digital technologies, including computed radiography and direct radiography, portable or stationary X-ray sources, 3D computed tomography and analytical X-ray.

## Film Radiography

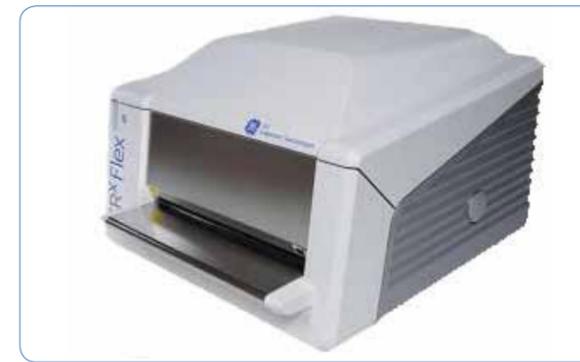
We offer a comprehensive range of radiographic films, processing equipment and chemicals, perfectly geared to one another. No object is too large or too small—a radiographic film of the appropriate size is available for almost every exposure.



AGFA Structurix film remains a global industry standard for quality and reliability with corrosion applications.

## Computed Radiography (CR)

Our wide range of CR scanners, imaging plates and software solutions provide an overall imaging solution to our customers. In addition, we offer proprietary high-performing CR imaging plates for a wide range of NDT applications including corrosion, erosion and crack detection.



The CRxFLEX computed radiography scanner can be used in office, labs or field environments. Image quality sets the CRxFLEX and our phosphor imaging plates apart from the competition.

## Direct Radiography (DR)

GE utilizes a variety of digital detector arrays to ensure optimal image quality and throughput for each application. We have the unique advantage of designing and manufacturing custom systems, allowing us to influence every stage of the process to provide a solution tailored specifically for field and shop industrial applications.



DXR250V is a 16 in x 16 in active area, field-hardened portable imaging digital detector array with a detachable cable. This product plugs directly into a laptop computer for direct radiographic testing and imaging analysis.

## Industrial X-ray Tubes & Generators

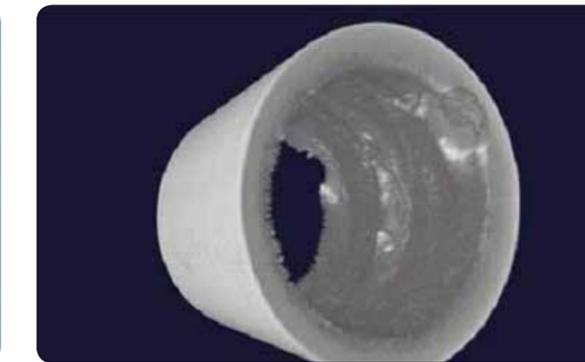
160-300kV portable and 160-450kV stationary equipment with directional or panoramic tubes and different combinations of focal-spot sizes provide the appropriate X-ray source to meet your specific requirements. In addition, we offer a complete line of micro- and nanofocus X-ray generators and tubes.



Field portable ERESKO X-ray generators are used for a wide variety of film, CR and DR corrosion detection and sizing applications.

## 3D Computed Tomography (CT)

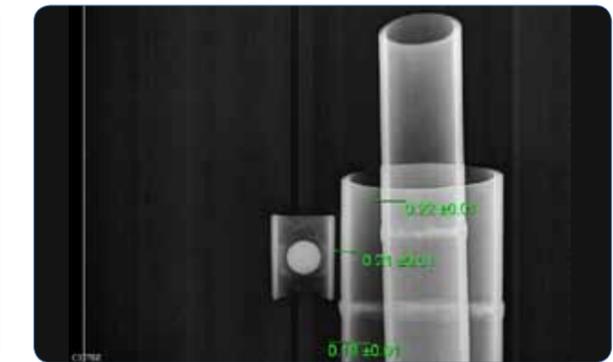
3D computed tomography machines are laboratory instruments and can be applied to many materials engineering and failure analysis applications. "Point cloud" data from 3D scans can be measured very accurately and sliced with software imaging tools.



A CT scan of a medium-sized furnace tube helps to analyze the failure's root cause.

## Rhythm® Software

Rhythm can acquire image data from CR and DR sources or from film digitizers. This data can be displayed on the monitor of a standard PC. Rhythm offers standardized reporting capability in easy-to-understand formats, with DICOM-tagged images. This allows fast historical and meaningful comparison of reports from different inspectors.



Flash! Filters™ for welds provides one-click image optimization, improving the speed and accuracy of defect detection and sizing by using the Wall Thickness Measurement Tool (WTMT) software.

# Eddy Current Testing (ET)

Eddy current is a fast, accurate and cost-effective electro-magnetic NDT method for detection of surface or near-surface flaws such as metal loss due to corrosion or erosion. It is commonly used for the inspection of heat exchanger tubing and piping, shell-side components such as support plates and rotating equipment such as turbine blades.

## Multi-Channel/Multi-Frequency Instrument

These systems are laptop compatible for easy data capture, viewing, analysis and mapping.



Apollo is a multi channel/multi-frequency digital eddy current instrument, which can drive conventional eddy current testing, remote field as well as large array probes.

## Probes

GE designs and manufactures a complete line of eddy current tubing probes for many heat exchanger tube diameters and materials including ferrous and non-ferrous. Custom probes are also available.



Detachable probe heads allow for quick change and re-use of the probe's push-pull cable. This unique design and construction increases field crew productivity, while lowering operating cost for heat exchanger inspection.

## Area Coverage

Special eddy current array probe technology allows for wide-area scanning on metal surfaces of unusual or complex geometry.



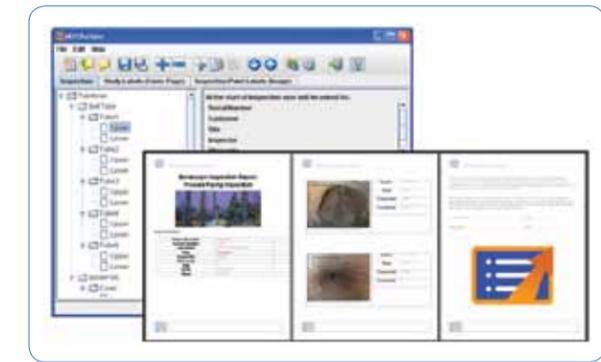
GE's unique eddy current array probes increase coverage while improving probability of detection of complex geometries, such as turbine rotor dovetails.

# Software Solutions

GE Inspection Technologies offers advanced and user-friendly software that improves productivity by helping you make smarter and quicker decisions in the field and in the office. Our software covers all Nondestructive Testing (NDT) applications and methods, including software for data input, analysis, image review, reporting, data management, remote collaboration and storage.

## Menu Directed Inspecton™ (MDI)/Reporting

MDI guides inspectors through the inspection process and generates automatic reports. Rhythm Reporting does the same for all NDT modalities on a PC.



MDI provides image inspection labels and one-click professional reporting.

## Rhythm® - Remote Expert

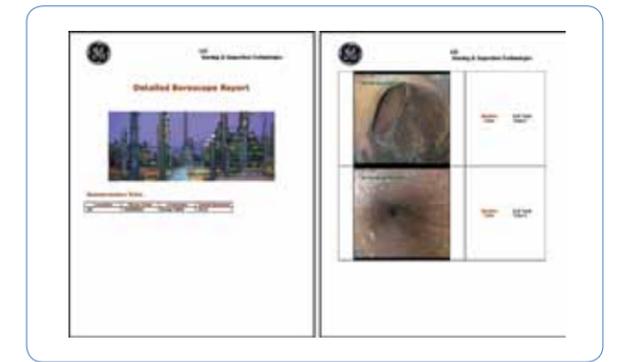
Rhythm makes it easy for experts to share images and information simply and quickly via removable media, LAN connections, or on the web.



By moving data instead of people, Rhythm allows real-time sharing of information with experts anywhere in the world.

## Rhythm - Data Management

Manage all your NDT inspection data in one platform. Rhythm makes querying and retrieving previous inspection data as simple as a few clicks. All data is stored in DICONDE, an industry standard, reducing any risk of data or information loss over time. Rhythm can tie directly to your ERP system.



Whether you're reporting, archiving or sharing, Rhythm provides a consistent platform for your NDT data.

DATA ➤ INFORMATION ➤ KNOWLEDGE ➤ DECISION

GE's Rhythm Software plays a key role in enabling asset owners to integrate NDT data and other information with additionally available knowledge in order to make well-informed decisions regarding plant components and their remaining life.

# Installed Ultrasonic Sensors

GE's Rightrax™ LT and Rightrax HT systems are changing the way that critical corrosion data is measured and managed. This breakthrough technology helps increase safety and productivity while reducing overall inspection costs. The Rightrax system uses permanently-installed sensors that permit remote monitoring of restricted, hard-to-access and/or high-temperature areas up to 350°C (662°F). Once fitted, the system provides continuous real-time access to corrosion data via direct & acquired wall thickness data, eliminating the need to erect scaffolding, remove insulation or shut down plant systems. Online monitoring also reduces labor-intensive traditional inspection routines by providing data that can be used for proactive maintenance planning.

- **Non-intrusive inspection**—Sensors simply bond or are clamped onto the inspection area
- **Remote locations**—Offshore platforms (manned and unmanned), remote pipeline sites or inaccessible areas
- **No scaffolding or rigging costs**—Once installed no need to revisit the site (fit & forget)
- **Early warning systems**—Software provides trending, warning and alarm information with data on demand
- **Accuracy**—Measurement repeatability to 0.2 mm (0.008") (low temp) or 0.0025 mm (0.0001") (high temp)
- **Operator safety**—Eliminates the need to send operators into hazardous environments or remote locations to carry out wall thickness monitoring
- **Increased asset integrity**—The application of monitoring techniques can easily be justified when you consider the consequences of internal wall loss:
  - Improved outage planning
  - Minimize unscheduled shutdowns
  - Eliminate hazard to personnel
  - Reduce probability of environmental issues
  - Enhanced API-RBI protocols



# More Than Just "Wall Thickness Measurement"

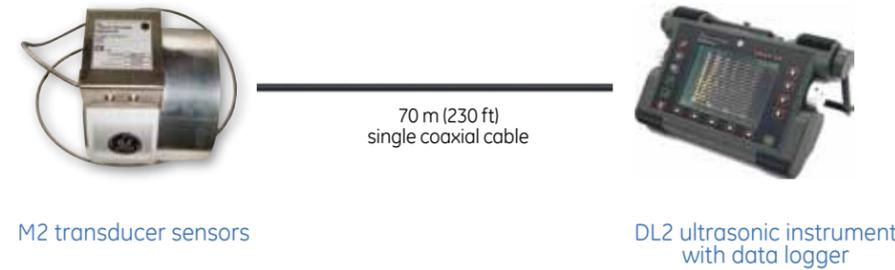
Make well-informed decisions; reduce total corrosion costs

- Provide accurate feedback to manage opportunity crude processing in a refinery by monitoring effects on pipe wall thicknesses
- Drive down probability of failure with data on demand/data on PCs
- Provide reliable and highly repeatable data that can be used to drive maintenance planning activities to save cost on unexpected material orders and spare inventory
- Provide support for chemical injection programs by supplying accurate and reliable pipe wall thickness data
- Interface with plant asset management systems, such as GE O&C System 1, viewing fixed and rotating asset conditions in a single system
- Real-time, highly accurate thickness data

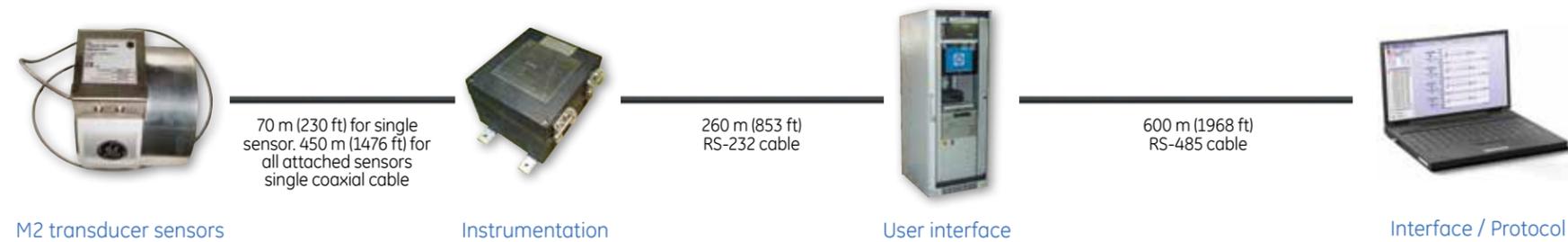


# 3 Rightrax Solutions for Many Applications

## Rightrax Portable Low-Temperature (LT) Installed-Sensor Manual System (- 40°C up to 120°C) (- 40°F up to 248°F)



## Rightrax Low-Temperature (LT) Sensor Automated System (- 40°C up to 120°C) (- 40°F up to 248°F)



## Rightrax High-Temperature (HT) Sensor Automated System (- 10°C up to 350°C) (- 40°F up to 662°F)



Hazardous area rating	Transducer type	Transducer frequency and diameter	Max number of transducers / system	Transducer temperature range min/ max	Operational measurement range (min/ max)	Resolution / accuracy	Maximum cable distance "A"	Maximum cable distance "B"	Maximum cable distance "C"	Interface / protocol
None	M2 Pad 14 elements	8.0 MHz measurement area 200 mm x 12 mm	14 elements Unlimited DL storage 100 sensors	-40° C to 120° C (-40° F to 248° F)	5 mm - 100 mm (0.197 in - 3.937 in)	+/- 0.1 mm (+/- 0.004 in)	70 m (230 ft) (single coaxial cable)	NA	NA	NA
ATEX Ex-proof	M2 Pad 14 elements	8.0 MHz measurement area 200 mm x 12 mm	10 M2 (14-elements) Pads/DL Unlimited DLs	-40° C to 120° C (-40° F to 248° F)	5 mm - 100 mm (0.197 in - 3.937 in)	+/- 0.2 mm (+/- 0.008 in)	70 m (230 ft) max for single sensor. 450 m (1476 ft) max for all attached sensors (single coaxial cable)	260 m (853 ft) (RS-232)	600 m (1968 ft) (RS-485)	MODBUS SCADA System 1 3rd Party
Intrinsically safe	Single-element delay-line sensor	5 MHz x single point	128 transducers	-40° C to 350° C (-40° F to 662° F)	3 mm - 17 mm (0.118 in - 0.669 in)	+/- 0.0025 mm (+/- 9.8x10 <sup>-5</sup> in)	5 m (16.4 feet)	600 m (1968 ft) (RS-485)	600 m (1968 ft) (RS-485 or ethernet)	MODBUS SCADA System 1 OPC 3rd Party

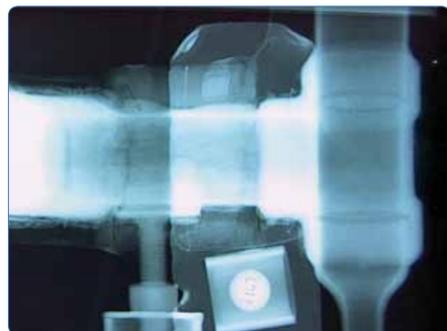
### Corrosion Under Insulation/Fireproofing

Radiographic Testing (RT)

- Insulation and fireproofing can accumulate moisture and cause accelerated corrosion
- Breaches of weather jacketing increases with age and mechanical damage
- Extensive stripping and abatement needed for visual testing and ultrasonic testing
- Digital X-ray can give general condition a specific thickness in recordable format for prioritization of additional inspection/remediation can be scheduled.
- See pages 11 - 12 for general description



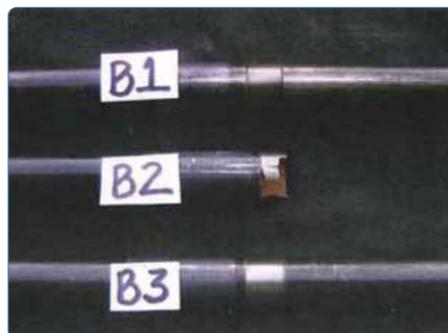
Industrial environments will promote significant corrosion of carbon steel piping components



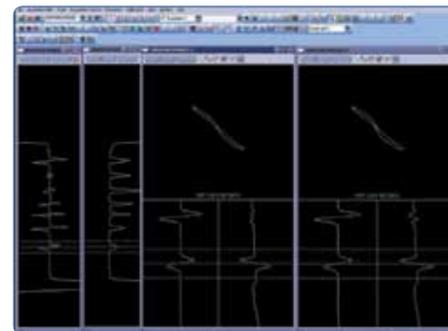
### Heat Exchanger Damage

Eddy Current Testing (ET)

- Heat exchanger tube problems can cause unit outages and environmental impact
- Damage can occur suddenly (titanium tube support plate wear after 2 weeks of above design flow conditions) or longer term
- RVI can provide internal condition. Leak testing does not provide volumetric assessment
- ET is preferred method of tube inspection for non-ferrous alloys
- See page 13 for general description



Heat exchanger tubing can suffer specific damage that can be precisely qualified by ET



### Boiler Tube Hydrogen Damage

Remote Visual Inspection (RVI)

- Hydrogen damage can be caused by condenser in leakage and failures can lead to unit outages
- External UT/EMAT scanning can be used to identify suspected areas of wall loss
- RVI can rapidly confirm external inspections for exact location and severity of boiler tubes for ID damage
- See pages 7 - 8 for general description



Localized corrosion damage in carbon steel can be confirmed using visual methods



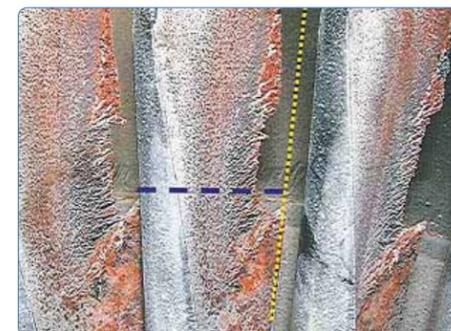
### Turbine Blade Erosion

Remote Visual Inspection (RVI)

- Turbine blade erosion can lead to decreased performance and blade failure
- Pitting may occur before vibration analysis can detect a problem
- RVI can rapidly assess blade condition and equipment can be scheduled for more detailed preventative maintenance
- See page 7 - 8 for general description



Catalyst and solid can cause severe damage to rotating and stationary blades



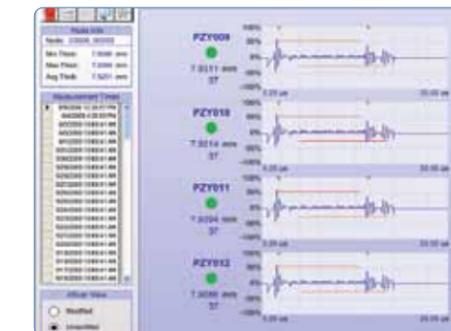
### Offshore Riser Sand Erosion via Installed Sensors

Ultrasonic Testing (UT)

- Sand erosion can occur at change in direction/diameter in offshore production risers due to solids ingestion, typified by a smooth surface with a sand dune pattern
- Riser locations where sand erosion may occur are difficult to access and inspect with conventional ultrasonic and X-ray testing
- Permanently-installed sensors can be applied to suspect areas for accurate monitoring without the need for repeated mobilization of inspection personnel
- See pages 15 - 18 for general description



Solid particles can generate rapid wall loss under proper conditions in offshore risers



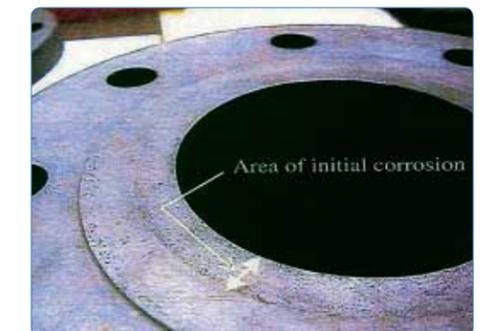
### HF Unit Flange Face Corrosion

Ultrasonic Phased Array (UT-PA)

- HF unit flange integrity must be assessed per API 751
- Manual flange opening and inspection nearly as costly as outright replacement
- UT-PA imaging can significantly enhance detection and sizing of flange face corrosion damage for replacement prioritization for turnaround
- Proven to be accurate and cost effective over conventional inspection methodologies
- See pages 9 - 10 for general description



HF scale and corrosion can significantly compromise flange integrity



### Flow-Assisted Corrosion Utility Steam Pipe

Radiographic Testing (RT)

- Flow-assisted corrosion can occur in all piping that contains water and water/steam mixtures
- Single liquid phase or dual phase (wet steam) as shown below can cause severe local metal wastage
- Water treatment, design and metallurgy can help prevent for damage
- Digital radiography can be used for volumetric examination of specific suspect locations
- See pages 11 - 12 for general description



Carbon steel piping has failed catastrophically from FAC



Corrosion & Erosion

### Creep of High-Pressure Steam Pipe

Ultrasonic Phased Array (UT-PA)

- High-pressure steam pipe may be exposed to stresses above design and suffer high-temperature creep damage causing industry incidents with multiple fatalities and major consequences
- Field metallographic replication (FMR), magnetic particle testing can only detect creep damage on outer surface, not a volumetric assessment
- Phase Array can easily be field deployed to investigate volumetric creep damage in areas of concern in steam pipes
- See page 9 - 10 for general description



Elevated temperature damage can occur with increasing age and operation severity



### Air Fin-Fan Tube ID Condition

Remote Visual Inspection (RVI)/Eddy Current Testing (ET)

- Carbon steel tubes can be inspected by eddy current techniques
- RVI can be rapidly used to assess specific tube conditions for assistance in run-replace decisions
- Tubes can be accessed with minimum preparation for fast evaluation of tube condition
- See pages 7 - 8 and 13 for general description



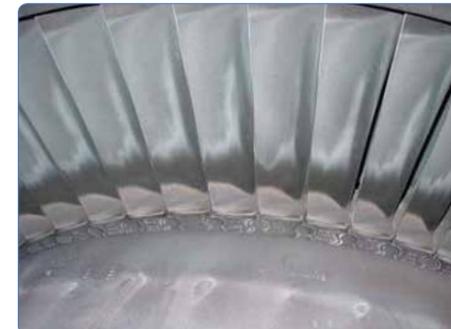
Air fin heat exchanger tube damage can cause significant operational problems



### Compressor Blade Damage

Remote Visual Inspection (RVI)

- Compressor blade rubbing and damage can lead to loss of efficiency and potential catastrophic failures
- Tip damage may be significant before serious vibration damage is noted
- RVI can allow rapid, recordable assessment of compressor blade condition for evaluation by experts in remote locations
- See pages 7 - 8 for general description



Tip damage (rubbing) can be identified by vibration analysis and monitored off line with RVI



### Refractory Vessel Damage

Remote Visual Inspection (RVI)

- Many refractory lining conditions can not be evaluated by UT or RT
- Manual inspection requires staging, scaffolding and proper confined space entry precautions
- RVI can be used to obtain refractory condition assessment to prioritize internal inspection and repair execution to expedite turnaround resources
- See pages 7 - 8 for general description



Refractory damage can be unexpected and lead to significant turnaround repair



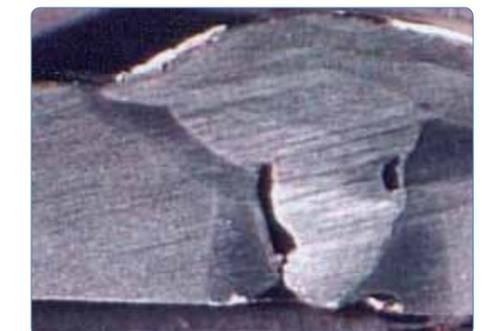
### Weld Heat-Affected-Zone Inspection

Radiographic Testing (CR & DR)

- Greatly enhance weld inspection and flaw sizing with digital radiography
- Digital radiography is both qualitative and quantitative
- Digital radiography produces fast scanning and can go through insulation
- See pages 11 - 12 for general description



Weld defects can cause significant equipment inspection challenges



Corrosion & Erosion

**Bottom Mounted Instrumentation (BMI)**  
Remote Visual Inspection/Ultrasonic Testing (RVI/UT)

- Instrument Penetrations have caused significant reliability concerns at nuclear plants
- Difficult access and need for detailed inspection data required multi-modal approach for proper integrity assessment
- Combination of RVI, UT and Eddy Current techniques help assess BMI guide tubes to prioritize need for repair
- See Pages 7 - 10 and 13 for general description



Bottom mounted Instruments present a challenge for mechanical Integrity assessment.



**Hydro-Processor Effluent Air Cooler**  
Rightrax Installed Sensor (UT)

- Reactor Effluent Air Coolers have suffered numerous Erosion/Corrosion incidents due to Ammonium Bisulfide erosion and Ammonium Chloride corrosion
- Rigorous monitoring of operating conditions must be followed by extensive UT and RT surveys
- Rightrax installed sensors allow continuous or intermittent monitoring of suspect areas
- See Pages 15 - 18 for general description



REAC pipe condition can be continuously assessed regardless of process service conditions in typical operation



**Service Water Piping Corrosion**  
Remote Visual Inspection/Ultrasonic Testing (RVI/UT)

- Extended downtimes and idle service water systems have promoted microbiological corrosion
- MIC can be highly localized and cause complete penetration in short time periods
- Use RVI or RT or both in complementary mode
- See Pages 7 - 10 and 13 for general description



MIC can be highly localized and cause penetration in a short period of time

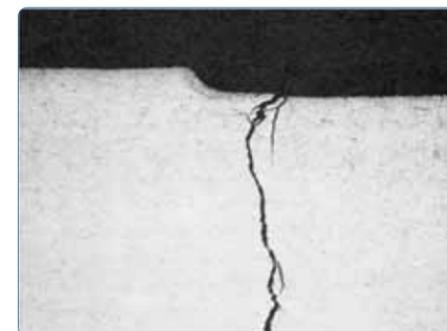


**High-Pressure Piping Ring-Joint Cracking**  
Remote Visual Inspection/Ultrasonic Testing (RVI/UT)

- Ring Joint flanges have had significant cracking from mechanical and Stress Corrosion Cracking
- Typically discovered by PT or manual UT after flanges have been opened during Turnaround. May extend unit downtime
- PA-UT significantly enhances detection and sizing of cracking damage while vessel is in service or just off line to allow for repair/replace planning
- See Pages 7 - 10 for general description

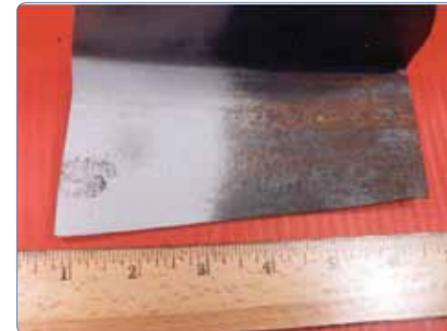


Ring Joint Cracking can be significant enough to necessitate replacement. PA-UT can be used to detect and size damage on line



**Tank Bottom Pitting**  
Ultrasonic Testing Phasor DM (UT)

- API 653 mandates periodic internal tank floor inspection with volumetric assessment
- Magnetic Flux scanners provide rapid general floor condition assessment
- Phasor DM can rapidly "prove-up" scanning results with greater detail than conventional UT
- See Pages 9-10 for general description



Phasor DM can be used to accurately quantify the extent and severity of general wall loss detected in tank bottoms by global scanners



**Injection Point Corrosion**  
Rightrax Installed Sensors (UT)

- Chemical and Process injection without proper control has been responsible for significant industry incidents
- API 570 mandates enhanced inspections of specific locations downstream of these injections
- Rightrax permanently mounted sensors can be installed in these locations and provide continuous thickness and profile readings in these locations
- System installation can be responsive to process changes without deploying personnel resulting in increased data integrity at reduced costs
- See Pages 15 - 18 for general description



Rightrax sensors can be applied directly over an Injection Point area of concern and provide continuous wall thickness monitoring



### Nuclear Containment Building: IWE/IWL

Remote Visual Inspection (RVI)

- 10CFR 50.55a requires inspection of the entire surface area of the containment building
- Containment liner and external extended surface must be inspected in accordance with ASME Section XI Subsections IWE and IWL
- Auto pan-tilt-zoom functions based on plant geometry & input grid for recordable, indexed, high quality documentation with 100% repeatability
- Capable of VT qualification with reduced personnel exposure and increased data integrity
- See Pages 7 -8 for general description



Remote Visual Inspection provides recordable, indexed, high quality documentation

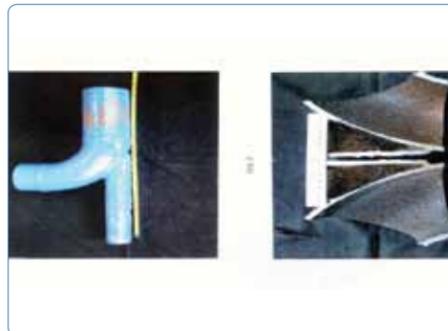


Corrosion & Erosion

### Dead-End Dead-Leg Corrosion

Digital and Computed Radiography (DR & CR)

- Intentional and unintentional stagnant piping legs and connections may have significantly higher corrosion conditions than existing pipe components
- Piping TML's and spot UT may be misleading as to connection condition
- DR and CR images provide measurable, recordable, remotely accessible, high-quality documentation of condition
- Images can be archived in typical plant Data Management systems
- See Pages 11 - 12 for general description



Dead Ends/Dead Legs may suffer significantly higher corrosion rates than adjacent piping components.



### Crude Unit Overhead Corrosion

Rightrax Installed Sensor (UT)

- Crude Unit Overhead lines may suffer high intermittent corrosion rates due to crude slate changes coupled with inadequate chemical corrosion control application
- Periodic piping TML's and spot UT may be not capture events that could cause significant wall loss of piping
- Remote/inaccessible locations generally allow for periodic monitoring with Crane/scaffold access only
- Rightrax permanently-mounted sensors provide recordable, remotely accessible, high quality documentation of wall condition
- See Pages 15 - 18 for general description



Crude Unit Overheads may suffer severe corrosion due to crude slate changes/treatment misapplications but require significant mobilization preparation for inspection



### Naphthenic Acid Corrosion

Rightrax Installed Sensor (UT)

- Crude Unit Overhead heater tubes and lower alloy convection crossover piping when higher TAN opportunity crudes are processed
- Periodic piping TML's and spot UT may be not capture events that could cause significant wall loss of piping
- Inaccessible locations generally do not allow for periodic monitoring
- Rightrax permanently mounted sensors provide recordable, remotely accessible, high quality documentation of wall condition
- See Pages 15 - 18 for general description



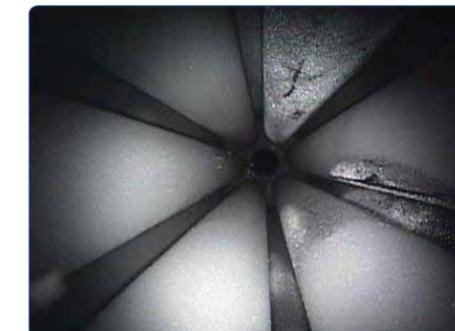
Crude Unit Convection Cross-Over's may suffer severe corrosion due to crude slate changes to higher TAN Crudes



### Heat Exchanger Tubing Failures

Remote Visual Inspection (RVI)

- Rapidly assess damage mechanism for expedited corrective actions
- Instant RVI diagnosis with experiences can produce immediate repair/plug/bring in additional NDT technique decisions
- Use of RVI with experienced plant personnel can greatly reduce outage duration
- Inspection provides recordable, indexed, high quality documentation for review
- See Pages 7-8 for general description



RVI with experienced personnel can provide rapid damage mode identification



### Corrosion Damage Sizing

Ultrasonic Testing (Phasor CV/DM)

- Phased Array capability in readily portable equipment
- Assess damage extent and improved sizing from field personnel
- Improved inspection productivity in a sharable format
- Obtain better information for RBI and FFS Evaluations
- See Pages 9 - 10 for general description



Phasor CV/DM has Dual Element Phased Array capability for accurate, rapid damage sizing



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