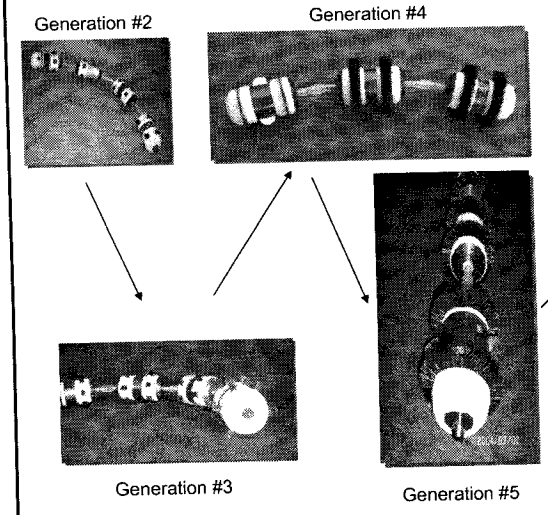
QUESTTRUTEC

Inspection Utilizing "Intelligent Pigging" of Coker Heater Coils

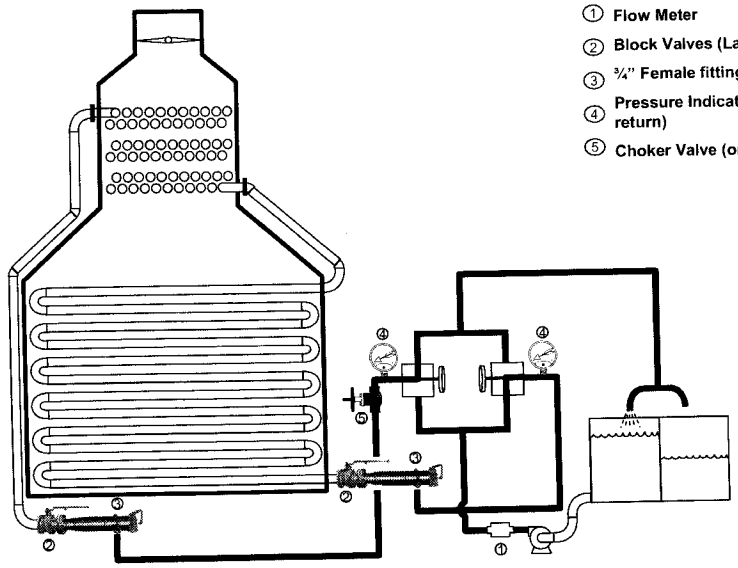
Author: Rich Roberts

FTIS™ Design Advancements



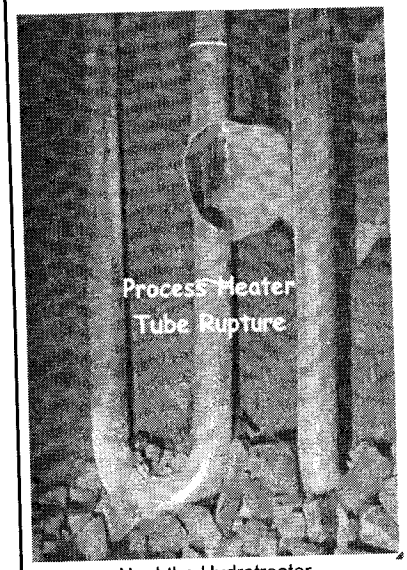
NextGEN FTIS

- 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



① Flow Meter
② Block Valves (Launcher & Receiver)
③ ¾" Female fitting (for pig locator)
④ Pressure Indication (supply and return)
⑤ Choker Valve (on return)

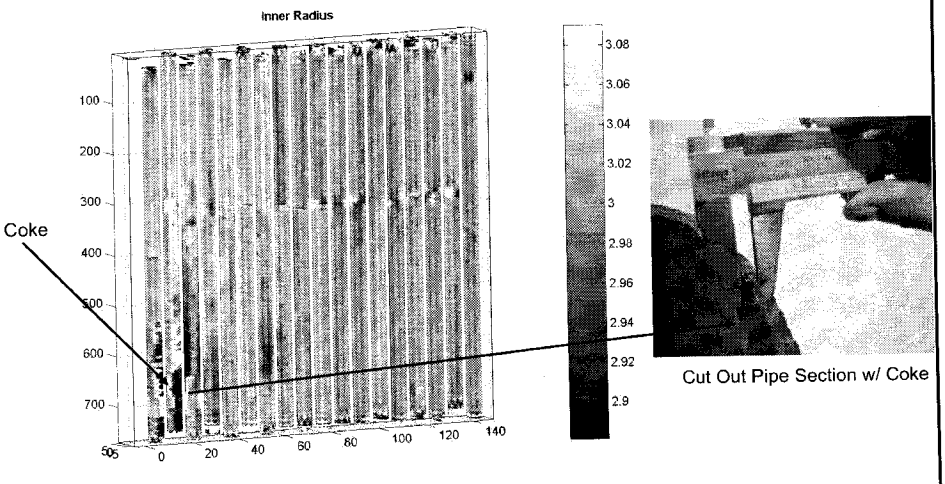
FTIS™ / LOTIS® Detectable Failure Mechanisms



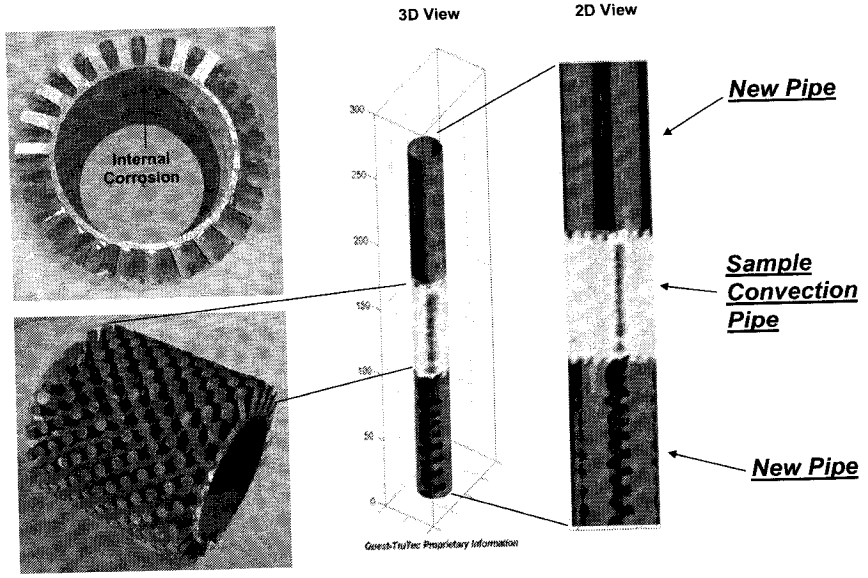
Naphtha Hydrotreater

- ❑ 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

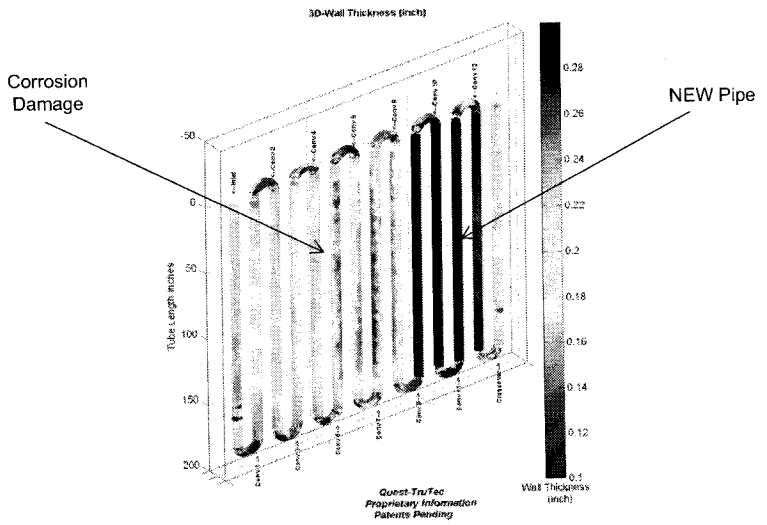
Decoking Quality Control (Q/C) / Quality Assurance (Q/A)



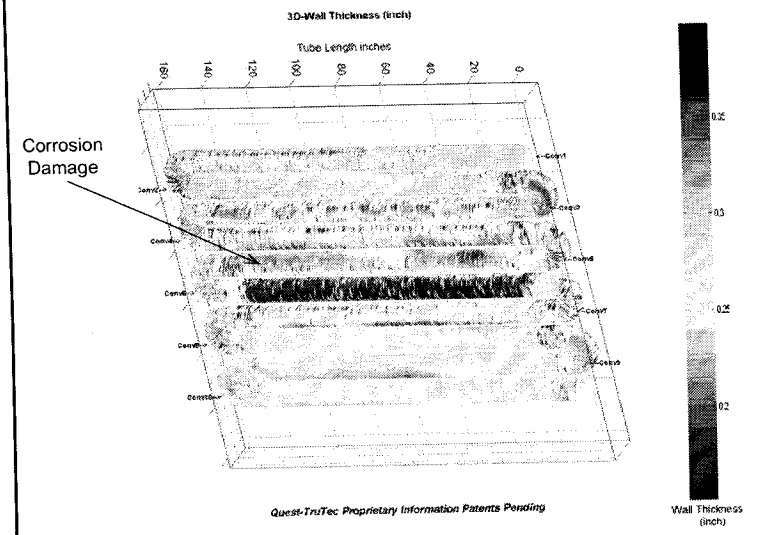
Convection Pipe Studded / Finned Pipe



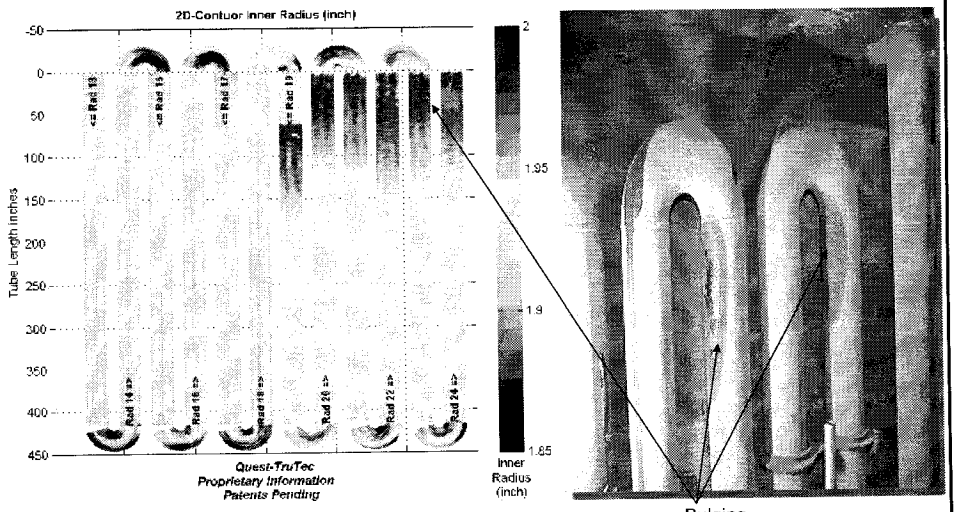
Corrosion (Convection Section Corrosion)



Corrosion (Convection Section Corrosion)

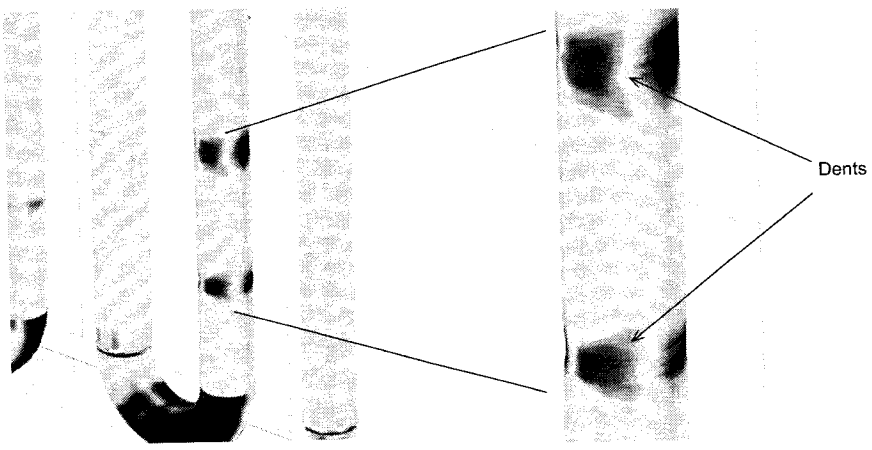


Flame Impingement Damage (Bulging / Swelling)



FTIS™ 2D Pipe Layout Display

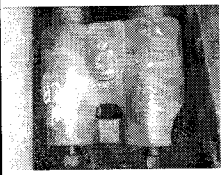
Dents In Pipe

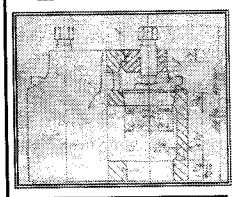


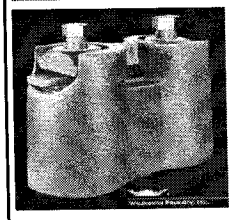
FTIS™ 3D Pipe Layout Display

"Zoom In" Display

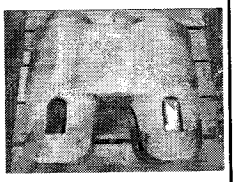
LOTIS® Inspection of Furnaces Containing *Plugged Headers (Mule Ears)*

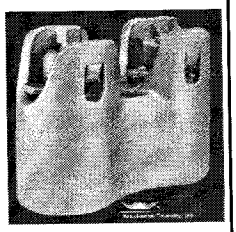






- ❑ LOTIS is capable of inspecting furnace coils which contain "Plugged Headers" *(a.k.a. Mule Ears)*
- ❑ Straight Section of Pipe is Inspected
- ❑ "*Internal*" flaws detectable and quantifiable:
  - ✓ Corrosion, Erosion, Pitting
  - ✓ Creep (Bulging / Swelling)



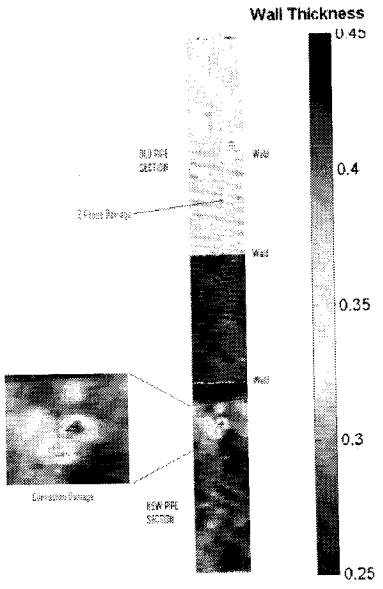


Case Study #1

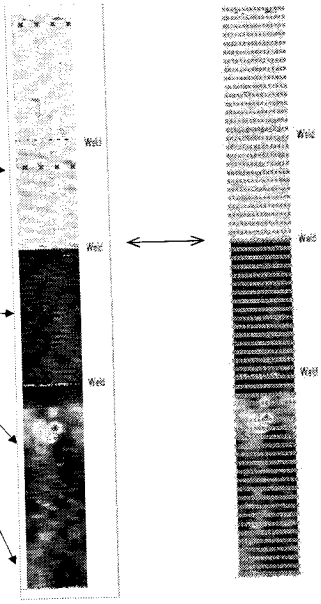
CRUDE HEATER

- 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)

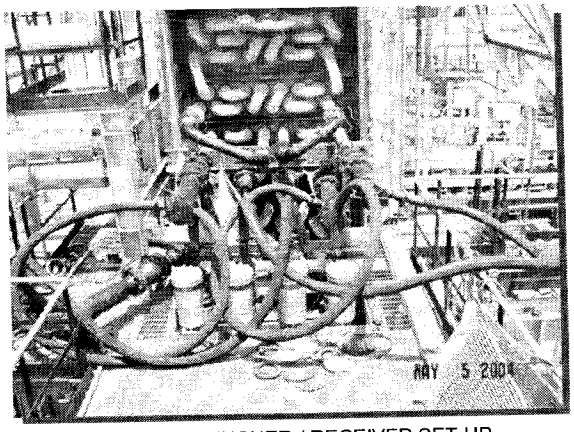
FTIS™
Intelligent Pig
Inspection Coverage
(75,600 Readings)

Case Study #2

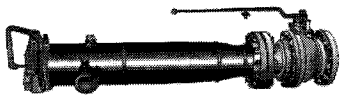
VACUUM HEATER

- 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.

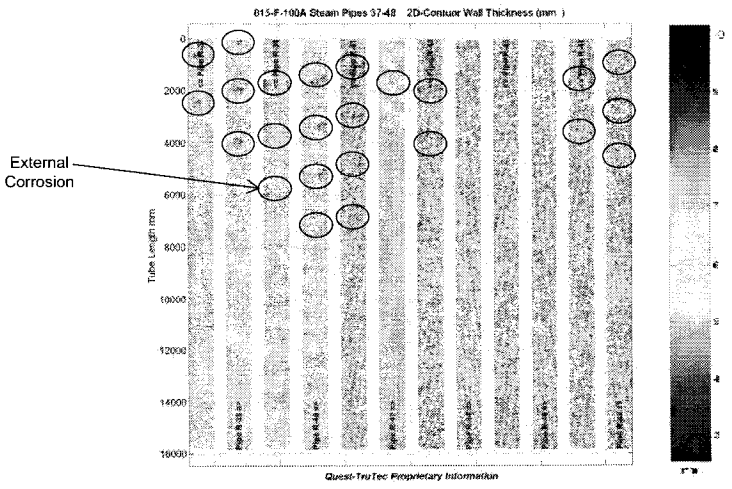
Case Study #2 Launcher / Receiver Set-Up



TYPICAL LAUNCHER / RECEIVER SET-UP

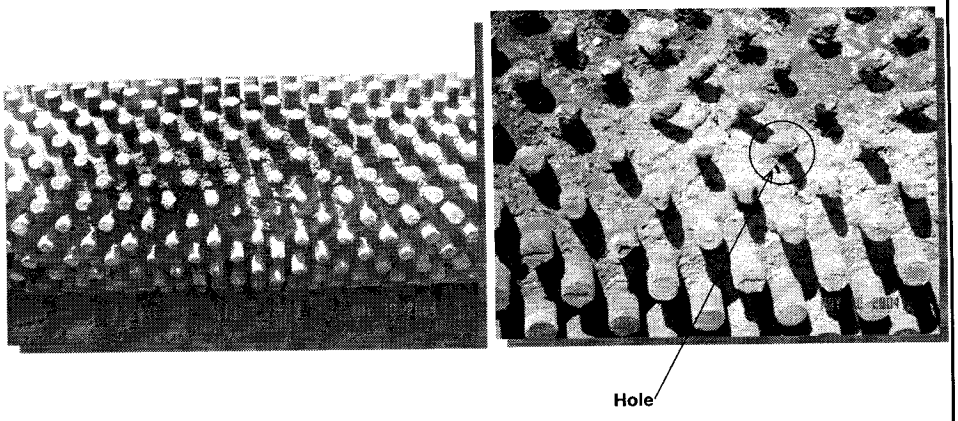


Case Study #2 FTIS™ Data Showing External Damage

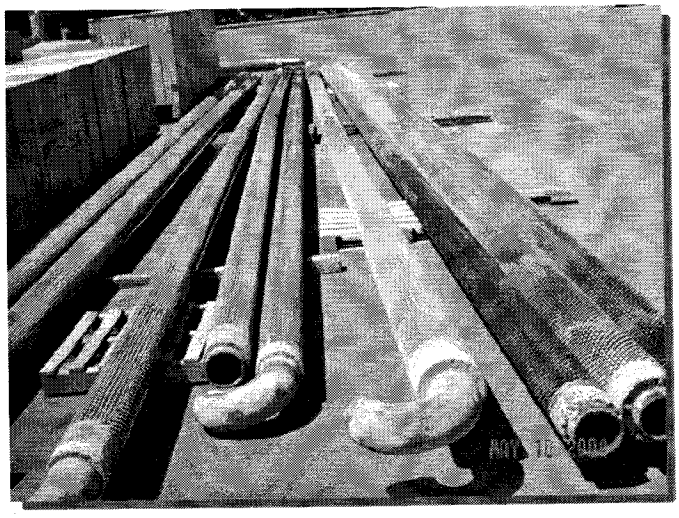


Obvious Patterns Developing in Damage Distribution

Case Study #2 "Externally" Corroded Convection Piping



Case Study #2 Removed Piping From Convection Section



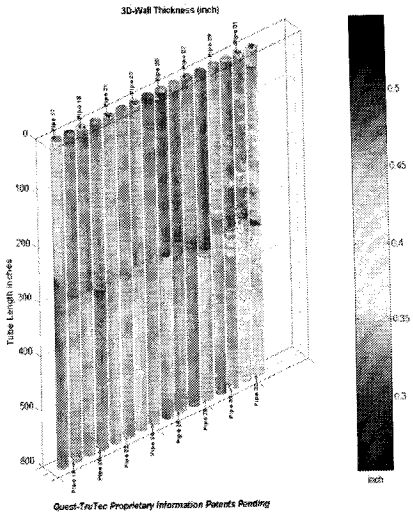
Case Study #2 Tube Repairs (½ New – ½ Old Material)

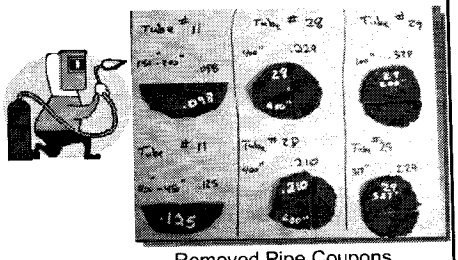
Case Study #3

ATMOSPHERIC HEATER

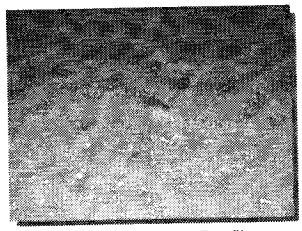
- Number of Coils / Passes = 4
- Pipe Material = 347Stainless (4", 5" & 6" x Sch-40/80)
- Plant anticipated damage, however nothing severe.
- FTIS™ Inspection revealed substantial damage in both Radiant and Convection sections of the coil.
- Plant cut out sections to confirm data. When the results matched 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



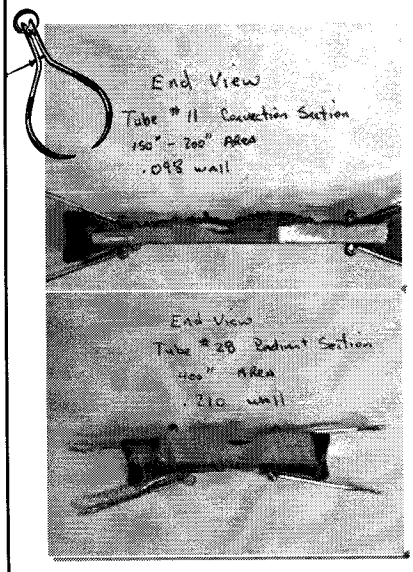


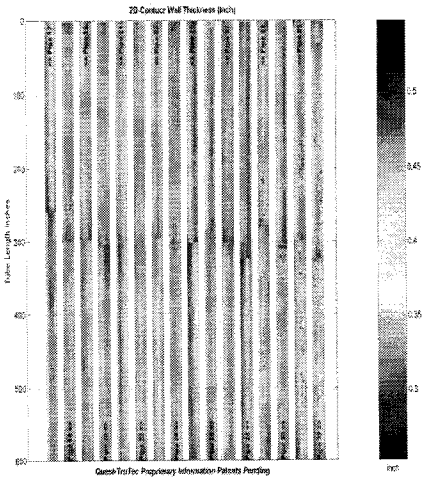
Removed Pipe Coupons



Interior 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	----	0.096" *(Remaining Wall)*
		MANUAL UT	----	0.095" *(Remaining Wall)*
		DRILLED HOLE w/CALIPER	----	0.098" *(Remaining Wall)*
2. PIPE# 11- 400"- 450" AREA	----	FTIS™ REPORTED	----	0.097" *(Remaining Wall)*
		MANUAL UT	----	0.110" *(Remaining Wall)*
		DRILLED HOLE w/CALIPER	----	0.098" *(Remaining Wall)*
3. PIPE # 28- 400" AREA	----	FTIS™ REPORTED	----	0.247" *(Remaining Wall)*
		DRILLED HOLE w/CALIPER	----	0.248" *(Remaining Wall)*
4. PIPE # 29 - 200" AREA	----	FTIS™ REPORTED	----	0.186" *(Remaining Wall)*
		DRILLED HOLE w/CALIPER	----	0.188" *(Remaining Wall)*

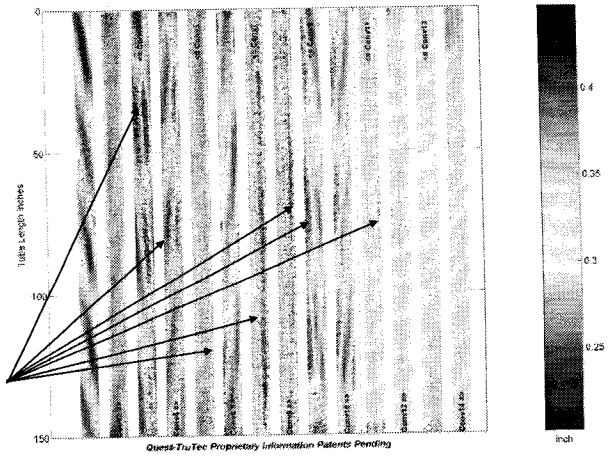
- THICKNESS CHECKS WERE INITIALLY PERFORMED BY FTIS™
- MANUAL UT THICKNESS WERE TAKEN ON EXTERIOR AFTER REMOVAL
- SAMPLES WERE CUT OUT / HOLE DRILLED AND MEASURED WITH A MICROMETER
  ALL FTIS REMAINING READINGS WERE VERY CLOSE TO MICROMETER READINGS (+/- 0.002").
- THE AREAS SHOWING LOCALIZED THINNING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

Case Study #4

CRUDE FURNACE

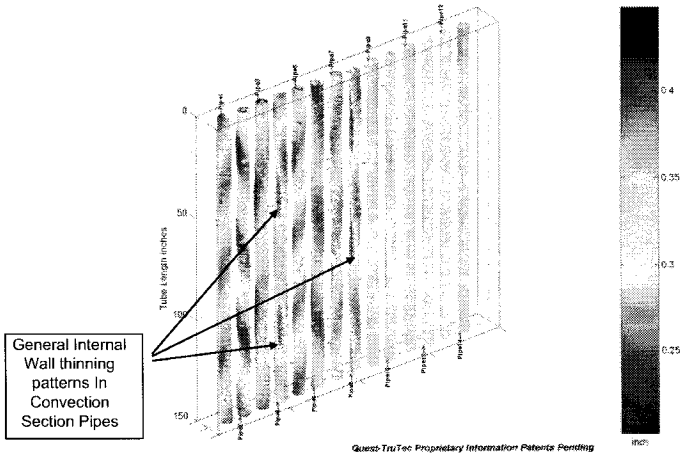
- Number of Coils / Passes = 2
- Pipe Material = ASTM A-106, Grade B (6-inch x Sch.40)
- Plant did not anticipate any "serious" problems with heater prior to FTIS™ Inspection.
- FTIS™ was primarily being used to test technology and satisfy internal routine inspection.
- FTIS™ data results showed coil 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



General Internal Wall thinning patterns In Convection Section

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

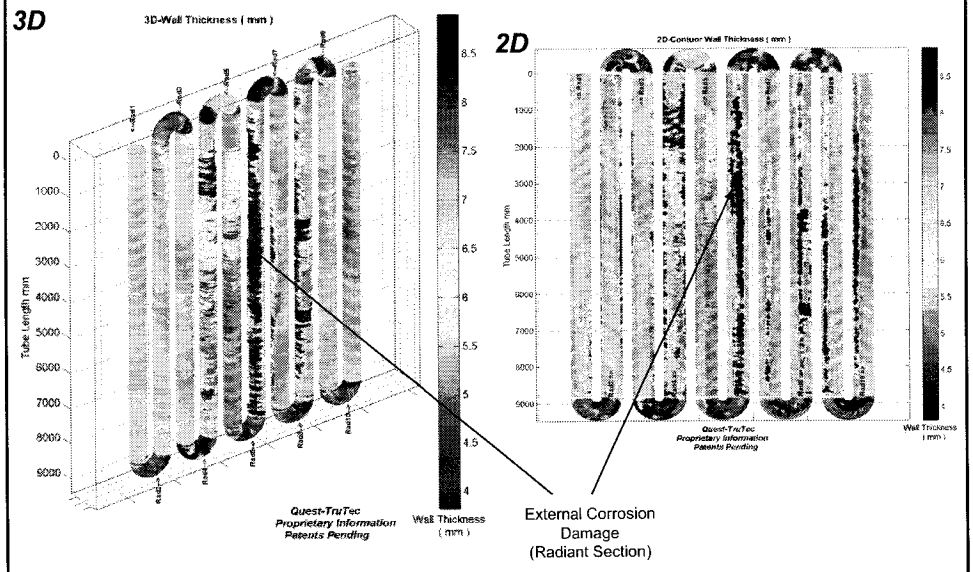


Case Study #5

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



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