

FTIS™ Advantage Comparison Table

Capabilities	FTIS™ Intelligent Pig (UT)	Tethered Inspection Technique	Infrared (IR)	X-Ray (RT)	Manual Ultrasonic (UT)	Visual Methods
Detects and quantifies pipe wall thinning occurring on the interior surface	✓	✓		✓ radiant section only	✓ radiant section only	
Detects and quantifies pipe wall thinning occurring on the exterior surface	✓	✓			✓ radiant section only	✓ radiant section only
Detects and quantifies bulging on one side of the pipe circumference	✓					✓ radiant section only
Detects and quantifies pipe swelling (360° of pipe circumference)	✓					✓ radiant section only
Detects and quantifies broad area corrosion damage	✓	✓		✓ radiant section only	✓ radiant section only	✓ radiant section only
Detects and quantifies broad area erosion damage	✓	✓			✓ radiant section only	✓ radiant section only
Detects and quantifies pipe ovality	✓					✓ radiant section only
Inspects 100% of piping coil convection section	✓					
Inspects 100% of piping coil radiant section	✓	✓		✓ radiant section only	✓ radiant section only	✓ radiant section only
Inspects convection section piping containing raised surfaces (studded, finned, etc.)	✓					
Provides 2D and 3D color layout views of the entire furnace piping coil with inspection data overlaid immediately upon completion of inspection	✓					
Accurate axial positioning of flaw locations within each pipe segment	✓		✓ radiant section only	✓ radiant section only	✓ radiant section only	✓ radiant section only



Quest Integrity, a TEAM company, is a global leader in the development and delivery of asset integrity and reliability management services. The company's integrated solutions consist of technology-enabled, advanced inspection and engineering assessment services and products that help organizations improve operational planning, increase profitability, and reduce operational and safety risks. Quest Integrity is built on a foundation of leading edge science and technology that has innovated and influenced industry best practices since 1971.

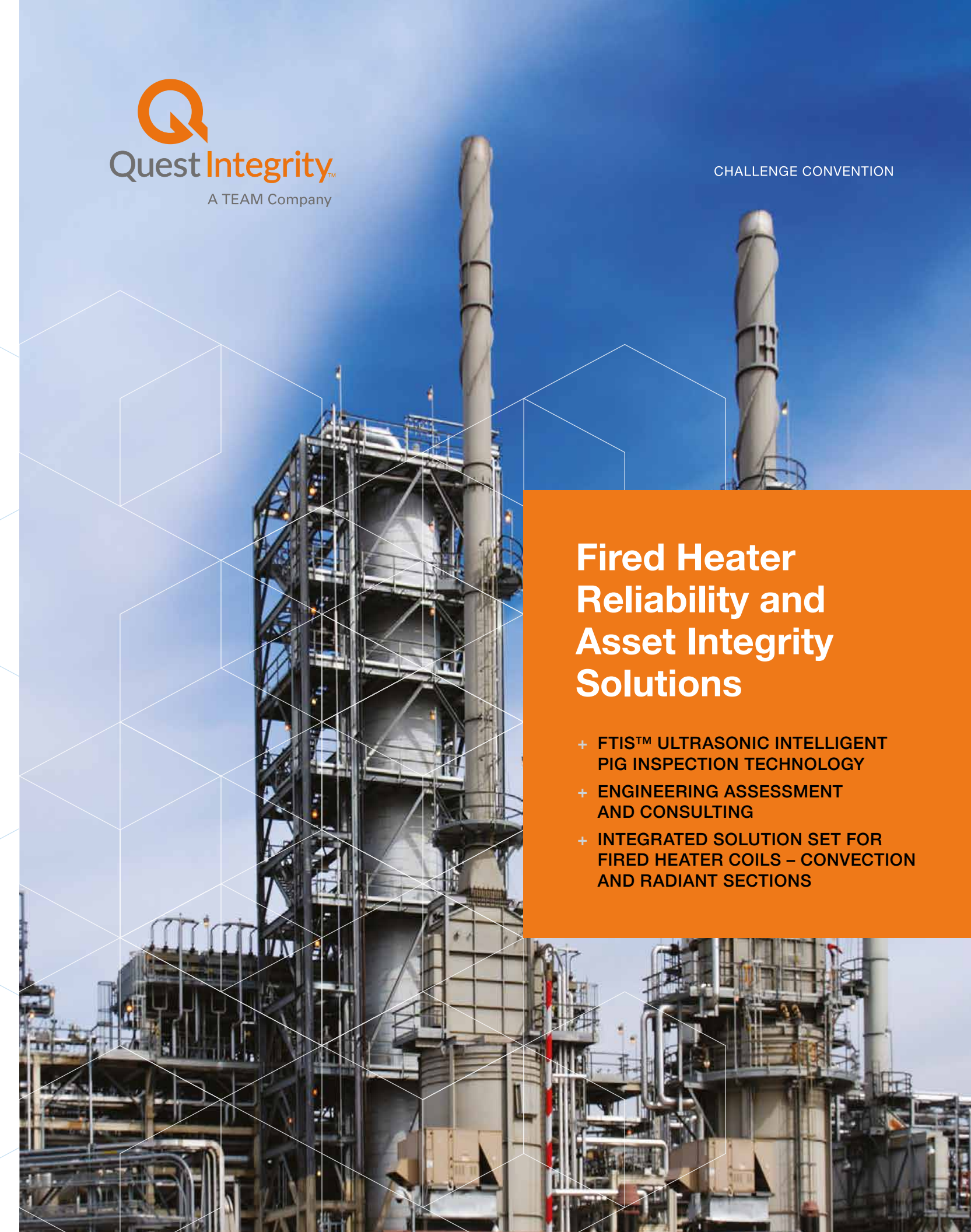
QuestIntegrity.com



CHALLENGE CONVENTION

Fired Heater Reliability and Asset Integrity Solutions

- + FTIS™ ULTRASONIC INTELLIGENT PIG INSPECTION TECHNOLOGY
- + ENGINEERING ASSESSMENT AND CONSULTING
- + INTEGRATED SOLUTION SET FOR FIRED HEATER COILS – CONVECTION AND RADIANT SECTIONS



FIRED HEATER RELIABILITY AND ASSET INTEGRITY SOLUTIONS

Supporting clients in the refining and chemical industries, Quest Integrity is the global leader in fired heater tube inspections. Our advanced ultrasonic inspection technology, FTIS™, quickly and accurately inspects the entire piping coil, collecting data in both the convection and radiant sections. Combined with our advanced engineering and assessment capabilities, we deliver the optimal solution for your integrity management program.



Solutions

- + FTIS™ ultrasonic intelligent pig inspection technology
- + LifeQuest™ Heater remaining life assessment data visualization, analysis and assessment software
- + Advanced engineering assessment of dents, gouges and crack-like flaws
- + Failure assessment and root cause analysis
- + Materials engineering and lab support

Benefits

Reduced Operational Risk

- + Improves heater reliability and decreases failure risk through convection, radiant and cross-over coil inspection
- + Enables operators to make real-time decisions about coil readiness
- + Improves maintenance accuracy

Cost-Effectiveness

- + Extends life of fired heater coils
- + Eliminates need for most conventional NDT methods
- + Requires no scaffolding or heater box entry

Time Efficiency

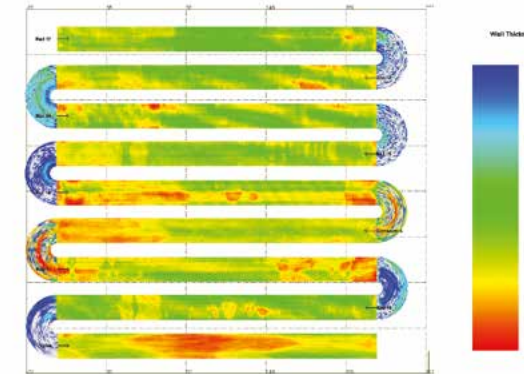
- + Minimize offline status with time efficient inspections
- + Travels at approximate speeds of 2 ft/s (0.6m/s) enabling inspection of 2,000 ft (610m) coil in 15 minutes and all coils in furnace within 1 day
- + Generates field report typically within 24 hours of inspection completion

Damage Mechanisms Identified

- + **Corrosion – broad area or localized**
- + **Pitting – broad area or localized**
- + **Erosion – broad area or localized**
- + **Mechanical damage (fretting)**
- + **Discriminates between interior and exterior wall thinning**
- + **Deformations (e.g. swelling, ovality, bulging)**
- + **Axial and circumferential flaws**
- + **Coke or scale build-up**

Features and Capabilities

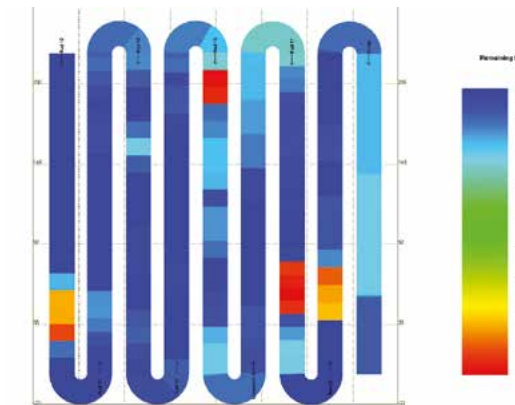
- + Provides 100% coverage of axial length in coils
- + Provides 100% overlapping coverage of coil components utilizing 48 to 168 ultrasonic sensors
- + Inspects heater coils of any length
- + Inspects pipe or tube diameters between 3–14 inches (76–355mm) NPS
- + Negotiates unlimited short radius x 1D 180° return bends
- + Travels and functions bi-directionally
- + Negotiates plug headers (mule ears) without the need for modifications
- + Provides exceptionally high quality data
- + Determines axial positioning of flaw locations
- + Calculates fitness-for-service and remaining life of coils utilizing LifeQuest Heater



Inspection data is viewed using LifeQuest Viewer

Remaining Life Engineering Assessment

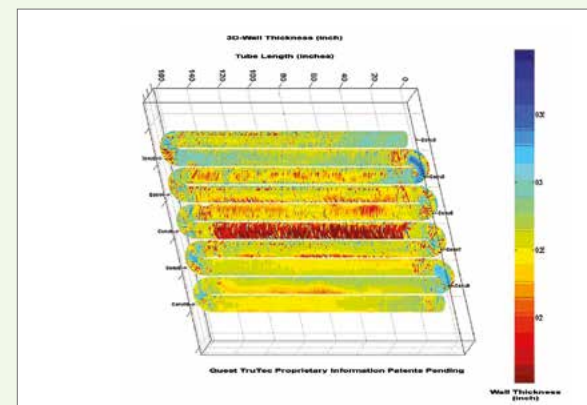
- + Provides fitness-for-service and remaining life engineering assessments in accordance with API 579 and ASME FFS-1/2007
- + Performs analysis and assessment of heater components in accordance with Section 5 (Local Metal Loss) and Section 10 (Creep); includes Monte Carlo simulation to account for variability in operating conditions
- + Provides comprehensive assessment of current and future operating risk for each furnace tube utilizing 100% of inspection data



A 2-D view of API 579, Remaining Life based on Part 5 and Part 10 damage mechanisms

Inspection Reports

- + **Patented color 2D and 3D graphics illustrate most severe damage in intuitive format**
- + **Patented 2D and 3D color plots of full serpentine heater coil in “wall thickness” and “internal profile” formats**
- + **Minimum wall thickness readings in tabular format**
- + **Computer-generated CAD drawing of piping coil layout with overlay of inspection results**
- + **Data archival for future comparison**



3D Convection Coil Layout – damage patterns are illustrated in 2D and 3D graphics

LifeQuest™ Heater Visualization and Assessment Software

PLATFORM FOR DELIVERY OF FTIS INSPECTION AND REMAINING LIFE ASSESSMENT RESULTS

Complete Analysis and Assessment Capabilities

- + Flexibility for manual or automatic import of past operating conditions, inspection histories and materials information for rapid assessment
- + Deterministic calculations of remaining life on foot-by-foot basis utilizing API 579
- + Final output of “system risk curve” displaying remaining life in hours versus probability of failure
- + Acceptable level of risk, tube removal and turnaround planning determinable based upon results
- + Combinable with heater performance monitoring and process modeling for extensive heater reliability management
- + Costs 4-6% of coil repair or replacement, saving significant future downtime and maintenance costs

Engineering Assessment

- + Level 2 and 3 Fitness-for-service assessment of refinery in accordance with API 579/ASME FFS-1
- + Finite element analysis for stress analysis, heat transfer and weld simulation
- + Computational fluid dynamics analysis of process vessels, heaters, boilers, heat exchangers and turbines
- + Fracture mechanics analysis, including 3D finite element analysis simulation of components with cracks
- + Failure analysis
- + Corrosion engineering
- + Remaining life assessment
- + Risked-based inspection/assessment
- + Creep and high-temperature materials testing and database access



Inspection of Fired Heaters with Plug Headers

Fired heaters such as a Coker Heaters contain plug headers (mule ears) in order to allow access to the coils interior without cutting off a return bend. This access is sometimes necessary in order to achieve recirculation in the event that the coil becomes plugged and circulation is not achievable at the optimal flow rate. Historically, the presence of plug headers has posed a major challenge to the inspection process due to difficulty in navigating the fittings.

Advances in Quest Integrity's Furnace Tube Inspection System, or FTISTM, have increased the capabilities of the technology and extended the benefits of ultrasonic intelligent pigging to heater coils containing plug headers (mule ears) – without the need for radial inserts.

Key benefits:

- + Navigates plug headers (mule ears) without the need for modifications
- + Eliminates the need to install radial inserts (slippers)

*2D and 3D modeling covered under U.S. Patent No. 7,542, 874; China Patent No. ZL200580017873.2; South Africa Patent No. 2006/09598; Canada Patent No. 2,568,174; Mexico Patent No. 269892; Australia 60/576,276; Russia 2392658.