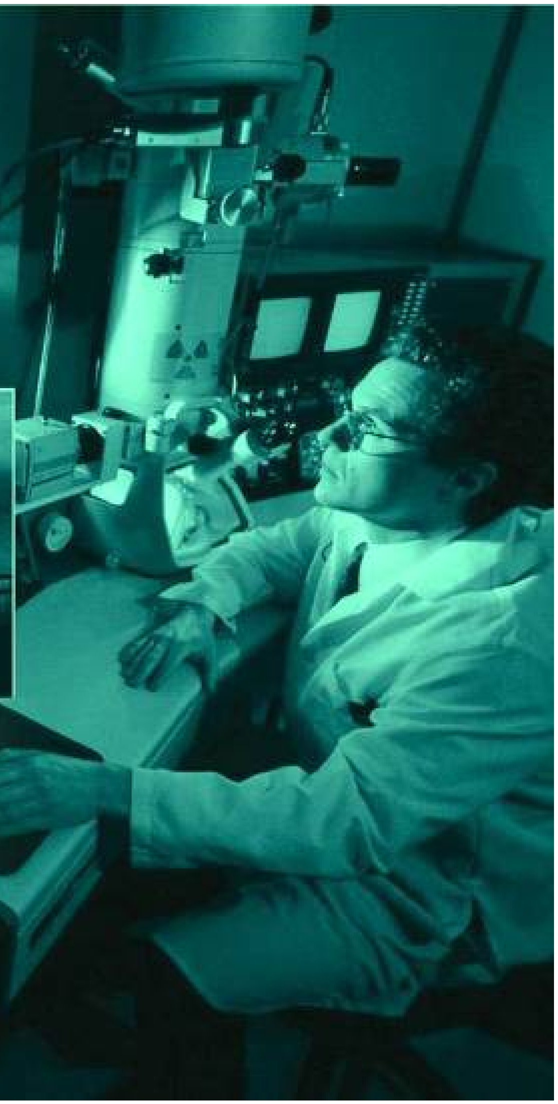
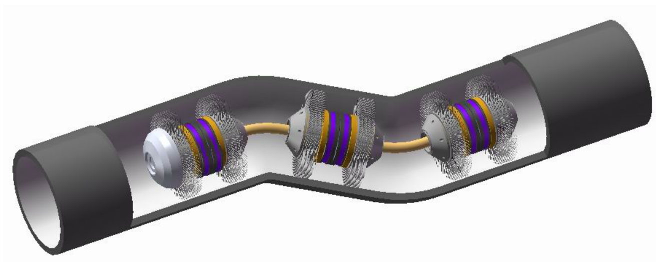
Increased Reliability & Reduced Risk



The Critical Link between Reliability and Safety Drives Global Acceptance of New Inspection Technologies for Fired Heaters

FTIS™ Design Advancements



1997 2000 2003 2006 2008

ONLY Eight (8) ***Single*** UT Transducers (1 - 15% Coverage) 384 Thickness Readings Per Linear Foot (Prototype → Gen-2)	Sixteen (16) ***Single*** UT Transducers (21 - 32% Coverage) 768 Thickness Readings Per Linear Foot (Gen-3 → Gen-5)	Thirty-Two (32) ***Single*** UT Transducers (31 - 63% Coverage) 1,536 Thickness Readings Per Linear Foot (Gen-3 → Gen-5)

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

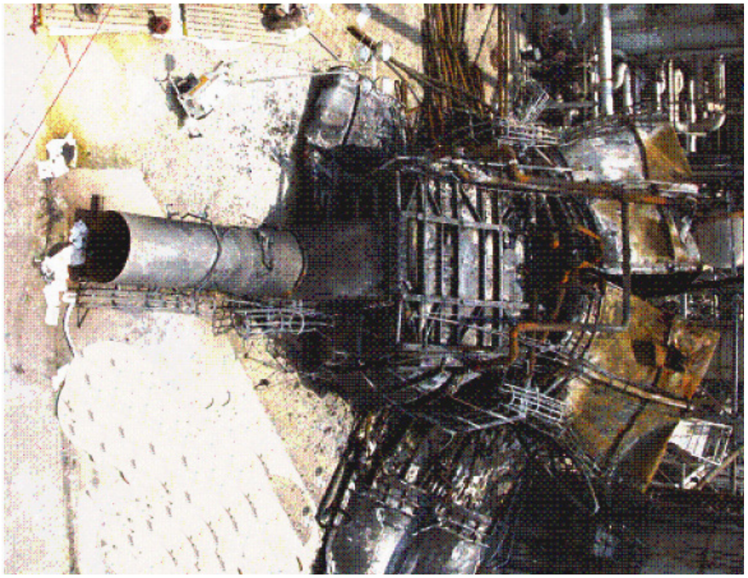
QUEST TRUTEC
Asset Longevity | Plant Performance

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*



QUEST TRUTEC
Asset Longevity | Plant Performance

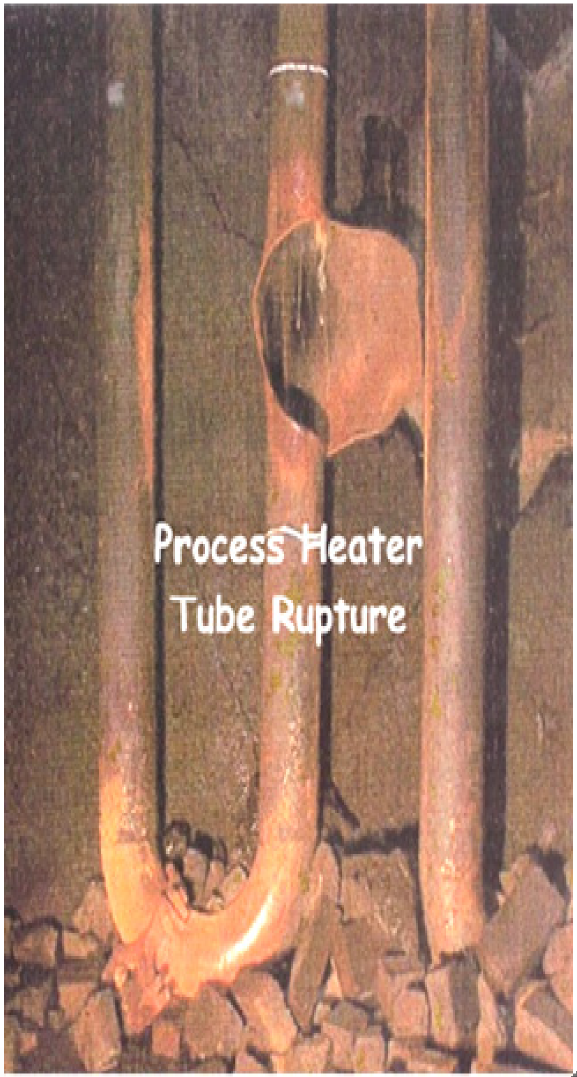
RDR3

Slide 3

RDR3 This is a "confidential" photo of the Header Delivery System.

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

RichR, 5/10/2006



Naphtha Hydrotreater

❑Pipe / Tube Wall Loss

- ✓Corrosion *(Int. or Ext.)*
- ✓Erosion *(Int. or Ext.)*
- ✓Pitting *(Int. or Ext.)* RDR4
- ✓Mechanical Damage *(Int. or Ext.)*

❑Deformation RDR5

- ✓Bulging *(i.e. Flame Impingement)*
- ✓Swelling *(i.e. Creep Strain)*
- ✓Denting
- ✓Ovality

RDR20 QUEST TRUTEC Asset Longevity | Plant Performance

Slide 4

RDR4 Mechanical Damage is sometimes caused during installation.

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

Some times these damages are in locations which can not be seen during routine visual inspections.
RichR, 5/10/2006

RDR5 Deformation or "Pipe Shape Change"
RichR, 5/10/2006

RDR20 This photo is of a NAPTHA HYDROTREATER

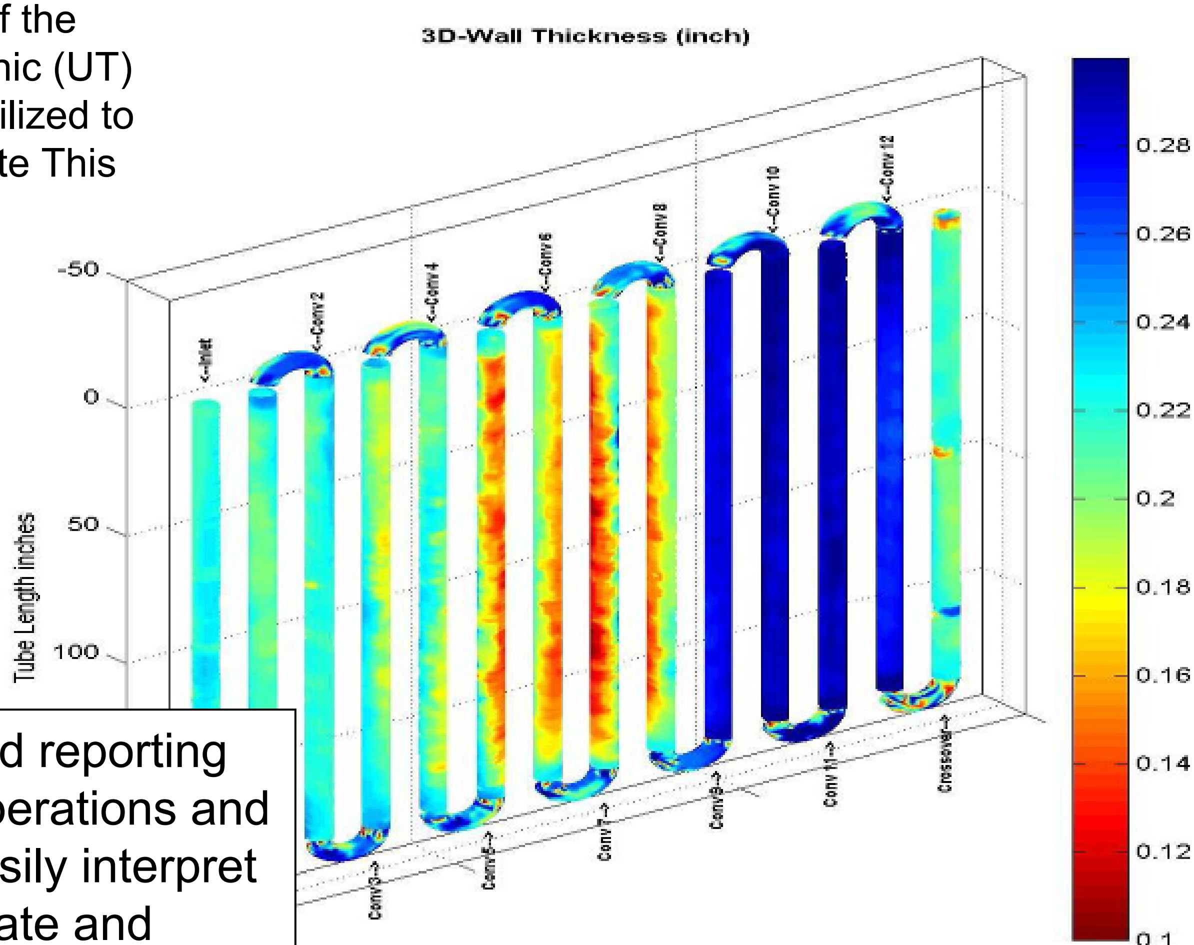
Make sure to point this out as Naptha Hydrotreater furances are often overlooked in refineries and should be considered a "HIGH PRIORITY"

(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.
RichR, 5/10/2006

3D Modeling of FULL Serpentine Coil

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

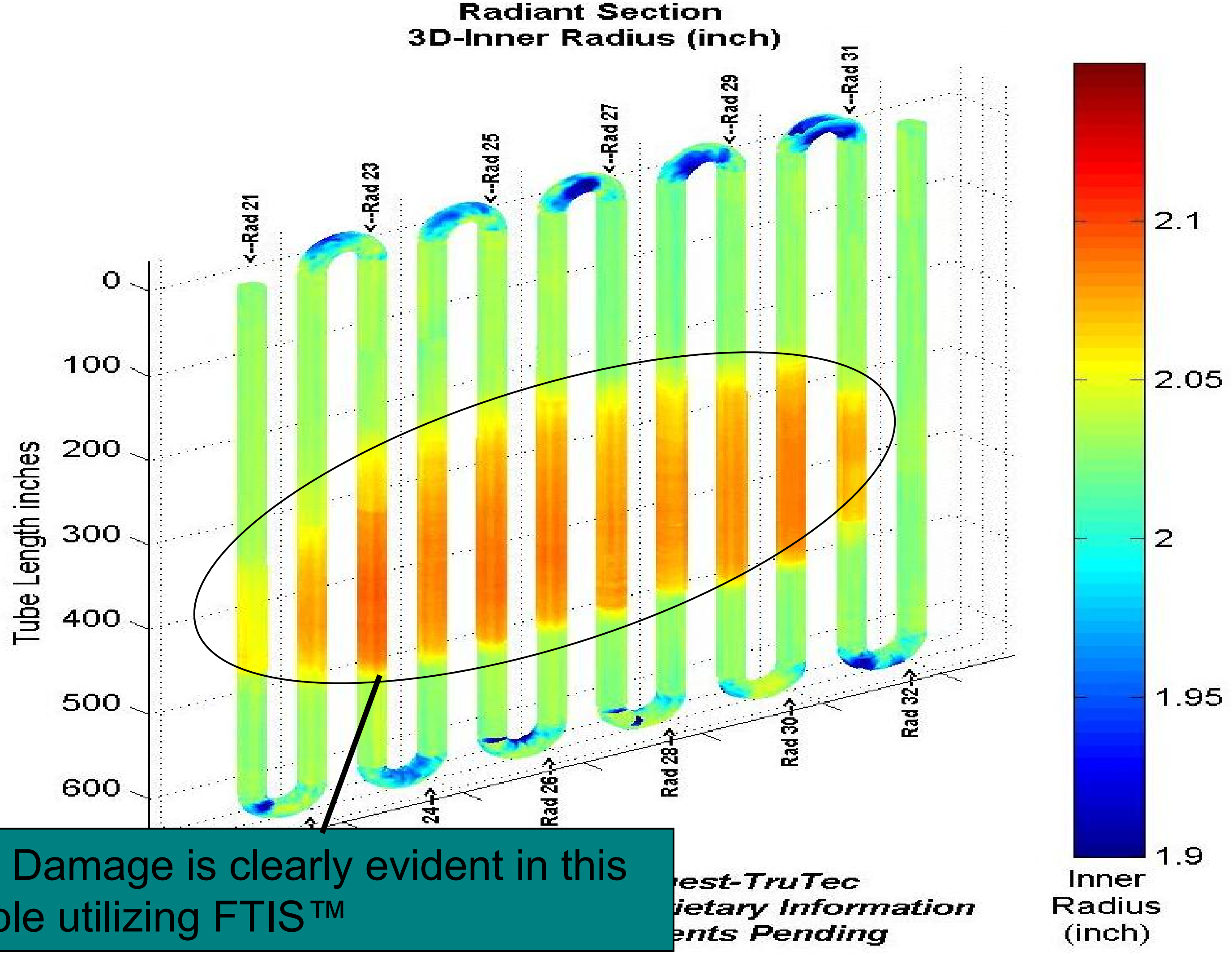


3D modeling and reporting options allow operations and inspection to easily interpret data for immediate and accurate corrective actions

Quest TruTec Proprietary Information Patents Pending

Wall Thickness (In)

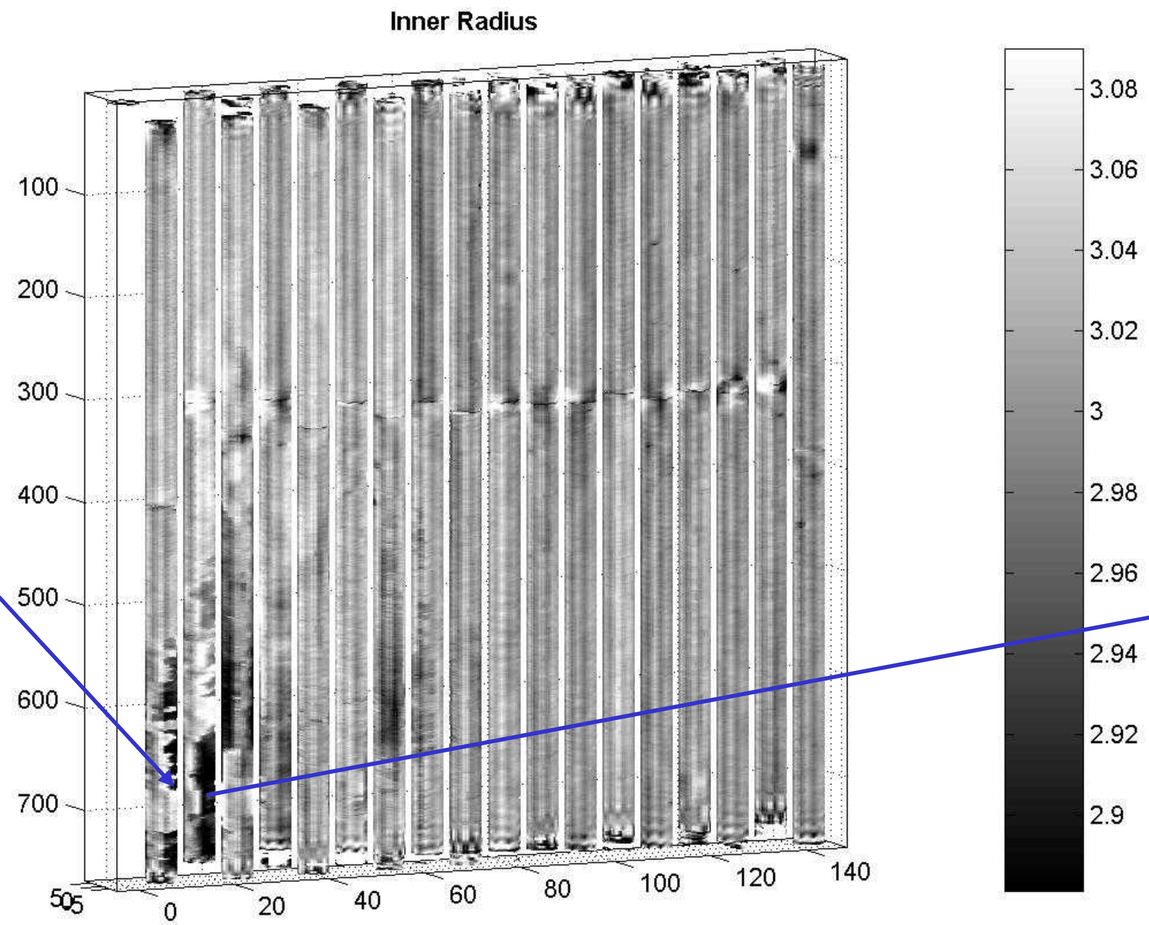
3D Modeling of FULL Serpentine Coil



Creep Damage is clearly evident in this example utilizing FTIS™

DeCoking Quality Control / Quality Assurance

Coke



Cut Out Pipe Section w/ Coke

QUEST TRUTEC
Asset Longevity | Plant Performance

RDR8

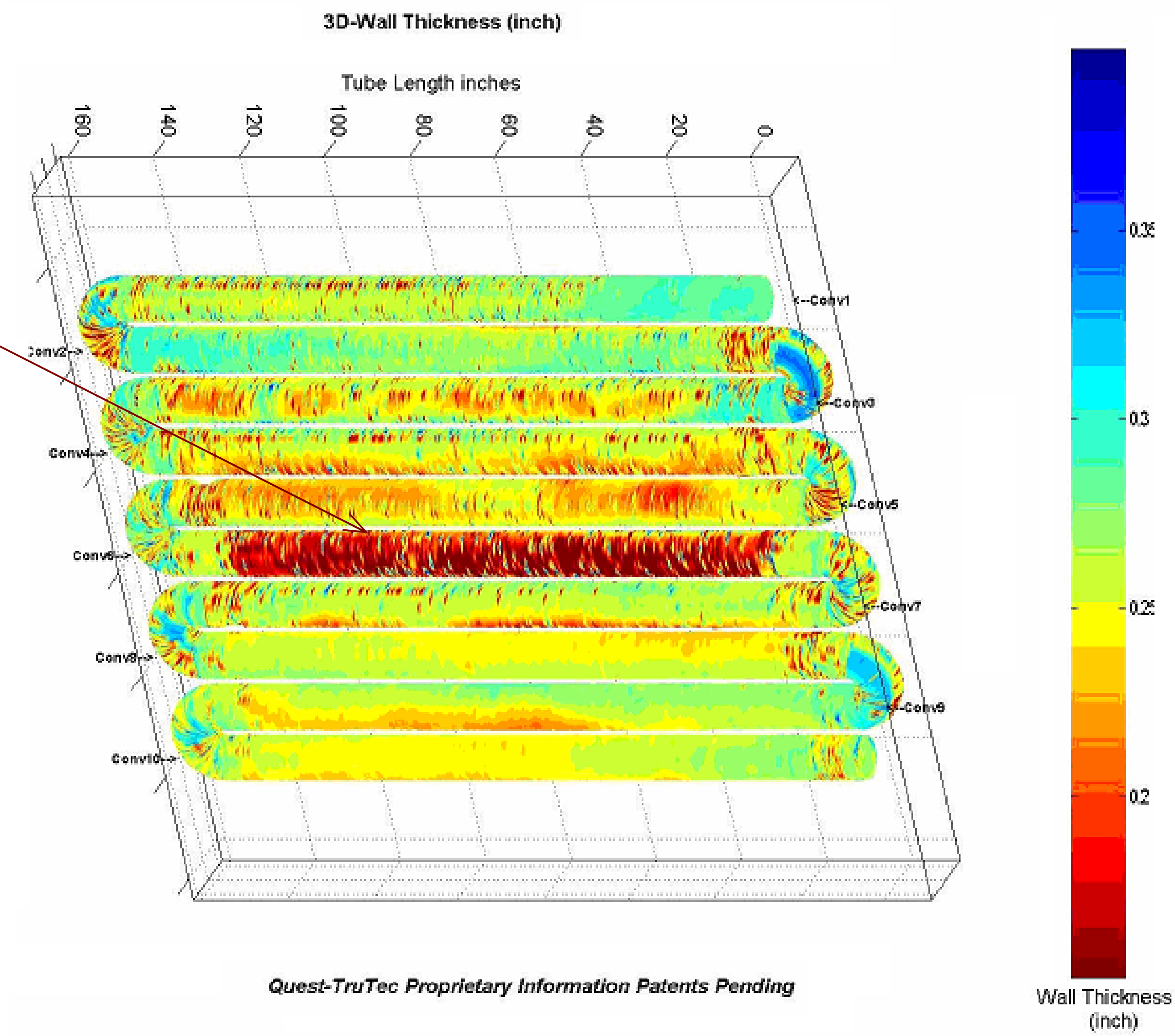
RDR8 Capability of flipping 3D plot to Grey Scale to assist mechanical decoking companies with understanding data.

Note coke on ID of tube in numerous locations

Photo is of a tube removed from a heater directly after FTIS inspection.
RichR, 5/10/2006

Corrosion (Convection Section)

Corrosion Damage



QUEST TRUTEC Asset Longevity | Plant Performance

RDR33

Slide 8

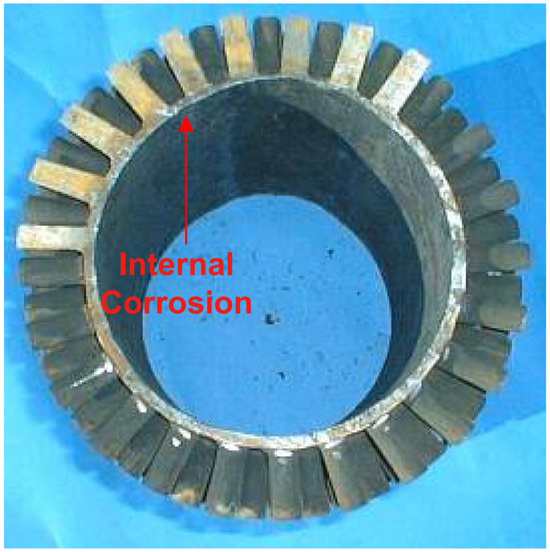
RDR33 Corrosion damage in the "CONVECTION" section of a heater coils is UNDETECTABLE by any other means besides FTIS.

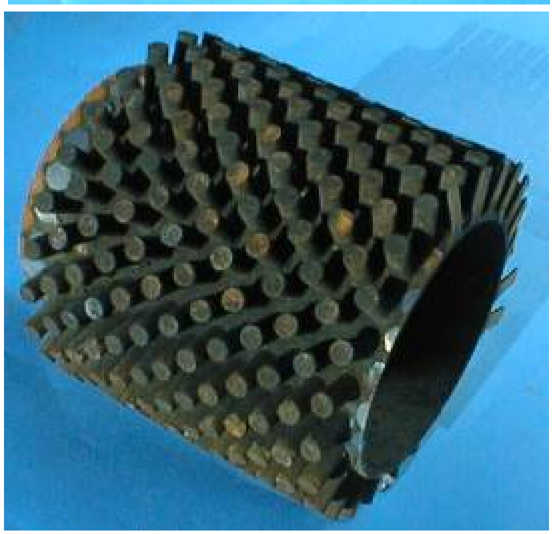
This image should be leveraged off of to justify cost of carrying out inspection with FTIS technology.

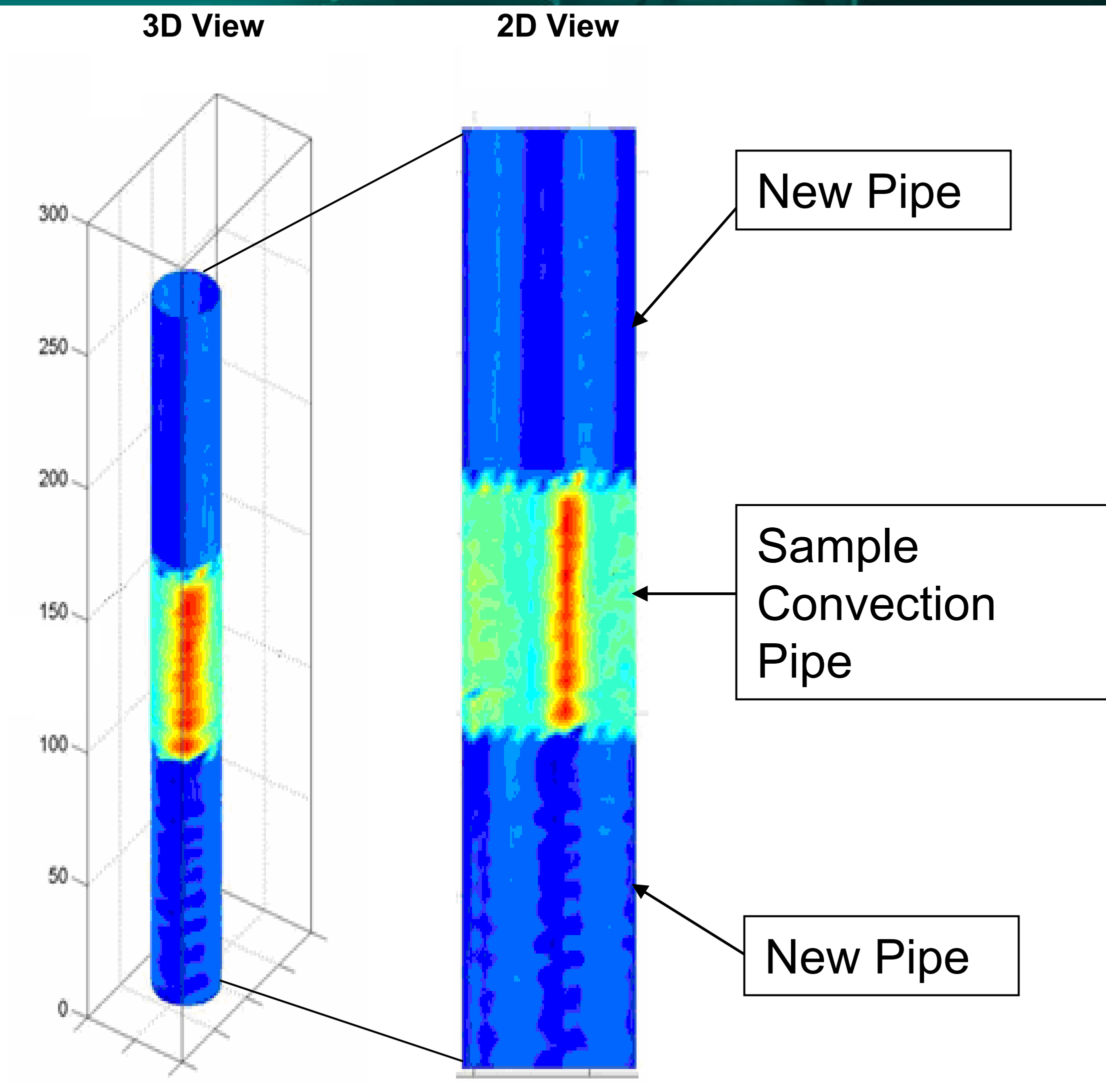
One heater failure will cost hundreds of thousands of dollars, while FTIS may only cost between $25k - $50k.

RichR, 5/10/2006

External Studded or Finned Surfaces



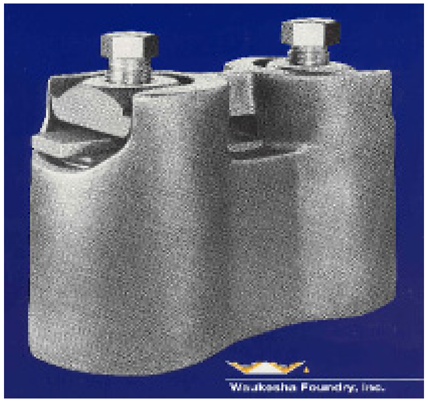


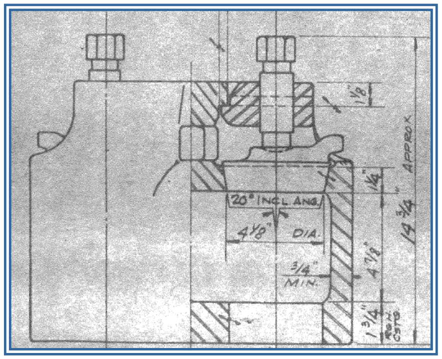


Quest TruTec Proprietary Information

QUEST TRUTEC
Asset Longevity | Plant Performance

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)

Slide 10

RDR13 FTIS currently cannot get through plugged headers (also commonly referred too as Mule Ears)

We can apply LOTIS to inspect plugged headers

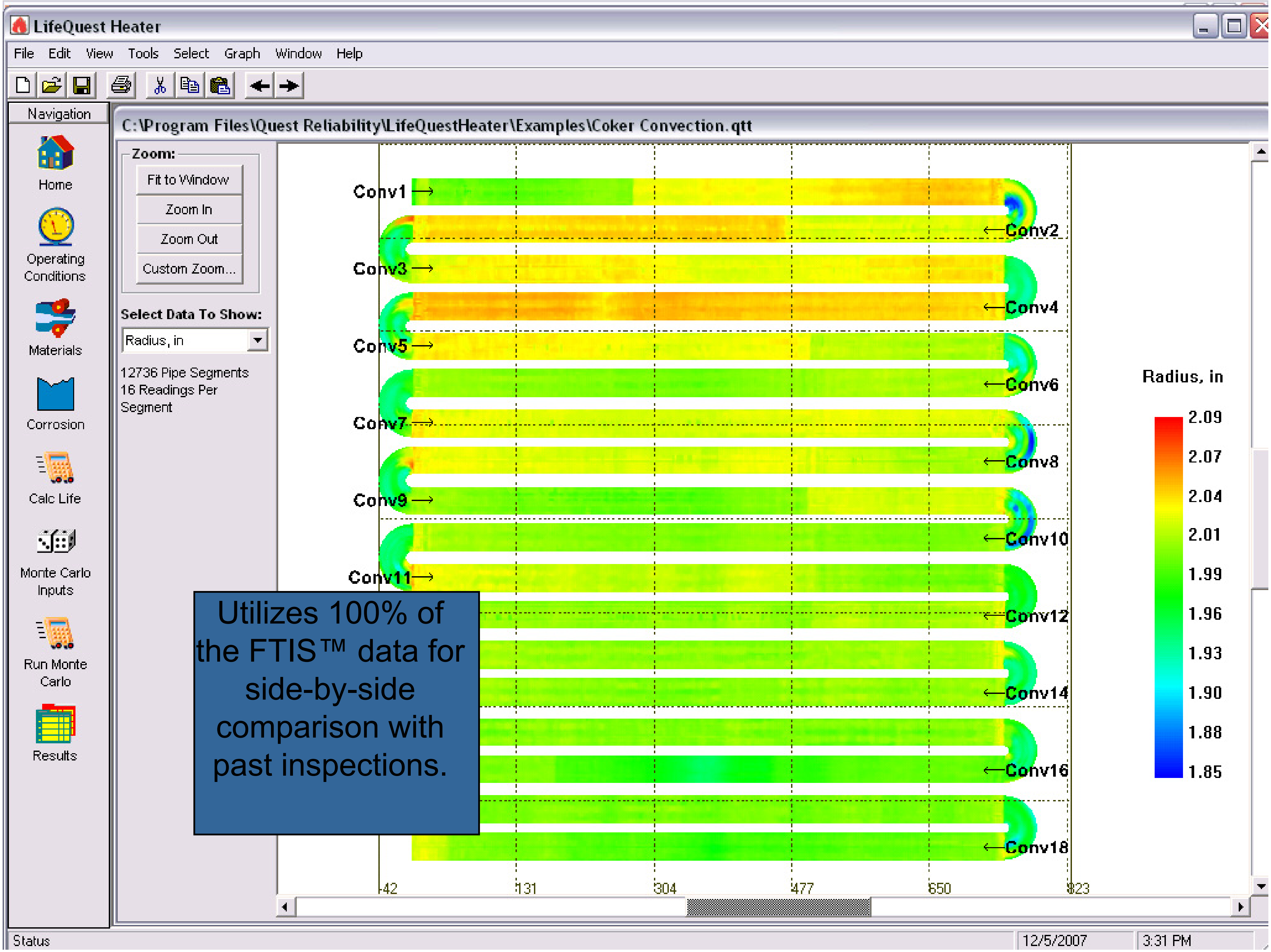
Have carried out several inspections to date with LOTIS
RichR, 5/10/2006

LifeQuest™ Heater Overview

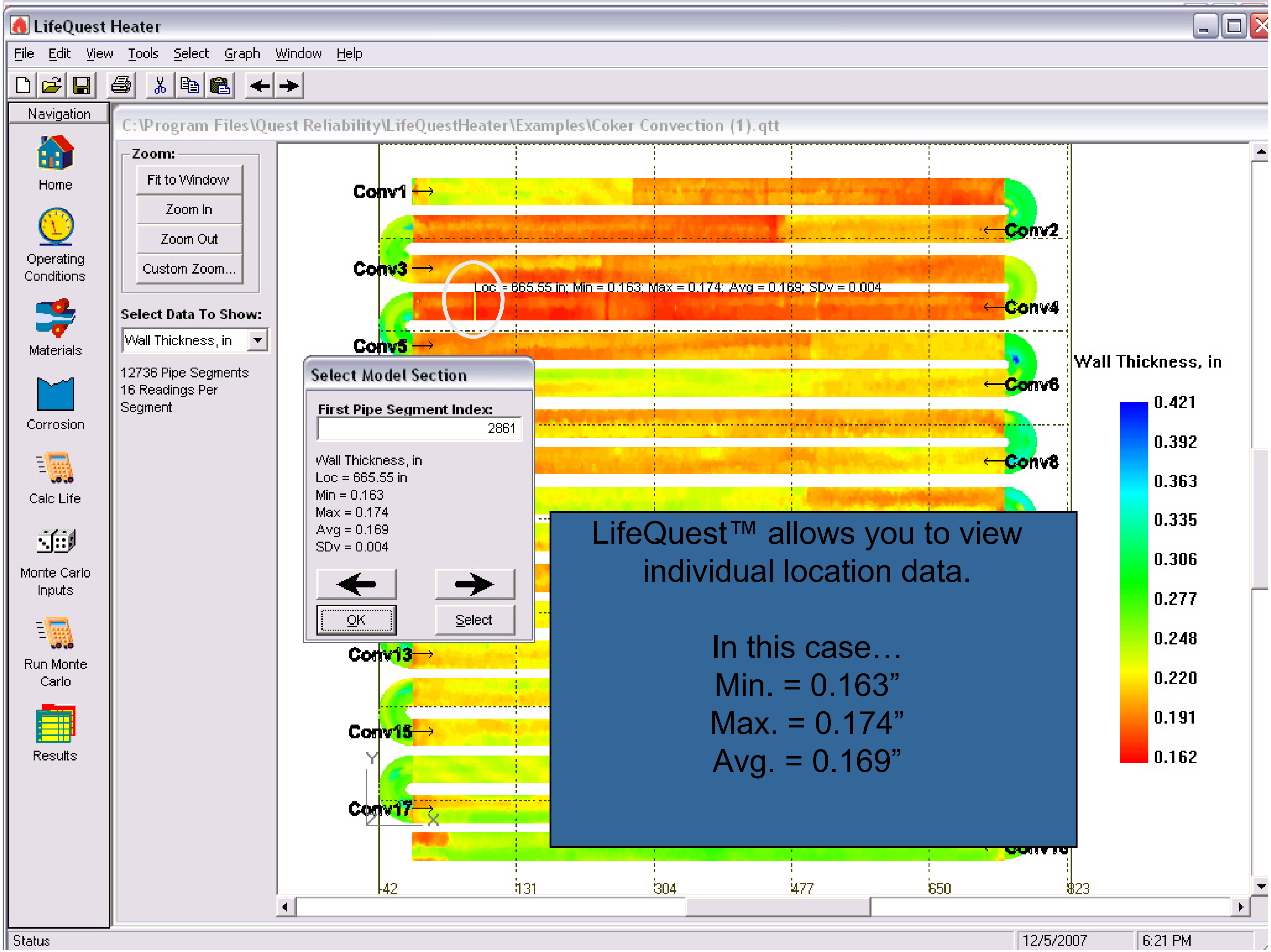
- Clients demanded the ability to use FTIS™ and LOTIS® data to make decisions concerning safe and reliable operations.
- What clients asked for:
  - Remaining Life Assessment within Turnaround
  - Utilization of historical data
  - Compare data sets
  - Assess risk versus time to help with turnaround 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



LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
C:\Program Files\Quest Reliability\LifeQuestHeater\Examples\Coker Convection.qtt
Zoom:
Fit to Window
Zoom In
Zoom Out
Custom Zoom...
Select Data To Show:
Radius, in
12736 Pipe Segments
16 Readings Per Segment
Conv1
Conv2
Conv3
Conv4
Conv5
Conv6
Conv7
Conv8
Conv9
Conv10
Conv11
Conv12
Conv14
Conv16
Conv18
-42
131
304
477
650
823
Radius, in
2.09
2.07
2.04
2.01
1.99
1.96
1.93
1.90
1.88
1.85
Status
12/5/2007
3:31 PM
Utilizes 100% of the FTIS™ data for side-by-side comparison with past inspections.



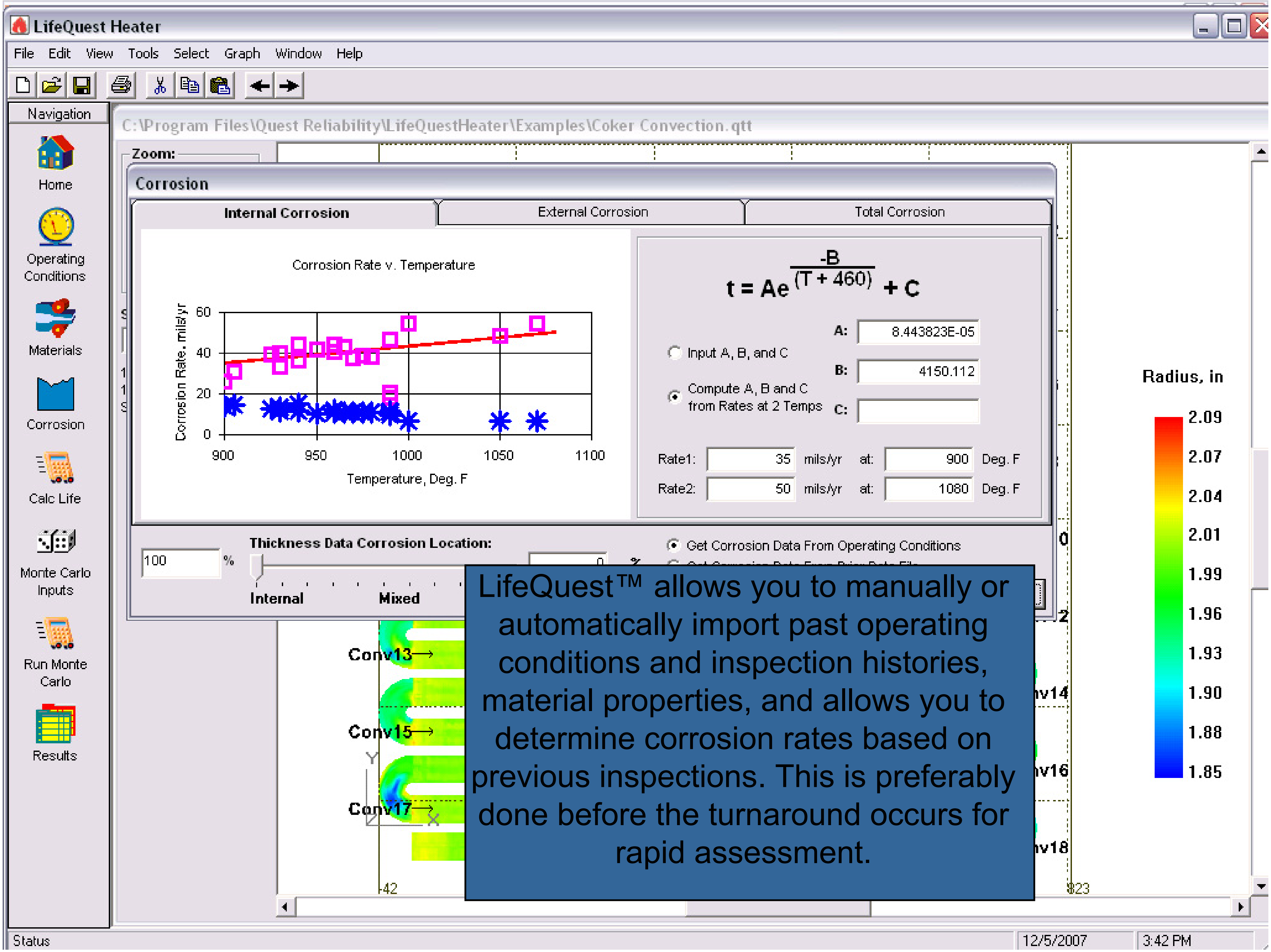
LifeQuest™ allows you to view individual location data.

In this case…

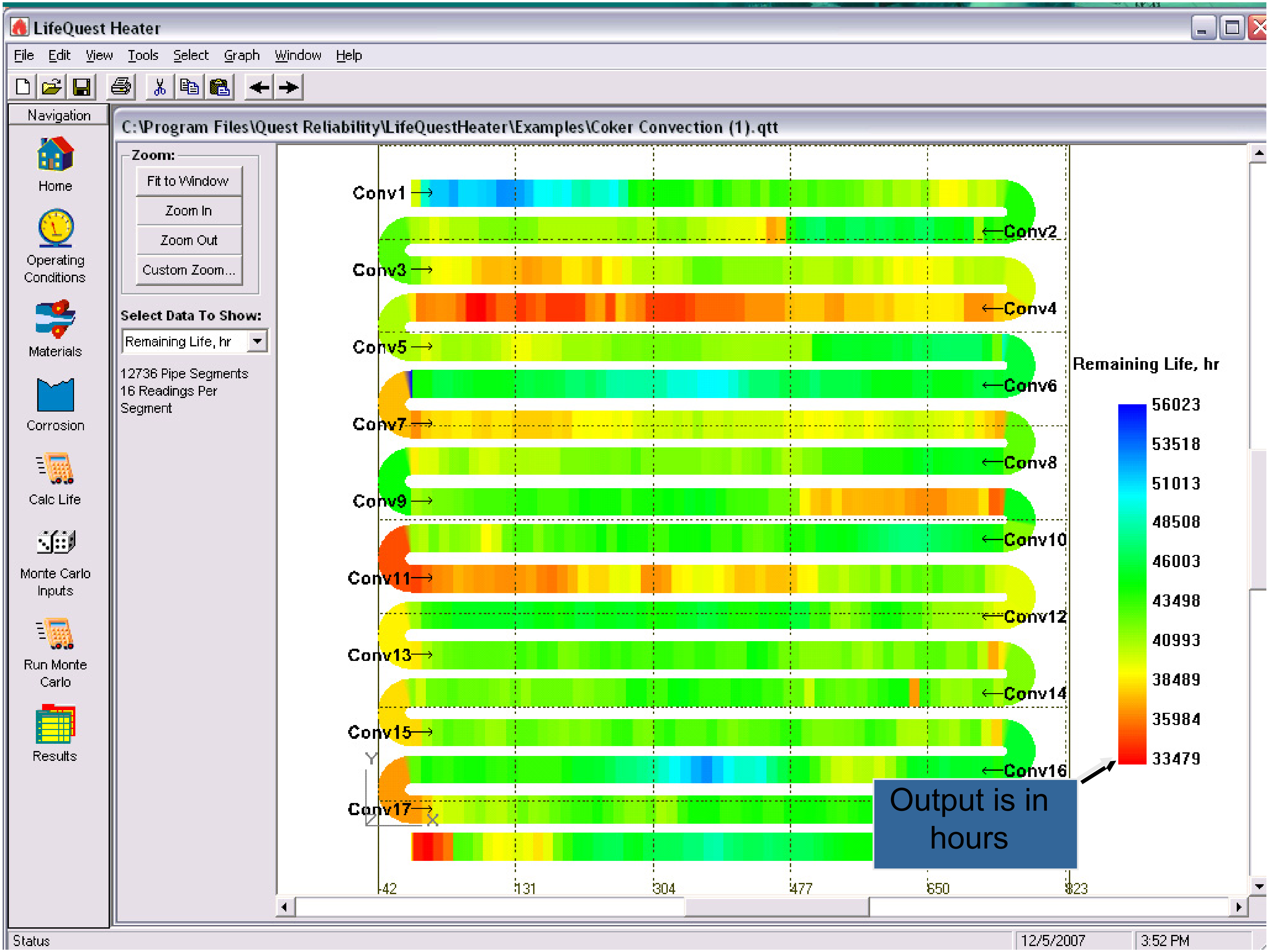
Min. = 0.163”

Max. = 0.174”

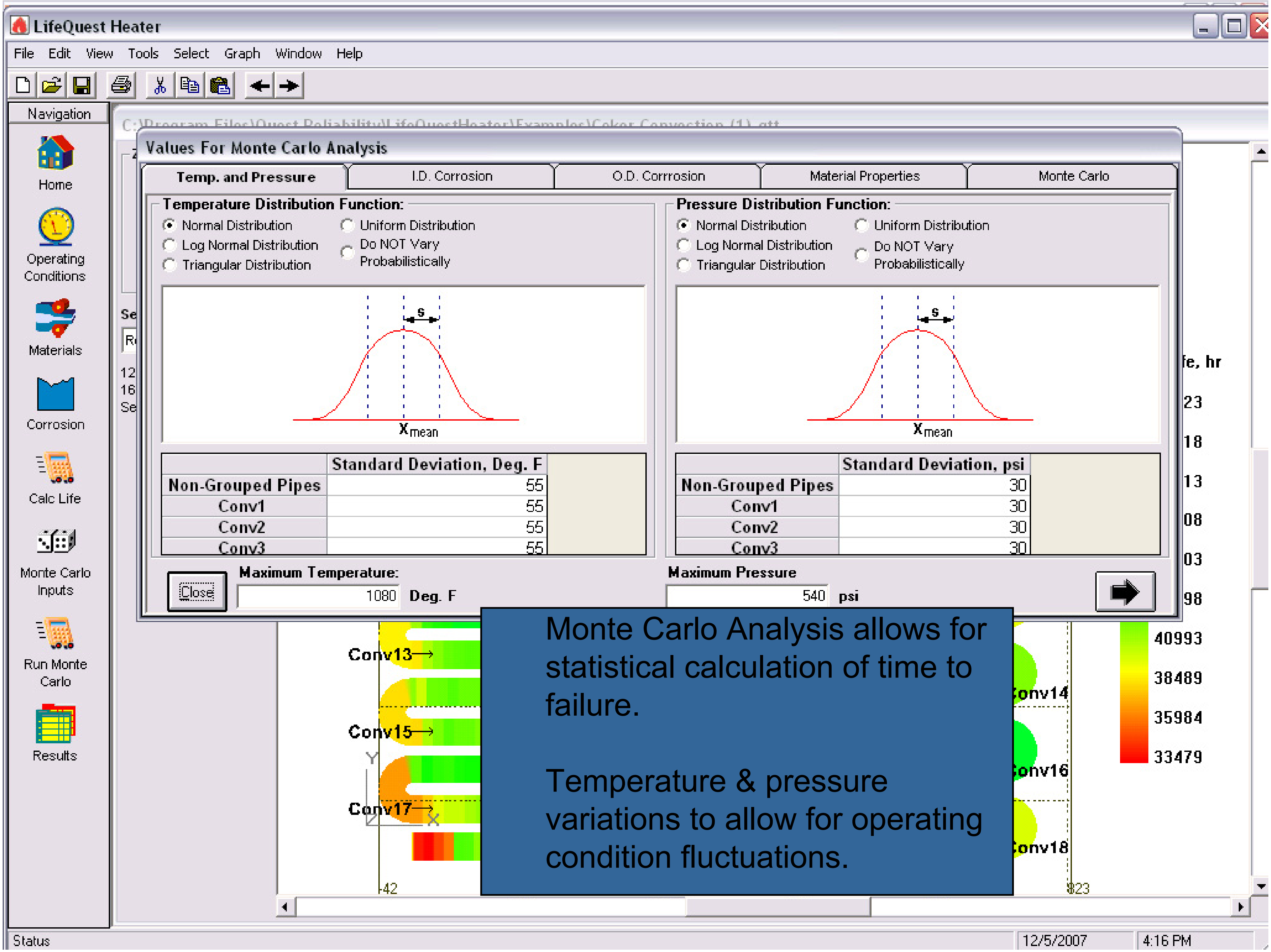
Avg. = 0.169”



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.

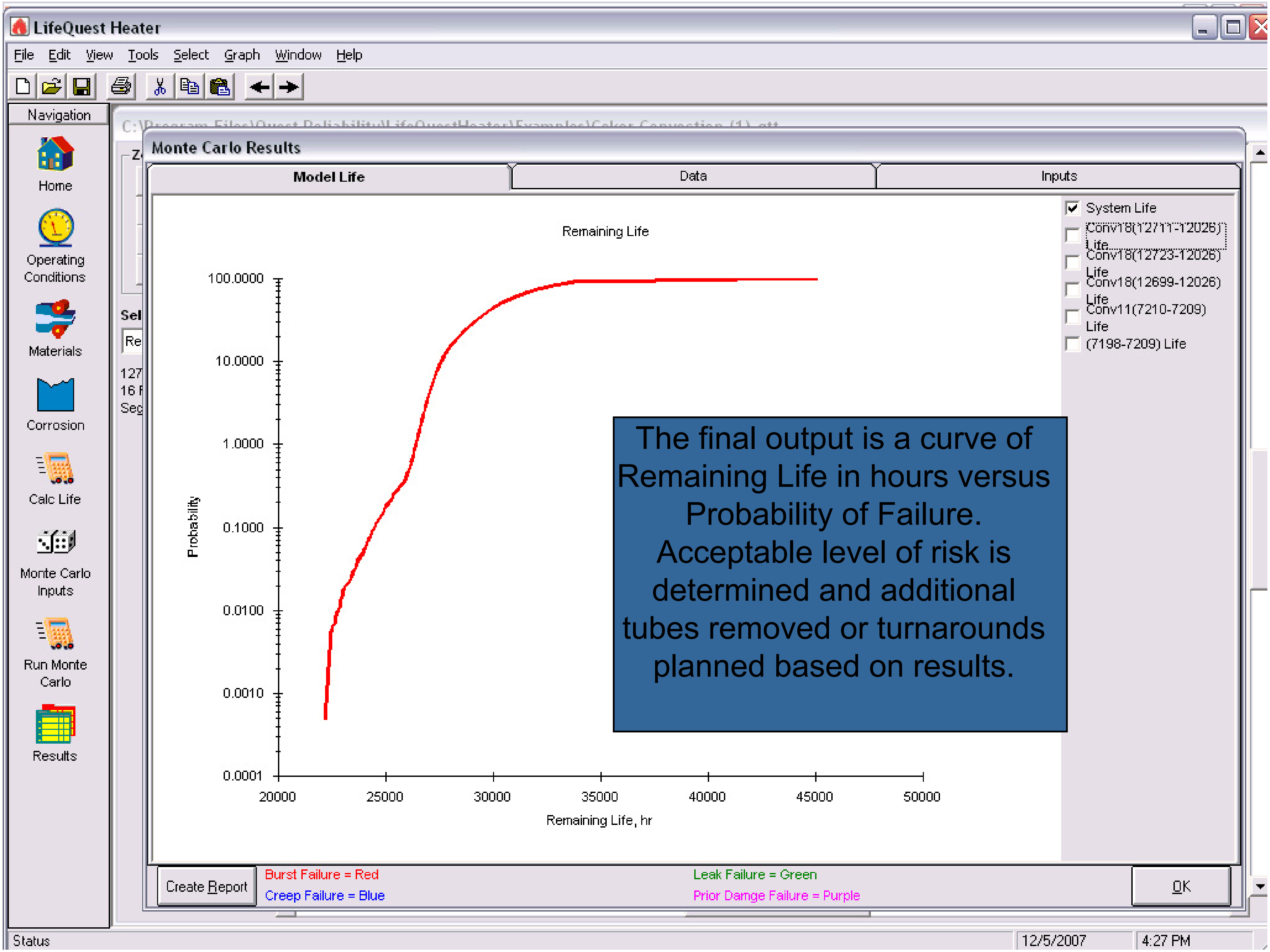


LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
C:\Program Files\Quest Reliability\LifeQuestHeater\Examples\Coker Convection (1).qtt
Zoom:
Fit to Window
Zoom In
Zoom Out
Custom Zoom...
Select Data To Show:
Remaining Life, hr
12736 Pipe Segments
16 Readings Per Segment
Conv1
Conv2
Conv3
Conv4
Conv5
Conv6
Conv7
Conv8
Conv9
Conv10
Conv11
Conv12
Conv13
Conv14
Conv15
Conv16
Conv17
42
131
304
477
650
823
Remaining Life, hr
56023
53518
51013
48508
46003
43498
40993
38489
35984
33479
Output is in hours
Status
12/5/2007
3:52 PM



Monte Carlo Analysis allows for statistical calculation of time to failure.

Temperature & pressure variations to allow for operating condition fluctuations.

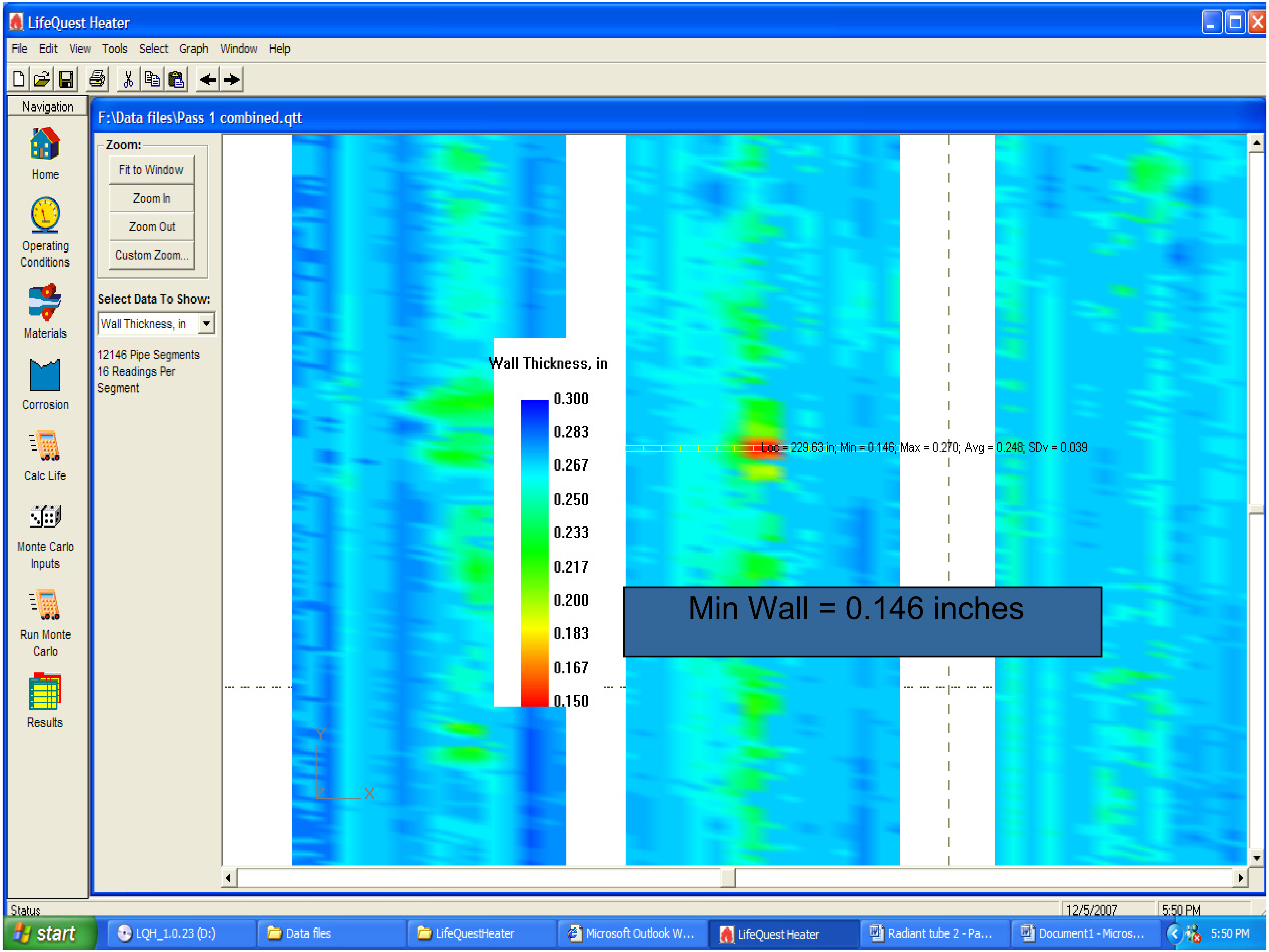


The final output is a curve of Remaining Life in hours versus Probability of Failure. Acceptable level of risk is determined and additional tubes removed or turnarounds planned based on results.

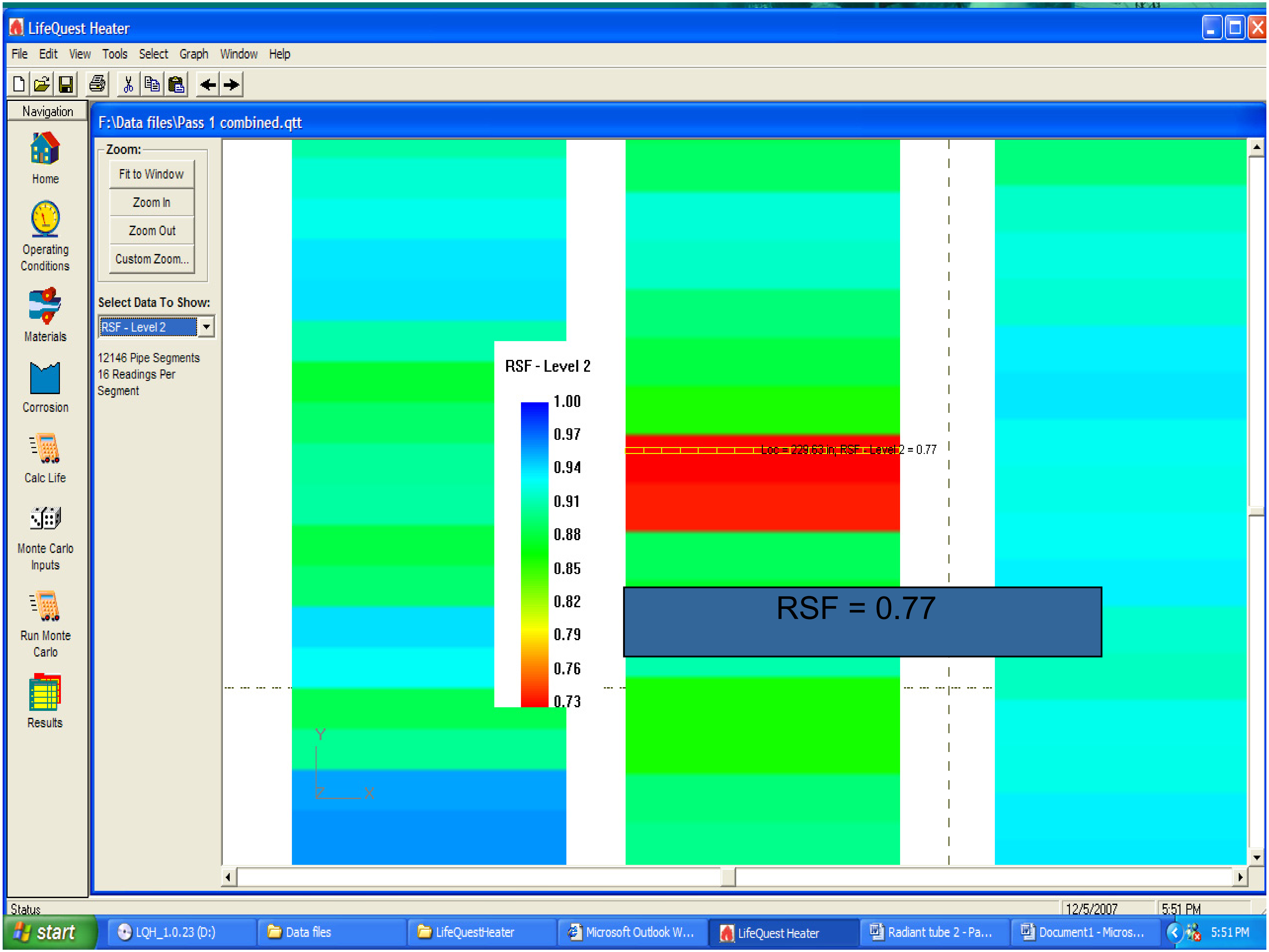
Case Study – Local Corrosion

Case Study

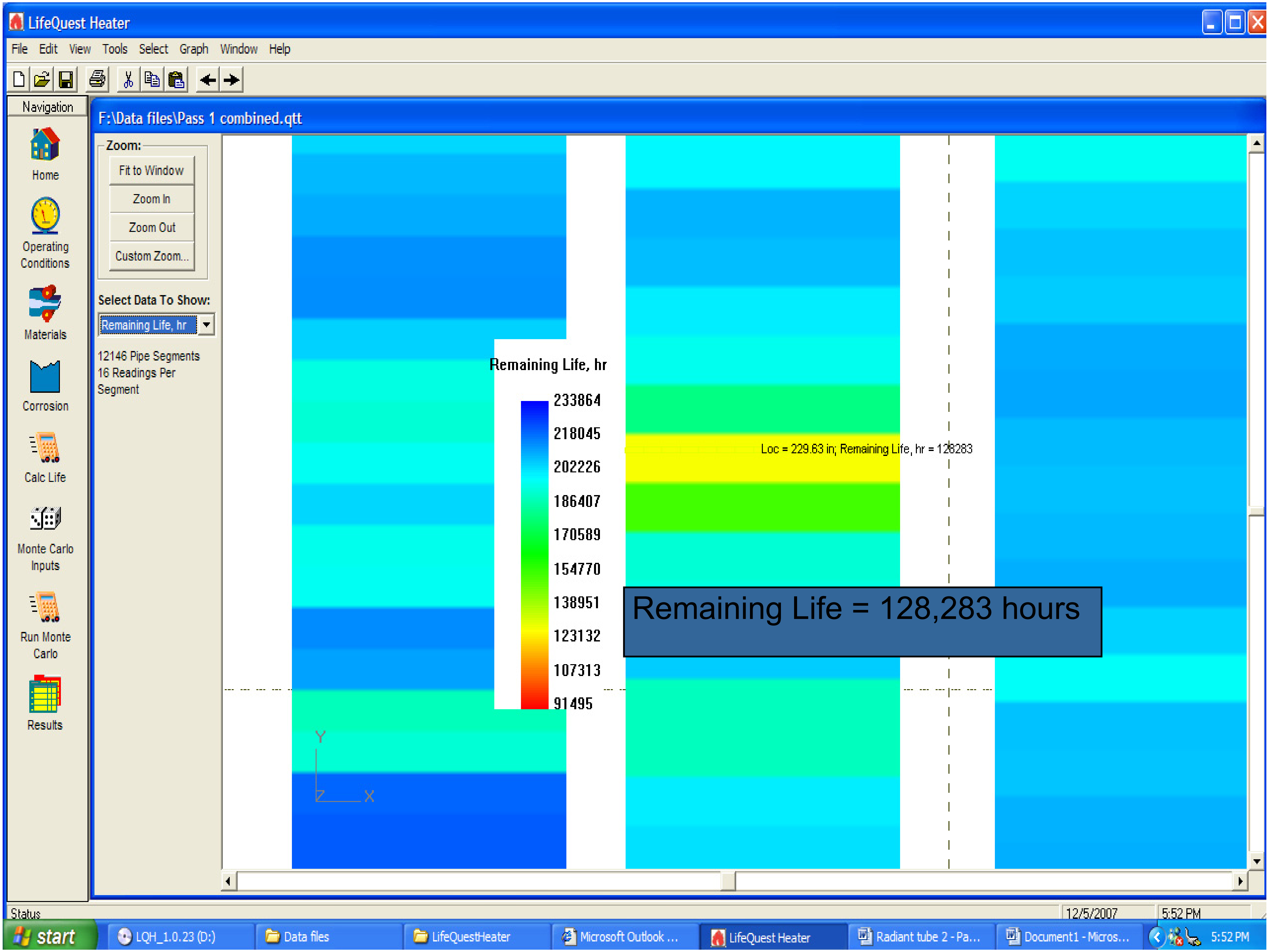
Local Corrosion

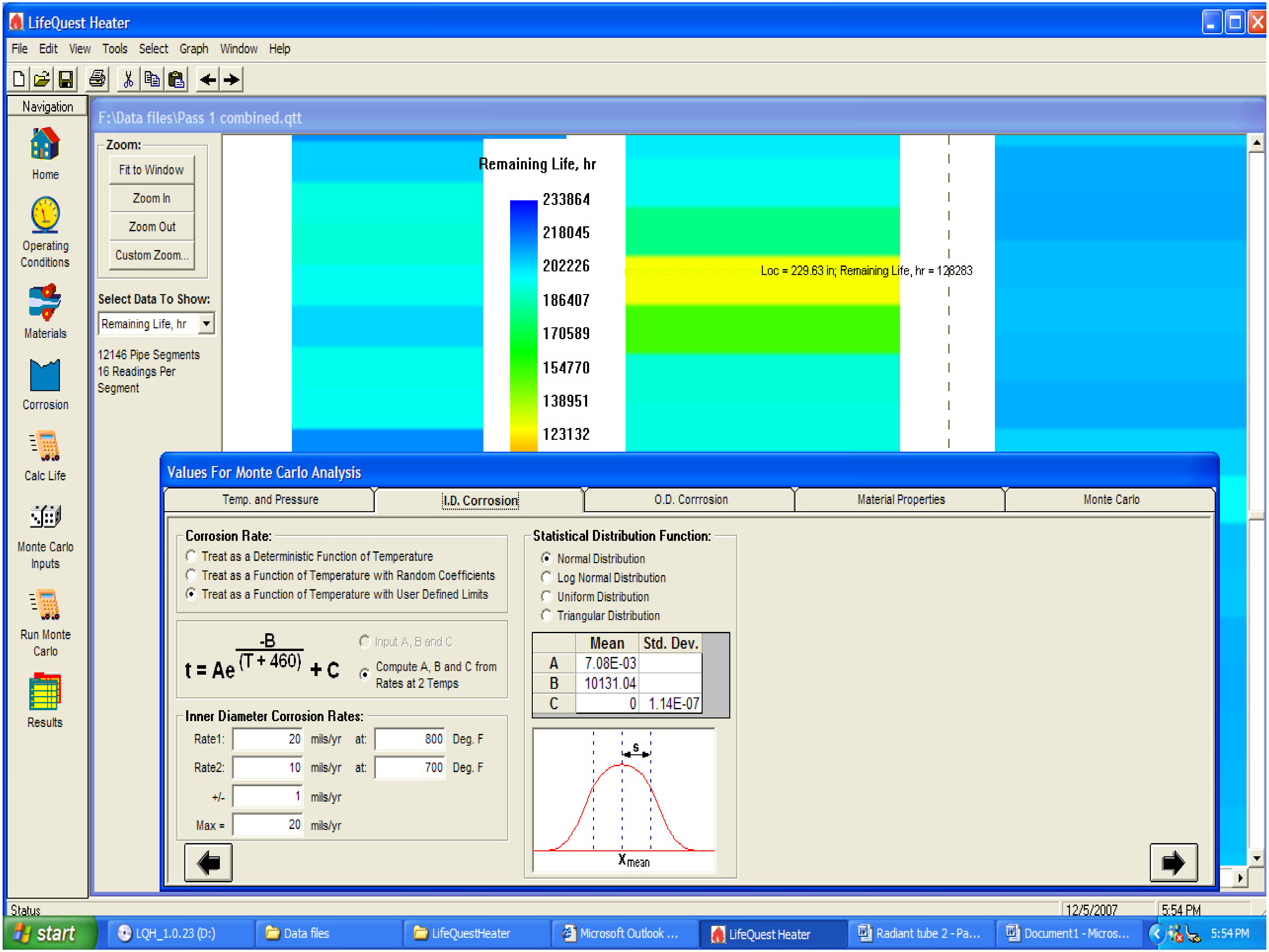


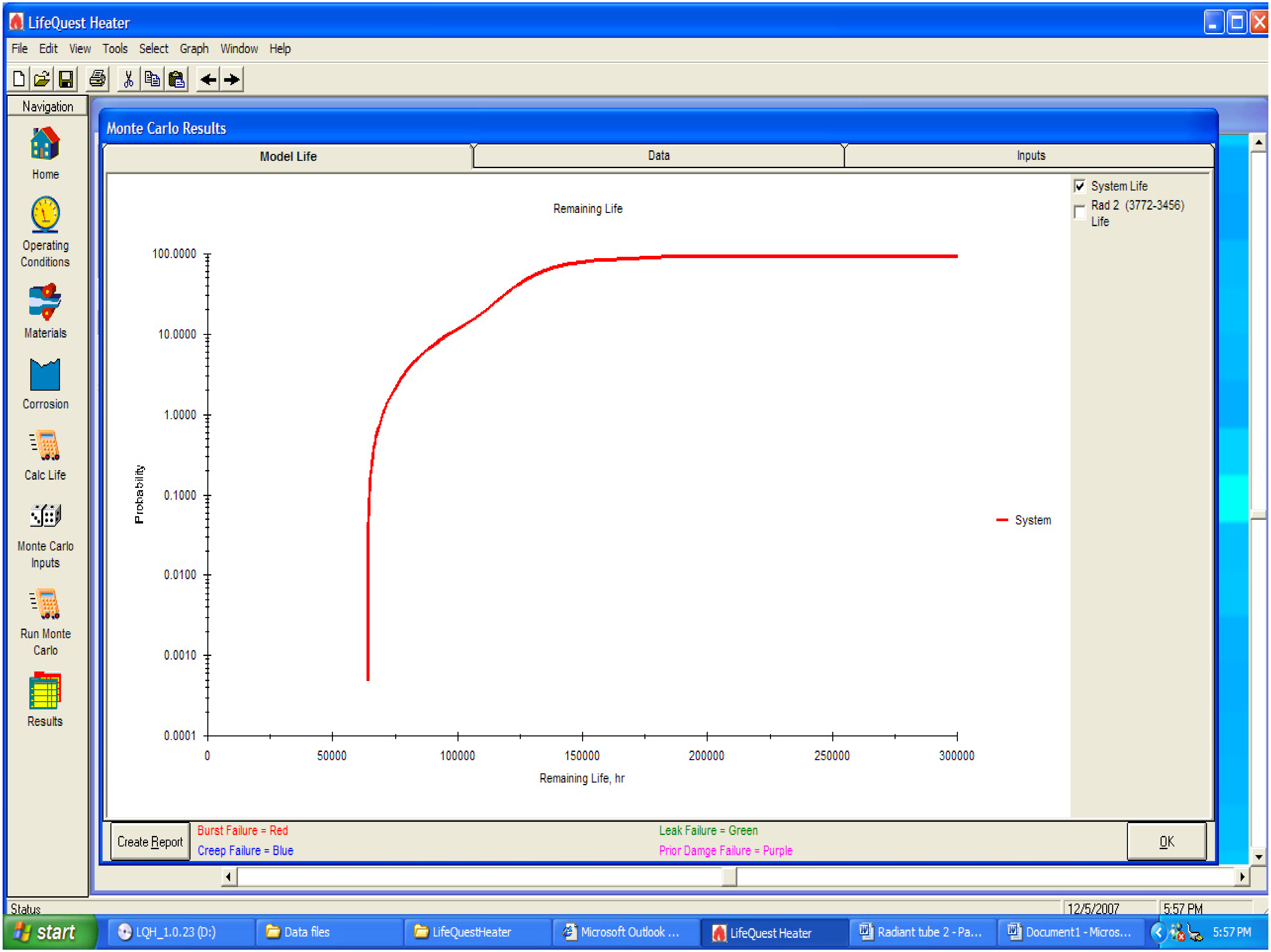
LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
F:\Data files\Pass 1 combined.qtt
Zoom:
Fit to Window
Zoom In
Zoom Out
Custom Zoom...
Select Data To Show:
Wall Thickness, in
12146 Pipe Segments
16 Readings Per Segment
Wall Thickness, in
0.300
0.283
0.267
0.250
0.233
0.217
0.200
0.183
0.167
0.150
Loc = 229.63 in; Min = 0.146; Max = 0.270; Avg = 0.248; SDv = 0.039
Min Wall = 0.146 inches
Y
X
Status
12/5/2007
5:50 PM
start
LQH_1.0.23 (D:)
Data files
LifeQuestHeater
Microsoft Outlook W...
LifeQuest Heater
Radiant tube 2 - Pa...
Document1 - Micros...
5:50 PM



LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
F:\Data files\Pass 1 combined.qtt
Zoom:
Fit to Window
Zoom In
Zoom Out
Custom Zoom...
Select Data To Show:
RSF - Level 2
12146 Pipe Segments
16 Readings Per Segment
RSF - Level 2
1.00
0.97
0.94
0.91
0.88
0.85
0.82
0.79
0.76
0.73
Loc = 229.63 in, RSF - Level 2 = 0.77
RSF = 0.77
Status
12/5/2007
5:51 PM
start
LQH_1.0.23 (D:)
Data files
LifeQuestHeater
Microsoft Outlook W...
LifeQuest Heater
Radiant tube 2 - Pa...
Document1 - Micros...
5:51 PM


LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
F:\Data files\Pass 1 combined.qtt
Zoom:
Fit to Window
Zoom In
Zoom Out
Custom Zoom...
Select Data To Show:
Remaining Life, hr
12146 Pipe Segments
16 Readings Per Segment
Remaining Life, hr
233864
218045
202226
186407
170589
154770
138951
123132
107313
91495
Loc = 229.63 in; Remaining Life, hr = 128283
Remaining Life = 128,283 hours
Y
X
Z
Status
12/5/2007
5:52 PM
start
LQH_1.0.23 (D:)
Data files
LifeQuestHeater
Microsoft Outlook ...
LifeQuest Heater
Radiant tube 2 - Pa...
Document1 - Micros...
5:52 PM


LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
F:\Data files\Pass 1 combined.qtt
Zoom:
Fit to Window
Zoom In
Zoom Out
Custom Zoom...
Select Data To Show:
Remaining Life, hr
12146 Pipe Segments
16 Readings Per Segment
Remaining Life, hr
233864
218045
202226
186407
170589
154770
138951
123132
Loc = 229.63 in; Remaining Life, hr = 128283
Values For Monte Carlo Analysis
Temp. and Pressure
I.D. Corrosion
O.D. Corrosion
Material Properties
Monte Carlo
Corrosion Rate:
Treat as a Deterministic Function of Temperature
Treat as a Function of Temperature with Random Coefficients
Treat as a Function of Temperature with User Defined Limits
$t = Ae^{\frac{-B}{(T+460)}} + C$
Input A, B and C
Compute A, B and C from Rates at 2 Temps
Inner Diameter Corrosion Rates:
Rate1: 20 mils/yr at: 800 Deg. F
Rate2: 10 mils/yr at: 700 Deg. F
+/- 1 mils/yr
Max = 20 mils/yr
Statistical Distribution Function:
Normal Distribution
Log Normal Distribution
Uniform Distribution
Triangular Distribution
Mean
Std. Dev.
A 7.08E-03
B 10131.04
C 0 1.14E-07
s
Xmean
Status
12/5/2007
5:54 PM
start
LQH_1.0.23 (D:)
Data files
LifeQuestHeater
Microsoft Outlook ...
LifeQuest Heater
Radiant tube 2 - Pa...
Document1 - Micros...
5:54 PM


LifeQuest Heater
File Edit View Tools Select Graph Window Help
Navigation
Home
Operating Conditions
Materials
Corrosion
Calc Life
Monte Carlo Inputs
Run Monte Carlo
Results
Monte Carlo Results
Model Life
Data
Inputs
Remaining Life
Probability
Remaining Life, hr
System
System Life
Rad 2 (3772-3456) Life
Create Report
Burst Failure = Red
Creep Failure = Blue
Leak Failure = Green
Prior Damge Failure = Purple
OK
Status
12/5/2007
5:57 PM

FTIS Case Study

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.

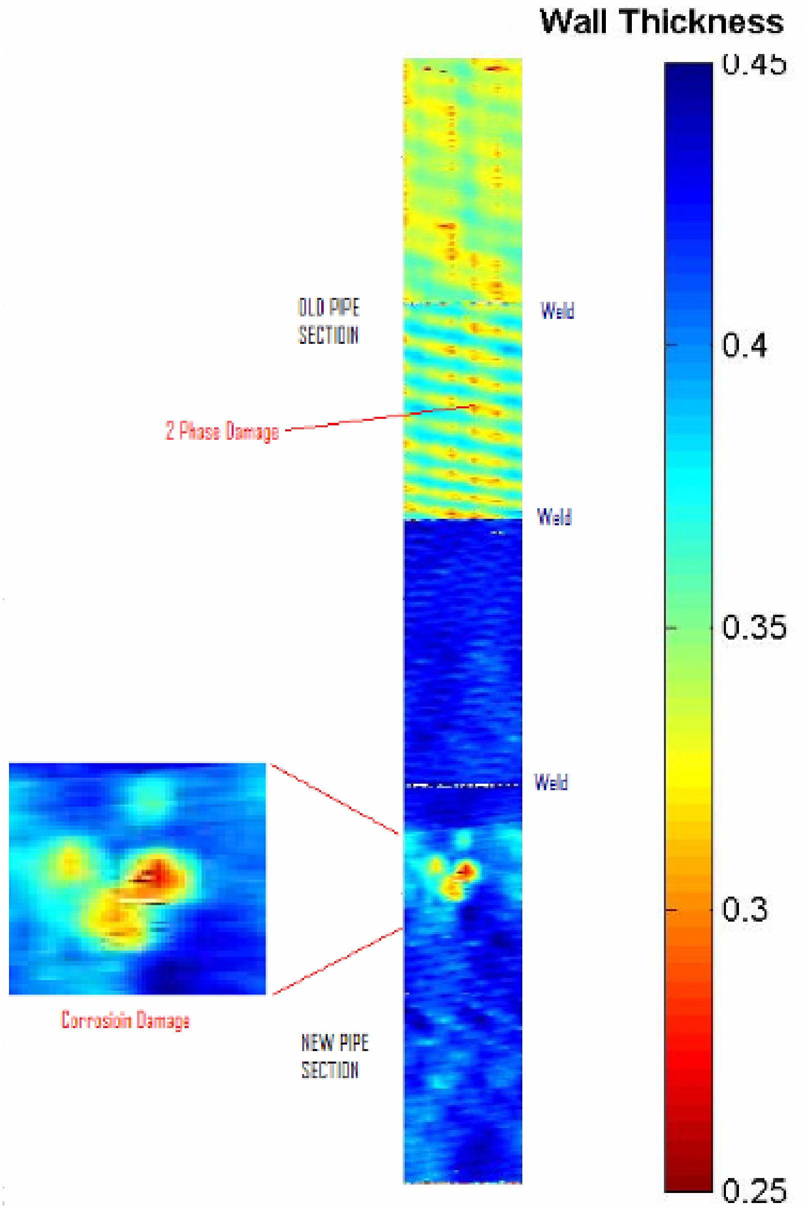
QUEST TRUTEC
Asset Longevity | Plant Performance

RDR21

Slide 25

RDR21 I usually just read each of the bullet points
RichR, 5/10/2006

Case Study #1 Isolated Corrosion Damage



QUEST TRUTEC
Asset Longevity | Plant Performance
RDR22

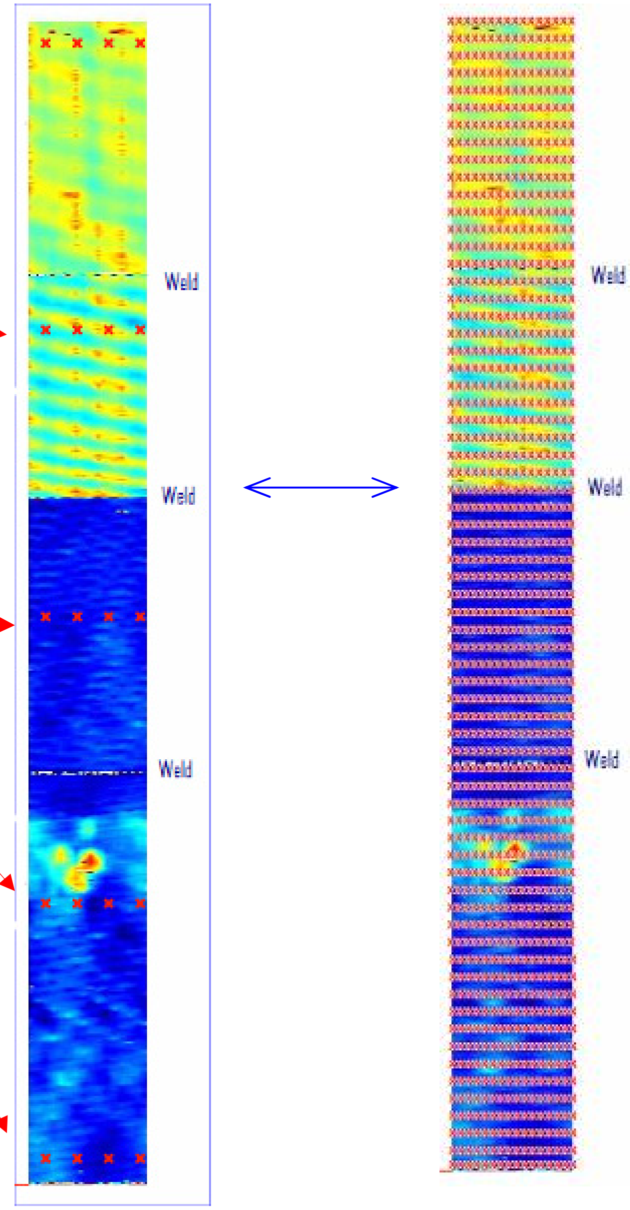
Slide 26

RDR22 2D plot shows the 95% through wall corroded area.

Only 5% wall remaining in NEW pipe section were "Corrosion Damage" zoom in is located.
RichR, 5/10/2006

Case Study #1 Inspection Method Comparison

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



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

QUEST TRUTEC
Asset Longevity | Plant Performance

RDR23

Slide 27

RDR23 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
RichR, 5/10/2006

Case Study #2

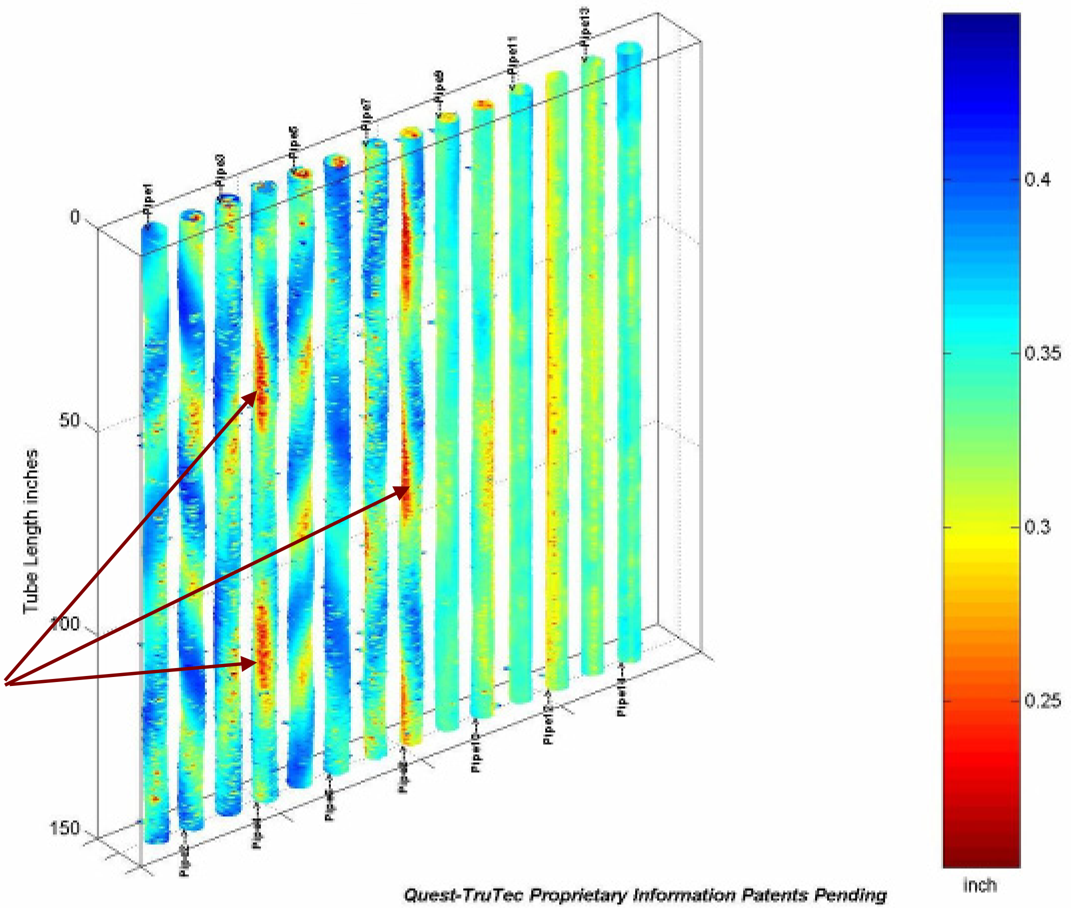
CRUDE FURNACE

- 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.

QUEST TRUTEC
Asset Longevity | Plant Performance

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

General internal wall thinning patterns in convection section pipes

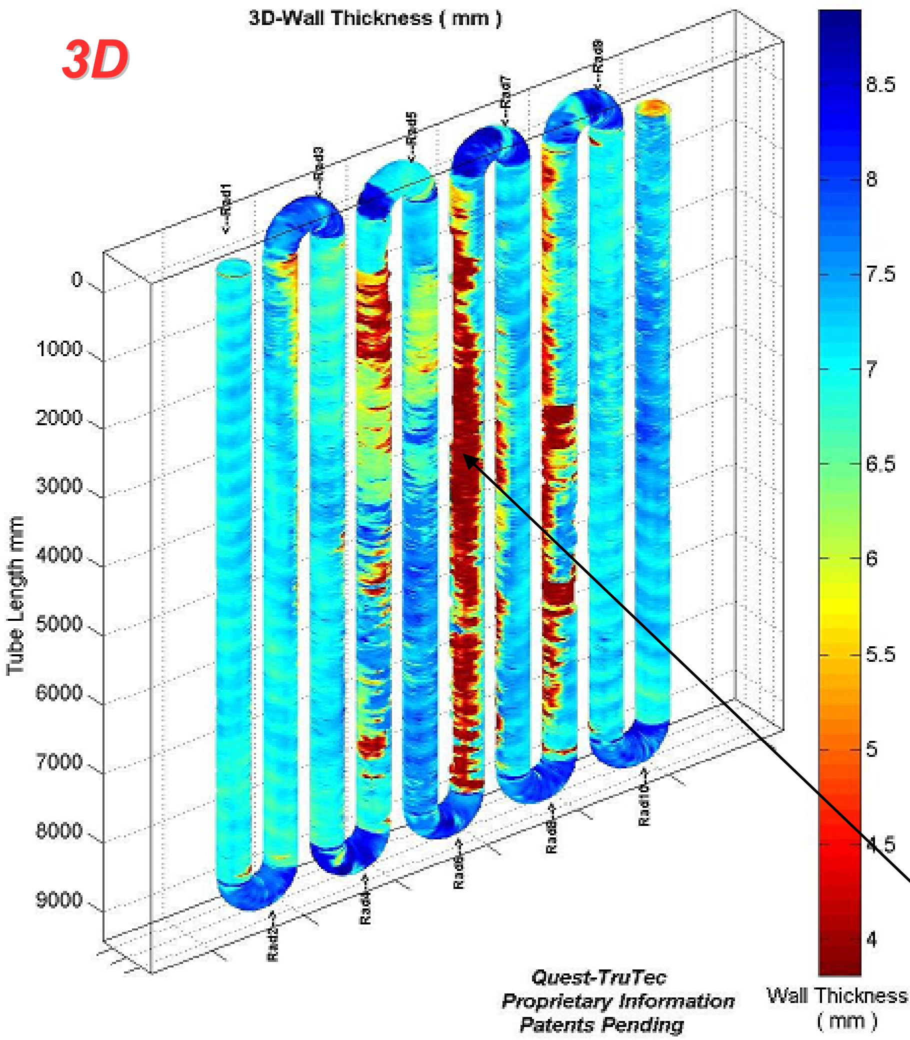


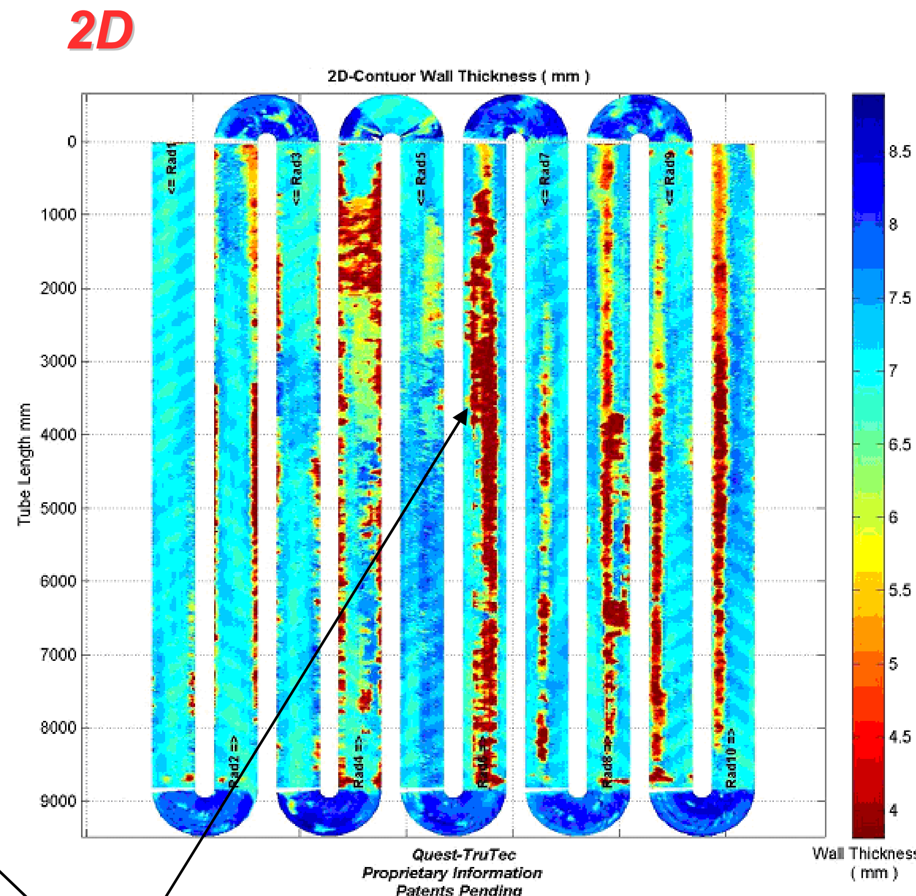
QUEST TRUTEC
Asset Longevity | Plant Performance

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





External Corrosion Damage (Radiant Section)

RDR35

Slide 31

RDR35 Damage was in "radiant" section.

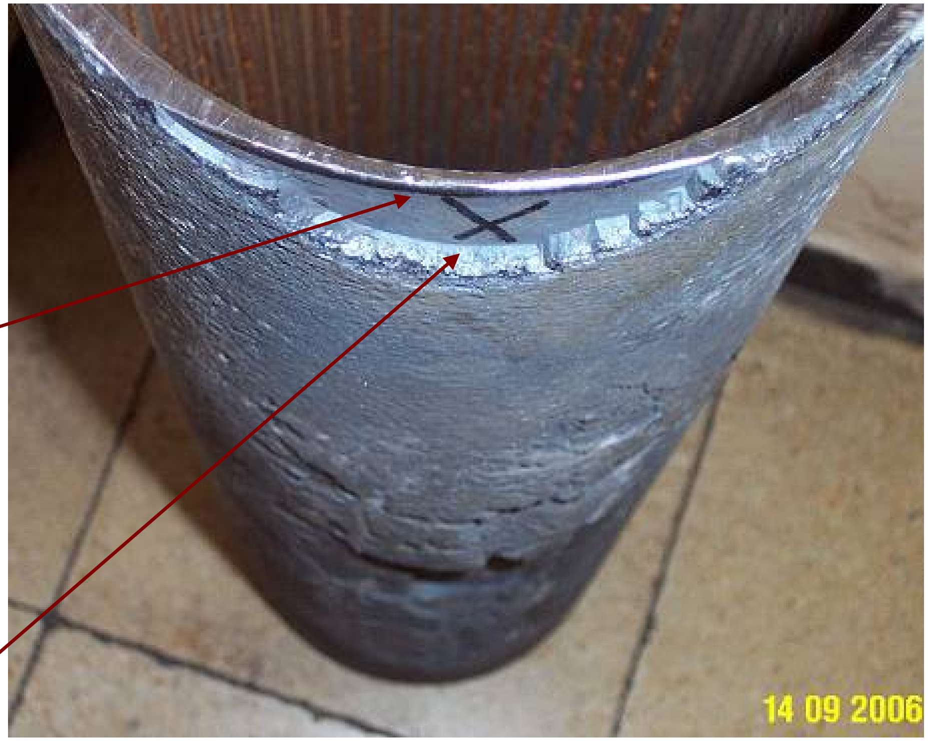
FTIS data was confirmed by both "visual" and "destructive" testing.

Plant stated that they may have not detected most severe area had they not applied the FTIS technology.
RichR, 10/5/2006

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

56% Wall Loss

Tightly Adhered Scale



Side View of Pipe

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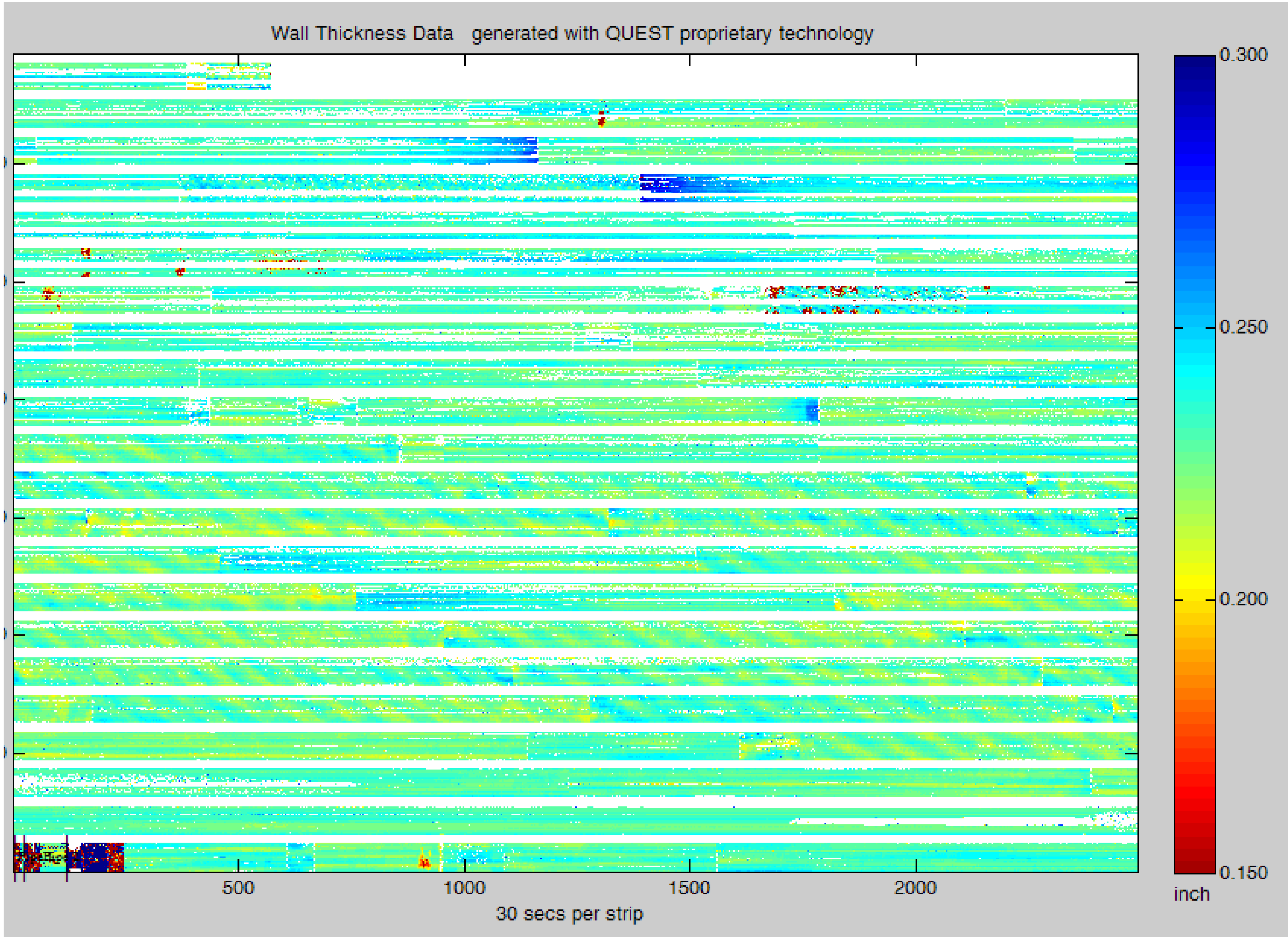
PIPELINE CASE STUDY
4” Crude Pipeline *(FTIS 2D Data Display)*



- 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

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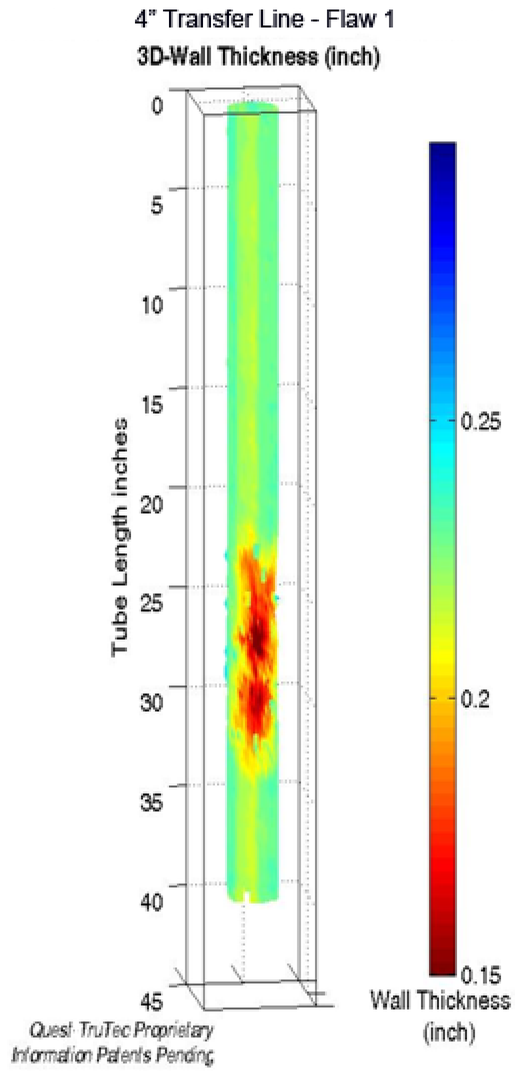
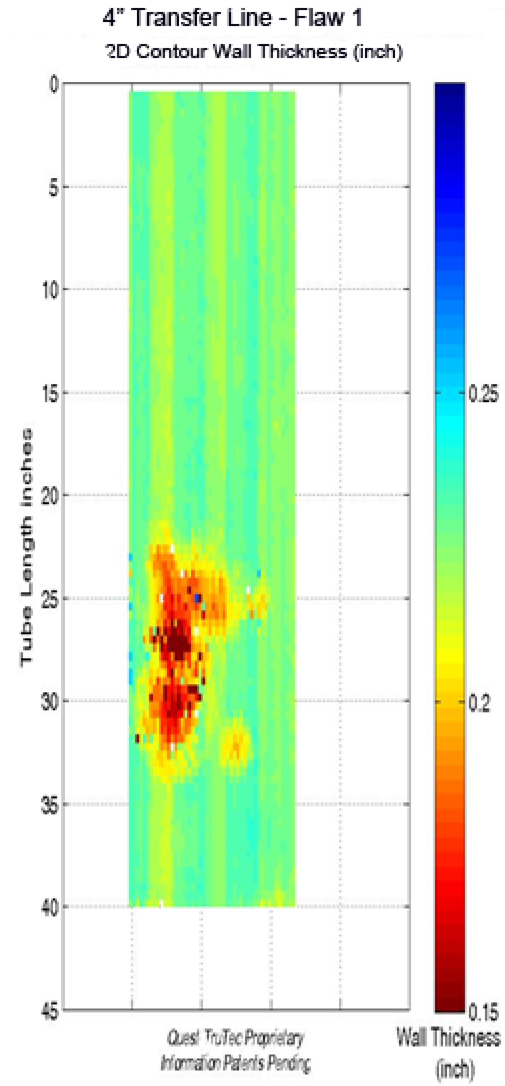
PIPELINE CASE STUDY

4" Crude Pipeline *(Photo – 3D – 2D Images)*





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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.

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Thank You