Increased Reliability & Reduced Risk

The Critical Link between Reliability and Safety Drives Global Acceptance of New Inspection Technologies for Fired Heaters
**FTIS™ Design Advancements**

**1997**

**ONLY Eight (8)**
- **Single** UT Transducers
- (1 - 15% Coverage)
- 384 Thickness Readings Per Linear Foot
  (Prototype → Gen-2)

**2000**

**Sixteen (16)**
- **Single** UT Transducers
- (21 - 32% Coverage)
- 768 Thickness Readings Per Linear Foot
  (Gen-3 → Gen-5)

**2003**

**Thirty-Two (32)**
- **Single** UT Transducers
- (31 - 63% Coverage)
- 1,536 Thickness Readings Per Linear Foot
  (Gen-3 → Gen-5)

**2006**

NextGEN FTIS™

- 360 Degree UT Transducer array
- Increase in resolution (3x – Circ / 7x – Axial)
- Increase memory storage (Up to 25 miles)
- Inspecting piping sizes between 3.5" to 8.0"
  (100 - 130% Coverage)
- 2,304 to 4,752 Thickness Readings Per Linear Foot

**2008**

**QUEST TRUTEC**

*Asset Longevity | Plant Performance*
Applications

- **Furnaces Piping / Tubing**
  - Numerous Furnace Types (*Platformers (CCR), Vacuum, Coker, Crude, Can, Cabin, etc.*)
  - Various Coil Configurations (*Vertical, Horizontal, U-Shape, etc.*)
  - Changing Diameter Coils (*4” → 5” → 6” → 8”*)
  - Non-pigable furnaces in some cases (*i.e. Common Headers*) (*Common Header Delivery Systems*)

- **Pipelines**
  - Underground / Buried / Road Crossings
  - Insulated (*i.e. Asbestos*)
  - Overhead (*i.e. Congested Pipe Racks*)
  - In Plant / Between Plants / Wharf Lines

*Common Header Delivery System only available in Europe at this time*
This is a "confidential" photo of the Header Delivery System.

The only Mechanical Decoking company who currently offers service with such a system is Turbine, who's based in HOLLAND. No company in the USA has this available today.

Pipe / Tube Wall Loss

- Corrosion (Int. or Ext.)
- Erosion (Int. or Ext.)
- Pitting (Int. or Ext.)
- Mechanical Damage (Int. or Ext.)

Deformation

- Bulging (i.e. Flame Impingement)
- Swelling (i.e. Creep Strain)
- Denting
- Ovality
Mechanical Damage is sometimes caused during installation.

For example if the coil is dropped or banged up against other equipment during installation denting and gouges can be caused.

Some times these damages are in locations which can not be seen during routine visual inspections.


Deformation or "Pipe Shape Change"


This photo is of a NAPTHA HYDROTREATER

Make sure to point this out as Naptha Hydrotreater furnaces are often overlooked in refineries and should be considered a "HIGH PRIORITY"

(more information below - double click mouse on comment to open)

This furnace is not suppose to be in a Coking Service, however quite often solids are carried forward, vaporizing, condensing and then attaching to the pipes interior surface. These are the areas which will fail as a result of overheating.

100% of the Ultrasonic (UT) Data Utilized to Generate This Image

3D modeling and reporting options allow operations and inspection to easily interpret data for immediate and accurate corrective actions.
Creep Damage is clearly evident in this example utilizing FTIS™.
DeCoking Quality Control / Quality Assurance

Inner Radius

Coke

Cut Out Pipe Section w/ Coke
RDR8  Capability of flipping 3D plot to Grey Scale to assist mechanical decoking companies with understanding data.

Note coke on ID of tube in numerous locations

Photo is of a tube removed from a heater directly after FTIS inspection.

Corrosion (Convection Section)

Corrosion Damage

3D-Wall Thickness (inch)

Wall Thickness (inch)

Quest-TruTec Proprietary Information Patents Pending
Corrosion damage in the "CONVECTION" section of a heater coils is UNDETECTABLE by any other means besides FTIS.

This image should be leveraged off of to justify cost of carrying out inspection with FTIS technology.

One heater failure will cost hundreds of thousands of dollars, while FTIS may only cost between $25k - $50k.

External Studded or Finned Surfaces

3D View

2D View

New Pipe

Sample Convection Pipe

New Pipe

Internal Corrosion
LOTIS® is capable of inspecting furnace coils which contain “Plugged Headers” (a.k.a. Mule Ears)

- Straight Section of Pipe is Inspected

- “Internal” flaws detectable and quantifiable:
  - Corrosion, Erosion, Pitting
  - Creep (Bulging / Swelling)
FTIS currently cannot get through plugged headers (also commonly referred too as Mule Ears)

We can apply LOTIS to inspect plugged headers

Have carried out several inspections to date with LOTIS

LifeQuest™ Heater Overview

• Clients demanded the ability to use FTIS™ and LOTIS® data to make decisions concerning safe and reliable operations.

• What clients asked for:
  – Remaining Life Assessment within Turnaround
  – Utilization of historical data
  – Compare data sets
  – Assess risk versus time to help with turnaround planning
  – In-house control over the process
Options for Consideration

- Acquire software and training to accomplish remnant life assessments utilizing previous FTIS™ inspection data
- Acquire software and training to accomplish remnant life assessments for upcoming turnaround and FTIS™ inspection
- Continue with FTIS™ inspections without further detail provided
Utilizes 100% of the FTIS™ data for side-by-side comparison with past inspections.
LifeQuest™ allows you to view individual location data.

In this case...
Min. = 0.163”
Max. = 0.174”
Avg. = 0.169”
LifeQuest™ allows you to manually or automatically import past operating conditions and inspection histories, material properties, and allows you to determine corrosion rates based on previous inspections. This is preferably done before the turnaround occurs for rapid assessment.
Output is in hours
Monte Carlo Analysis allows for statistical calculation of time to failure.

Temperature & pressure variations to allow for operating condition fluctuations.
The final output is a curve of Remaining Life in hours versus Probability of Failure. Acceptable level of risk is determined and additional tubes removed or turnarounds planned based on results.
Case Study – Local Corrosion

Case Study

Local Corrosion
Min Wall = 0.146 inches
Remaining Life = 128,283 hours
CRUDE HEATER

- Number of Coils / Passes = 12
- Pipe Material = 9Cr – MO (A335-P9) (6” x Sch-80)
- Plant had several sections in which partial sections of piping coil had been replaced with new material.
- Plant engineers did not expect any damage in new coil sections, however were concerned with older coil sections.
- Manual Ultrasonic inspection had not found any damage in previous years’ inspections (inspection limited to only radiant section).
- A FTIS™ Inspection was carried out on all 12 coils / passes (inspection included both radiant and convection sections).
- FTIS™ data showed severe corrosion damage in both new and old coil sections.
- Plant has reconsidered use of conventional NDE inspection.
I usually just read each of the bullet points
Case Study #1  Isolated Corrosion Damage
2D plot shows the 95% through wall corroded area.

Only 5% wall remaining in NEW pipe section were "Corrosion Damage" zoom in is located.

Case Study #1  Inspection Method Comparison

Manual Ultrasonic (UT) Thickness Locations (20 UT Readings)

FTIS™ Intelligent Pig Inspection Coverage (75,600 Readings)
This plot is to illustrate why plants should not use Manual UT thickness monitoring.

Manual UT has very limited coverage

FTIS has significantly more coverage

(more info below - double click mouse on note to open)

Red graph on right places an "x" on every data sample taken with FTIS and "x" on the left plot show sampling density of Manual UT

CRUDE FURNACE

- Number of Coils / Passes = 2
- Pipe Material = ASTM A-106, Grade B (6” x Sch40)
- Plant did not anticipate any “serious” problems with heater prior to FTIS™ inspection.
- FTIS™ was primarily being used to test technology and satisfy internal routine inspection.
- FTIS™ data results showed coil was exceptionally cleaned by mechanical pigging contractor.
- FTIS™ inspection results clearly showed extensive corrosion damage in the convection section.
- FTIS™ pointed out to plant that 6” x Schedule-20 piping was installed in the cross-over regions of the coil. **NOT** Schedule-40 as originally thought.
- Plant engineers later informed Quest TruTec, that based upon the FTIS™ results, they replaced the coil.
- FTIS™ inspection potentially prevented furnace failure.
Case Study #2 (3D Plot) Corrosion in Convection Section Piping

General internal wall thinning patterns in convection section pipes
Case Study #3

VACUUM FURNACE

- Number of Coils / Passes = 2
- Pipe Material = ASTM A335 – P5 (6-inch x Sch40)
- Heater Vintage = 1976
- FTIS™ was applied to inspect both process coils.
- FTIS™ inspection results detected extensive external corrosion damage in the radiant section.
- Visual inspection found tightly adhered scale on piping exterior surface.
- FTIS™ results were not impacted by tightly adhered scale.
- Large broad areas with 56% external wall loss were noted.
- Plant engineers utilized FTIS™ inspection results to make decision for replacement of several pipe sections.
Case Study #3  Extensive External Corrosion Masked by Tightly-Adhered Scaling

3D Wall Thickness (mm)

2D Corrug Wall Thickness (mm)

External Corrosion Damage (Radiant Section)
Damage was in "radiant" section.

FTIS data was confirmed by both "visual" and "destructive" testing.

Plant stated that they may have not detected most severe area had they not applied the FTIS technology.

Case Study #3 Extensive External Corrosion Masked by Tightly-Adhered Scalling

56% Wall Loss

Tightly Adhered Scale

Side View of Pipe
PIPELINE CASE STUDY
4" Crude Pipeline (FTIS 2D Data Display)

- 7 major flaws detected with FTIS
- Corrosion and pitting damage mechanisms
- Customer verified each flaw with an alternate manual NDT method (i.e. pit gauge and/or manual ultrasonic scope)
- Repairs were made to all areas based upon FTIS™ inspection results
PIPELINE CASE STUDY
4" Crude Pipeline (Photo – 3D – 2D Images)
Summary

- Aging infrastructures, PSM concerns, and capacity requirements are driving refiners globally to re-examine and redefine their entire inspection and reliability programs for Fired Heaters and Plant Piping.
QUESTIONS?