Inspection Utilizing “Intelligent Pigging” of Coker Heater Coils

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FTIS™ Design Advancements

NextGEN FTIS
- 360 Degree UT Transducer array
- Increased sample frequency (40Hz → 100Hz)
- Increased memory storage (1 mile → 20 miles)
- Capable of inspecting piping sizes between 2.5’ to 8.0’
- Capable of Negotiating Mule Ear (Plugged Header) returns
- Additional algorithms to further enhance data analysis process
- Anticipate 2nd-3rd Qtr 2007
FTIS™/LOTIS® Detectable Failure Mechanisms

- **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
Decoking Quality Control (Q/C) / Quality Assurance (Q/A)

Convection Pipe Studded / Finned Pipe

New Pipe

Sample Convection Pipe

New Pipe
**Corrosion** (Convection Section Corrosion)

![3D diagram of Corrosion Damage and NEW Pipe](image)

**Corrosion** (Convection Section Corrosion)

![3D diagram of Corrosion Damage and NEW Pipe](image)
Flame Impingement Damage (Bulging / Swelling)

FTIS™ 2D Pipe Layout Display

Dents In Pipe

FTIS™ 3D Pipe Layout Display

"Zoom In" Display
LOTIS® Inspection of Furnaces Containing *Plugged Headers* (Mule Ears)

- 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)

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**Case Study #1**

**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 encompassed “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 methods.
Case Study #1 Isolated Corrosion Damage

Case Study #1 Inspection Method Comparison

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

FTIS™ Intelligent Pig Inspection Coverage (75,600 Readings)
Case Study #2

VACUUM HEATER

- Number of Coils / Passes = 8
- Pipe Material = 5Cr (5", 6" & 8" x Sch-80)
- Plant had modified heater convection section. *(Installed soot blower)*
- During mechanical pig cleaning process *water was observed coming from Convection Section*.
- Plant then elected to have FTIS™ inspection performed, rather than start cutting off return bends to find damage.
- A FTIS™ Inspection was carried out on all 8 coils/passes (Inspection encompassed "both" Radiant and Convection sections)
- FTIS™ Intelligent Pig revealed only 8 pipe sections were damaged and localized to one end. All damage was "*external*".
- Plant stated that FTIS™ saved them over $1M in coil replacement costs.

Case Study #2 Launcher / Receiver Set-Up

*TYPICAL LAUNCHER / RECEIVER SET-UP*
Case Study #2  FTIS™ Data Showing External Damage

Obvious Patterns Developing in Damage Distribution

Case Study #2  "Externally" Corroded Convection Piping

Hole
Case Study #2  Removed Piping From Convection Section

Case Study #2  Tube Repairs (½ New – ½ Old Material)
Case Study #3

ATMOSPHERIC HEATER

- Number of Coils / Passes = 4
- Pipe Material = 347 Stainless (4", 5" & 6" x Sch-40/80)
- Plant anticipated damage, however nothing severe.
- FTIS™ Inspection revealed substantial damage in both Radiant and Convection sections of the coil.
- Plant cut out sections to confirm data. When the results matched perfectly, plant then elected to expand scope of work and inspect a total of three (3) heaters.
- FTIS™ data clearly showed two types of damage patterns.
- Plant cut out all damaged areas above threshold and confirmed accuracy of FTIS™. FTIS™ data matched destructive testing perfectly.
- Plant is now using FTIS™ data to better understand why damage is occurring.

Case Study #3 (3D Plot) Corrosion in Radiant Section Piping

[Graphs and images showing corrosion data and pipe surface profile]
Case Study #3  (2D Plot) Corrosion in Radiant Section Piping

Case Study #3  DESTRUCTIVE TEST RESULTS

PIPING COIL
INSPECTION RESULTS CONFIRMATION

1. PIPE # 11  -  150'-200' AREA
   - FTIS™ REPORTED
   - MANUAL UT
   - DRILLED HOLE w/CALIPER
   - 0.096" (Remaining Wall)

2. PIPE # 15  -  400'-450' AREA
   - FTIS™ REPORTED
   - MANUAL UT
   - DRILLED HOLE w/CALIPER
   - 0.097" (Remaining Wall)

3. PIPE # 28  -  400' AREA
   - FTIS™ REPORTED
   - DRILLED HOLE w/CALIPER
   - 0.247" (Remaining Wall)

4. PIPE # 28  -  200' AREA
   - FTIS™ REPORTED
   - DRILLED HOLE w/CALIPER
   - 0.185" (Remaining Wall)

- THICKNESS CHECKS WERE INITIALLY PERFORMED BY FTIS™
- MANUAL UT THICKNESS WERE TAKEN ON EXTERIOR AFTER REMOVAL
- SAMPLES WERE CUT OUT / HOLE DRILLED AND MEASURED WITH A MICROMETER
  ALL FTIS REMAINING READINGS WERE VERY CLOSE TO MICROMETER READINGS (+/- 0.002").
- THE AREAS SHOWING LOCALIZED THINNING IN THE FTIS REPORT HAVE EROSION AREAS
  THROUGHOUT ENTIRE PIPE LENGTH, WITH SCATTERED DEEPER PITTING.
Case Study #4

CRUDE FURNACE

- Number of Coils / Passes = 2
- Pipe Material = ASTM A-106, Grade B (6-inch x Sch.40)
- 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 coil.
- FTIS™ inspection potentially saved furnace failure.

Case Study #4 (2D Plot) Corrosion in Convection Section Piping
Case Study #4 (3D Plot) Corrosion in Convection Section Piping

Case Study #5

VACUUM FURNACE

- Number of Coils / Passes = 2
- Pipe Material = ASTM A335 – P5 (6-inch x Sch.40 )
- 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™ test results to make decision for replacement of several pipe sections.
Case Study #5 Corrosion in Convection Section Piping

3D

2D

External Corrosion Damage (Radiator Section)

Case Study #5 (3D Plot) Corrosion in Convection Section Piping

59% Wall Loss

Tightly Attached Scale