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Internal Ultrasonic Pipe & Tube Inspection – IRIS

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Abstract

IRIS is an ultrasonic pulse/echo immersion technique for the internal inspection of tubes and pipes. After the tubes are cleaned each tube is then flooded with water and a rotating probe is pushed the length of the tube scanning the circumference of the wall.

Operator‘s view screen displays a real time “B” scan data image of the tube wall as the probe travels. Images can be frozen at any time for closer inspection. Scanned data is recorded to the computer’s hard-drive. Each scan shows ID & OD wall profile including pitting, corrosion, bulging, dents, thinning, Wall thickness is measured directly on screen. Color “C” scan and tube mapping views are also available. Data is easy to interpret, and can be viewed on any Windows (IBM) computer

The technique allows for inspection of both ferrous & non ferrous materials in tube sizes from 9mm to 30mm ID and pipe sizes up to 1100mm in diameter. Lengths up to 5 km can be inspected. Tube cleaning is essential; data can be compromised by poor tube preparation

Typical units inspected with this method include, feed-water heaters, air-fin coolers, condensers, boilers, heat-exchangers, process piping, loading lines and product flow lines. Industries where the technique is used include petroleum, chemical, paper, electric, food, pipelines and utilities.

1. Introduction

IRIS is a pulse/echo ultrasonic immersion technique since 1979, for inspection of the tubes from the inside. The tube is flooded with water. As the probe is pushed down the length of the tube it scans both the ID & OD tube wall.
Inspection is done in real time with operator monitoring screen as data is recorded to computer hard-drive

The Ultrasonic transducer is housed in a rotating turbine head with a 45* mirror. The turbine assembly is centered in the tube axis.

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Figure 1. Turbine and centering device

The pulses are emitted parallel to the tube axis and reflected by the 45º mirror and directed around the circumference into the tube wall.

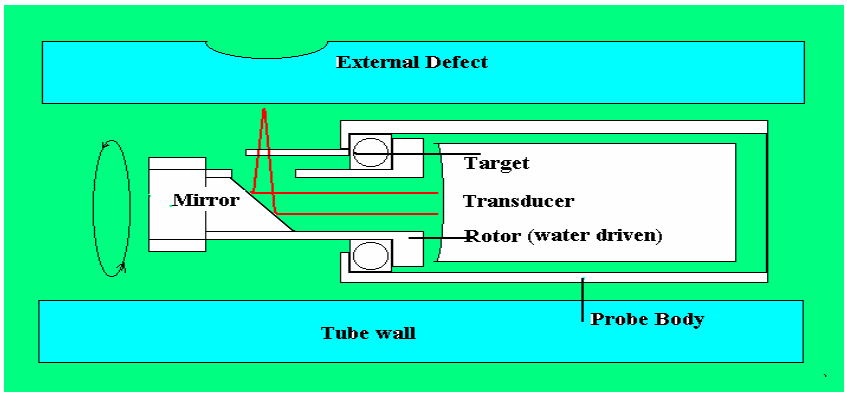


Figure 2. Probe assembly

2. Ultrasonic Principles

The time interval between the first echo (front wall) and second echo, (back wall) is the measure of wall thickness.(1)
As the mirror rotates, the ultrasonic beam sweeps the circumference of the tube wall taking 360 readings per revolution.
The scan width of each rotation is 1.5mm.

Turbine speed and PRF are adjustable to allow inspection pulls up to 5m per minute. Water provides the drive power for the turbine & is the couplant for the signal.

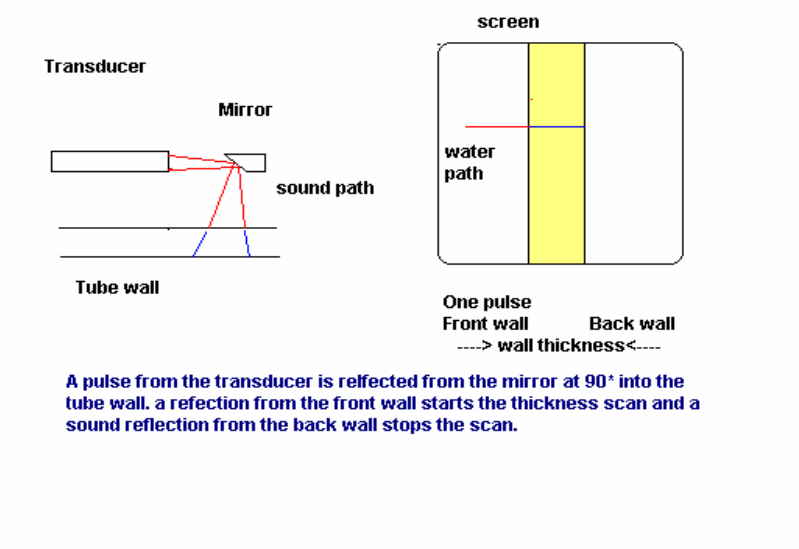


Figure 3. Thickness measurement principle

On each revolution, the firings are stacked to create a B scan image of that section of the tube. The visual image shows ID and OD surface profile and wall thickness.[2]

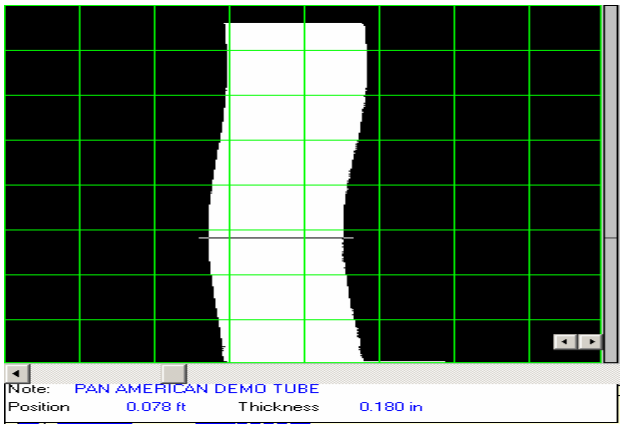


Figure 4. B Scan image of the tube

2.1 Internal defects measurement principle

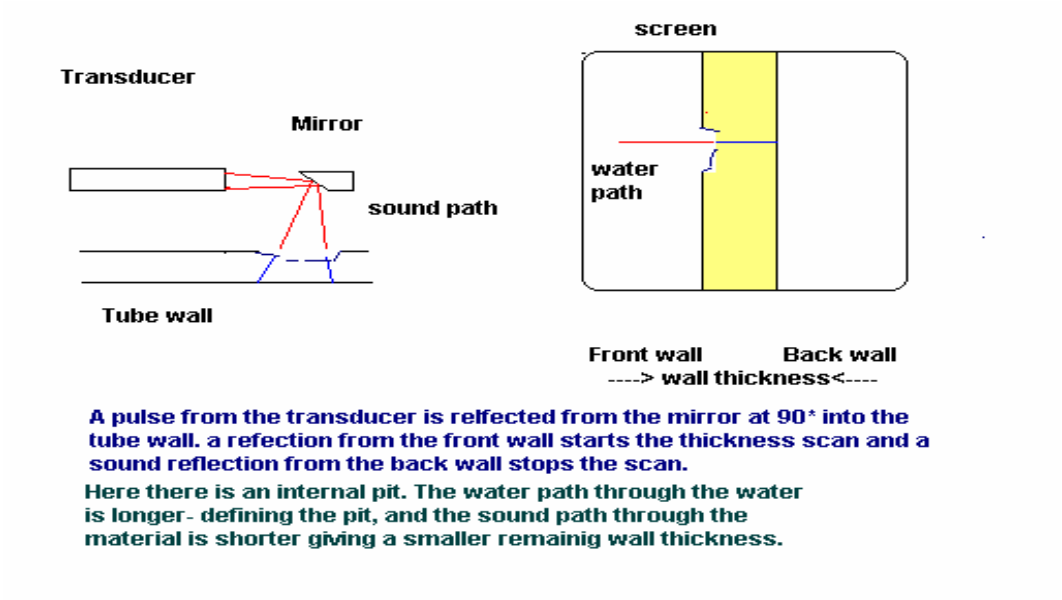


Figure 5. Internal defects measurement

2.2 External defects measurement principle

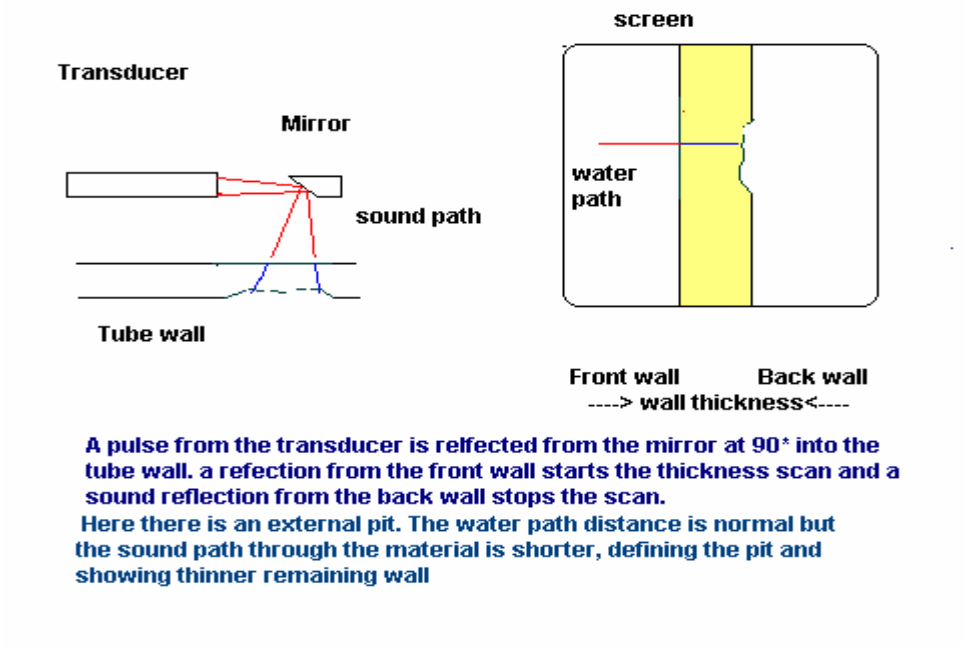


Figure 6. External defect measurement

2.3 The B Scan image thickness measurement

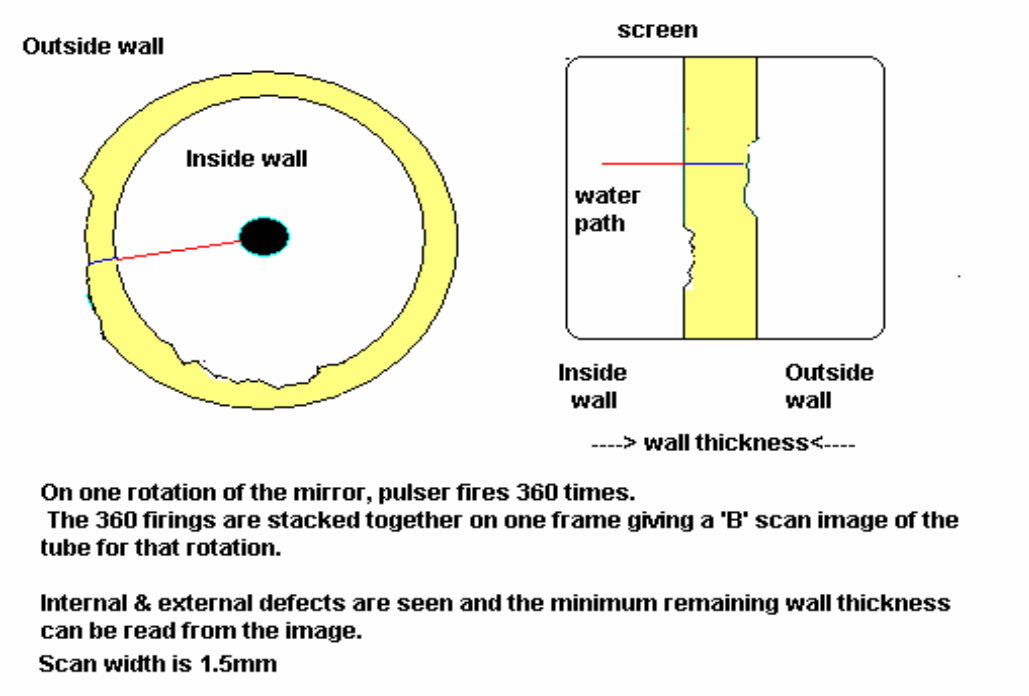


Figure 7. The B Scan image

3. Examples of tube defects

IRIS can detect internal & external Erosion, corrosion, pitting, fretting, denting, bulges, restrictions , remaining wall thickness, channeling, tube sheet defects. It is used as a preventative tool to monitor tube wear, so customer should not have untimely shut-downs . Here are some actual problem tubes from exchangers with the IRIS B scan image (Figures 8 to 13).

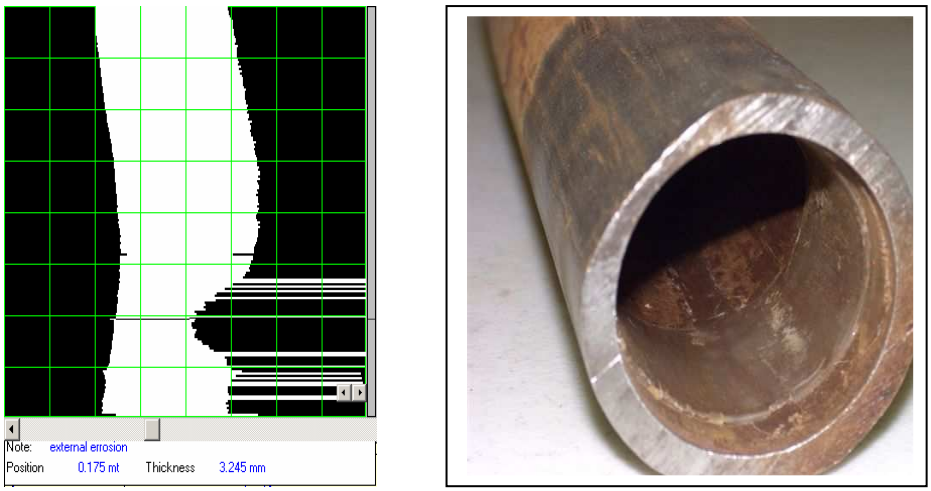
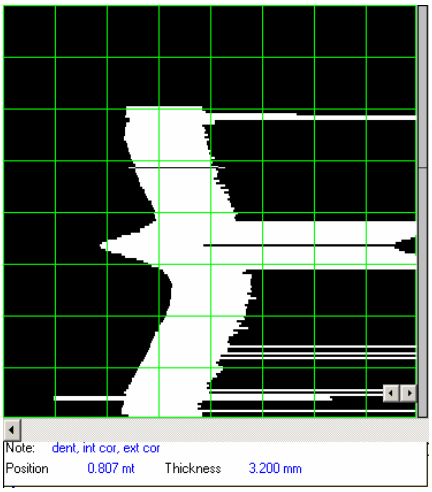


Figure 8. External erosion



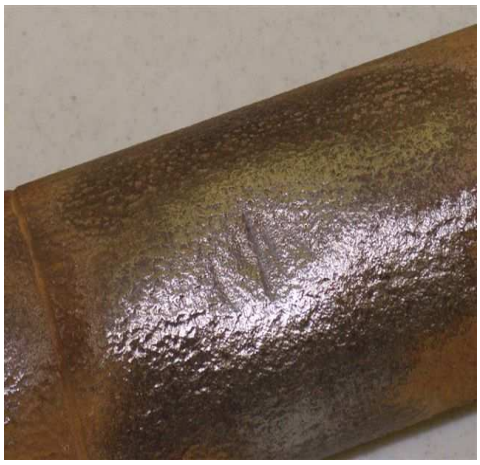


Figure 9. Internal Dent

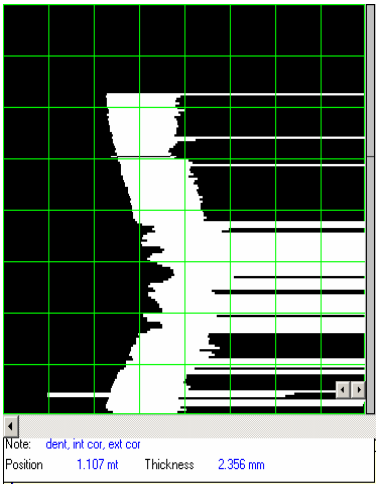


Figure 10. Severe internal corrosion area

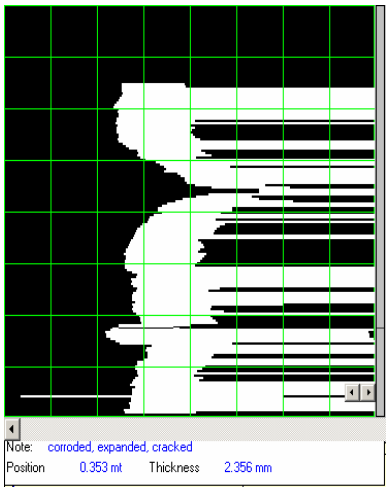


Figure 11. Expanded, split tube

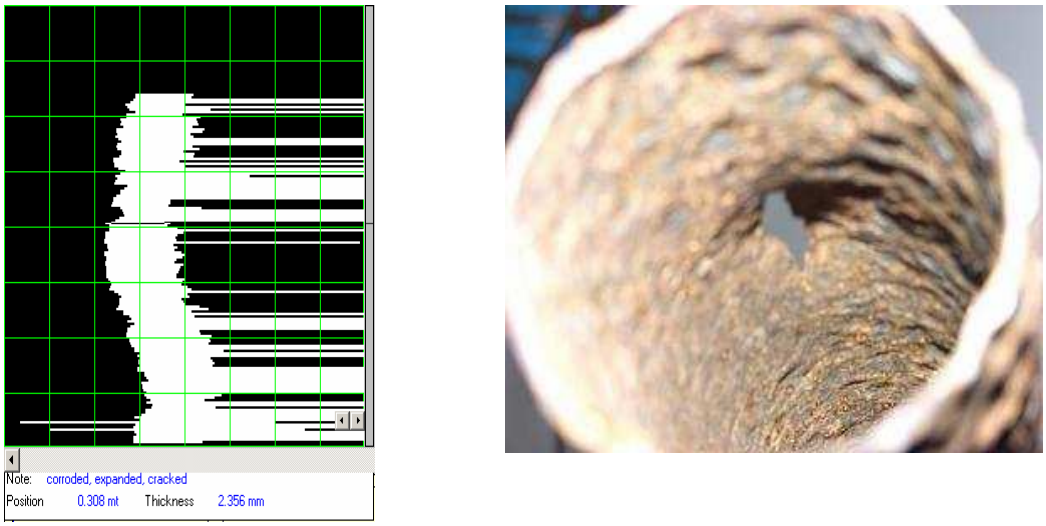


Figure 12. Corroded tube

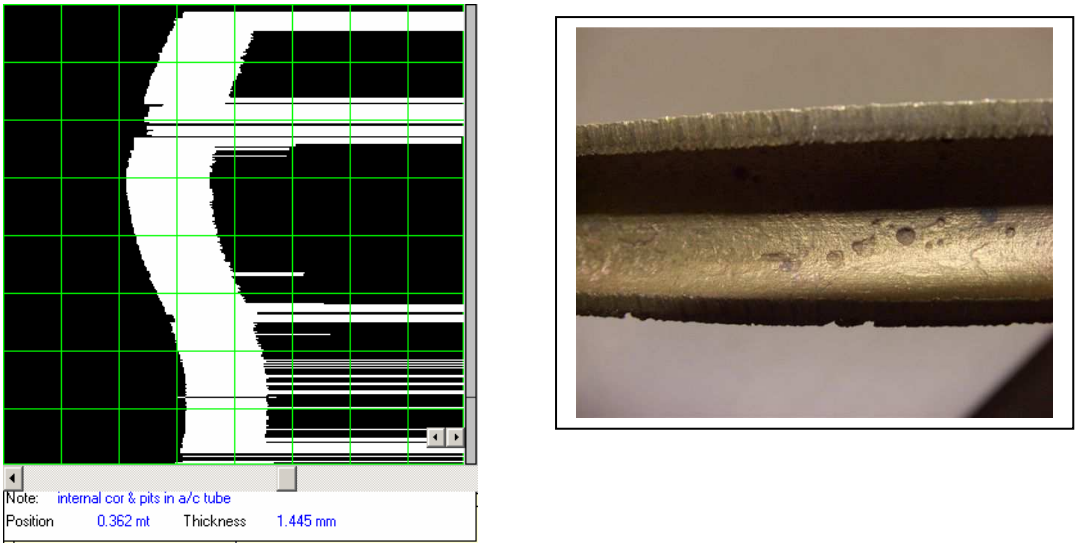
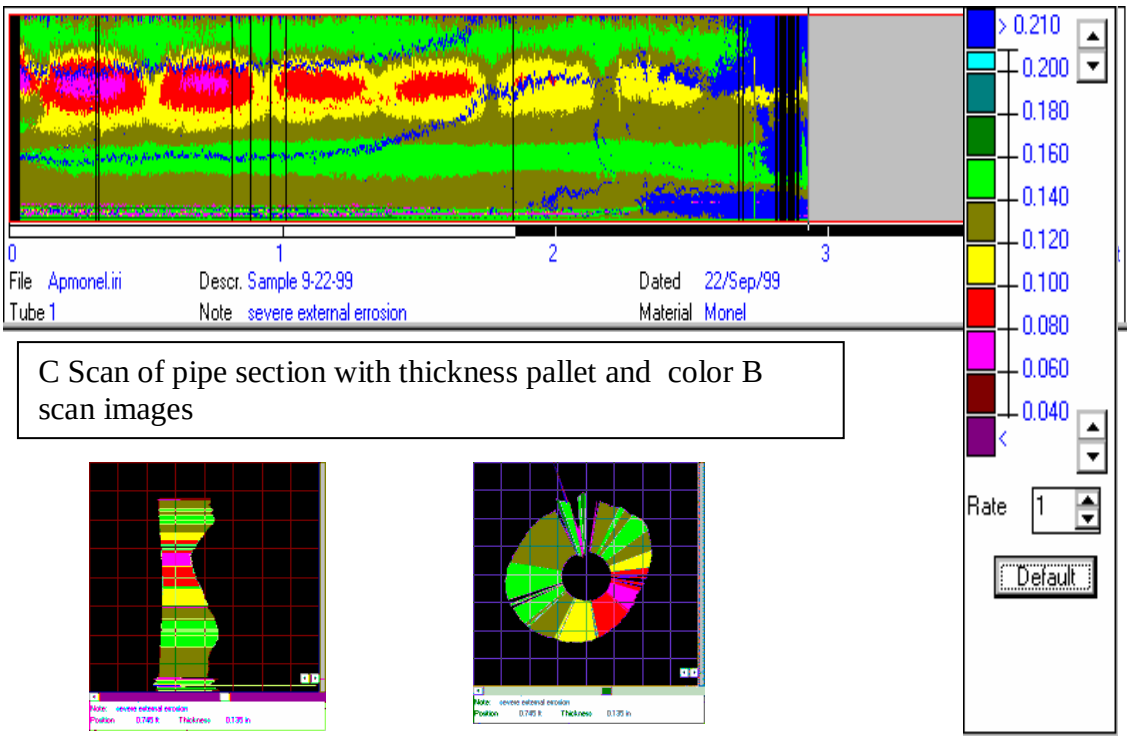


Figure 13. Internal Pitting

4. Data processing

As the probe is pushed through the pipe, consecutive B scan images are joined to form a color coded C-scan of the tube wall.[3]
Scans can be frozen at any point to examine image closely. Thickness is measured on screen. .
The C scan image and tube mapping are seen in the Windows Viewer program. Fig 14 and 15.

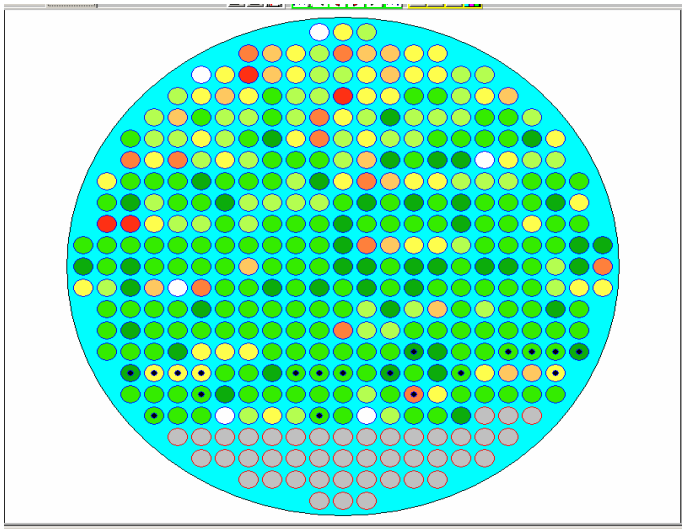
Colors indicate various wall thickness



C Scan of pipe section with thickness pallet and color B scan images

Figure 14. Windows Viewer program

Tube data is recorded on an Excel type interactive spread sheet. A tube sheet diagram easily shows patterns of problem areas. Meaning that there is something wrong within the exchanger.
Tube map is interactive with the recorded tube data



MWT/Defect		Tubes	% Insp.	% Map
> 0.263		0		
0.250 to 0.263		0		
0.225 to 0.250		47	13.7	12.2
0.200 to 0.225		158	46.2	41.0
0.175 to 0.200		55	16.1	14.3
0.150 to 0.175		44	12.9	11.4
0.125 to 0.150		16	4.7	4.2
0.100 to 0.125		12	3.5	3.1
0.075 to 0.100		4	1.2	1.0
0.050 to 0.075		0		
0.0 to 0.050		0		
Int. Corr.		0		
Int. Pitt.		0		
Ext. Corr.		0		
Ext. Pitt.		0		
Dirty		19	5.6	4.9
No ObsMWT		6	1.8	1.6
Plugged		0		
Not inspected		43		11.2
Total		**385**	100.0	100.0

Figure 15. Tube sheet map

5. Uses in tube inspection

IRIS is used to inspect tubes and piping from 8.6mm up to 300 mm and pipeline (IRIS Pig) up to 1100 mm Internal diameter. [4,5]
It inspects ferrous & Non ferrous materials.
Primary use is inspection of heat exchangers, air coolers, boilers, condensers, re-boilers, heaters, flow lines, overhead piping.and loading lines

Secondary use - to confirm results obtained with other inspection techniques.

6. Centering devices

Different types of centering devices are used for different diameters of tubes.

Figure 16. Centering devices up to 75 mm diameter

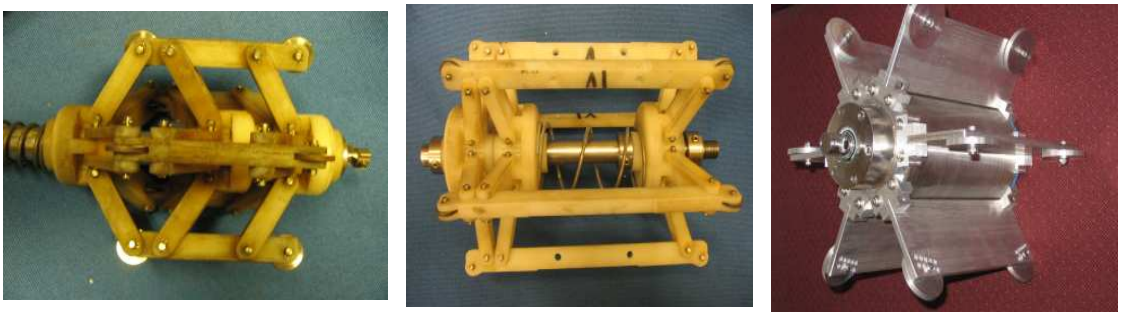


Figure 17. Centering devices for diameters up to 300 mm

Figure 18. Centering devices for 250 mm – 1100 mm diameters pipelines

7. Limitations to Inspection

A good inspection can be compromised by customer failing to clean tubes properly.
Bonded scales, loose debris and wax or oily deposits will affect data readings,
Cleaning is done with Very High pressure water blast, brushing or with chemicals.
Results can also be affected by dirty / low pressure water and electrical interference.

8. Conclusions

IRIS inspects ferrous & non ferrous materials up to 300mm diameter and pipeline (IRIS Pig) up to 1100 mm internal diameter.
Standard probe lengths to 30m but can go to 600m.
Easy to read data shows ID & OD wall problems and remaining wall thickness.
Tubes need to be cleaned before inspection.
Inspection Data is recorded to Hard Drive and can be reviewed in Windows software.

IRIS is used as preventative tool to monitor tube conditions in exchangers and boilers so untimely shut downs can be avoided.
On large diameter piping, IRIS can be pushed up to 5km, plotting ID / OD corrosion, dents, pipe anomalies and remaining wall thickness

References

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