IRIS TUBE INSPECTION

Client:	**Client a**
Facility:	**site b**
Item Inspected:	**Unit 123**
Inspection Method:	**IRIS (Ultrasonic)**
Date Commenced:	**01/01/2015**
Date of Completed:	**12/01/2015**
Type of Report:	**Final Report**
Report Number:	**K0xx-15 (Jxx22)**

nqa. ISO 9001 ISO 14001 OHSAS 18001 Registered

UKAS MANAGEMENT SYSTEMS 015

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innospection

IRIS TUBE INSPECTION REPORT

Executive Summary

As requested by InCon Inspection Consultants acting for Client a, Innospection has carried out an IRIS (Internal Rotational Inspection System) Ultrasonic tube inspection, on the heat exchanger tube bundle identified as 123.

The inspection was conducted at the Client's site, located in the United Kingdom on the 12th May 2016.

This inspection report documents in detail the specific inspection(s) that have been conducted; the individual technique(s) and equipment utilised, and the results/observations that were obtained.

The IRIS Inspection carried out on unit 123, identified external tube wall damage noted near to the support plates (wall loss percentages are identified per tube within the appendices).

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1. Test Object Data

Object Identification : Heat Exchanger Unit 123

Location of Object : Site b, United Kingdom

Orientation of Object : Horizontal

Tube Dimensions :
OD : 31.75 mm
Wall Thickness : 1.65mm
Length : 3500 mm

Material : Nickel Alloy 200 - ASTM SB162

No. of Tubes / Legs : 60 Straight tubes

2. Inspection Task

As requested by Client a; IRIS (Internal Rotational Inspection System) Ultrasonic Tube Inspection, was carried out on the heat exchanger unit 123.

This unit is found located at the Client's site, and was examined during the 12th May 2016.

The client requested the inspection of 100% of all the tubes.

The purpose of the inspection was carried out as a routine quality assessment.

3. Inspection Personnel

Inspection Operator Technician a, ET/UT PCN Level 2 (Certification No.000000)

Inspection Assistant Technician b

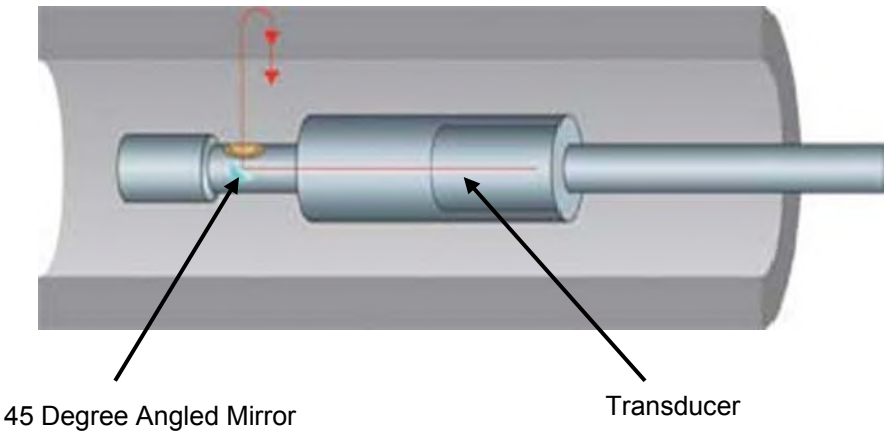
4. Inspection Equipment

4.1. IRIS Equipment

The inspection equipment consisted of the following:

Inspection System :	RD Tech Multiscan MS5800U / TC5800 IRIS System Serial No. 876445
Software Version :	Multi-view 6.0R4
Data Storage :	Laptop Hardware

4.2. Concept of IRIS



IRIS is a technique based around the principle of Ultrasonic inspection.

As shown in the above illustration, a sound beam is emitted from an Ultrasonic transducer and reflected of a mirror set at 45 degrees. This reflected beam impinges on the tube ID at right angles where part of the beam is reflected from the tube ID, while the remainder is further transmitted through the wall thickness and then reflected back from the tube OD.

The time difference between these two reflected signals is used to measure the tube wall thickness. The mirror is mounted on a water driven turbine that can rotate at speeds of approximately 2000rpm; measurements are made around the full tube circumference of the tube as the probe is withdrawn.

The ultrasonic beam maps out a spiral along the tube length, therefore if the probe pulling speed is sufficiently low enough, the scan will follow a helical overlap of each individual rotation (taking into account the inspection parameters), giving a 100% coverage of the tube surface.

4.3. Probes and Turbines

The following type of inspection probe and turbine was used:

Probe Type : 15 MHz, Serial No. 609521

Turbine Diameter : Ø 18mm

5. IRIS Equipment Calibration

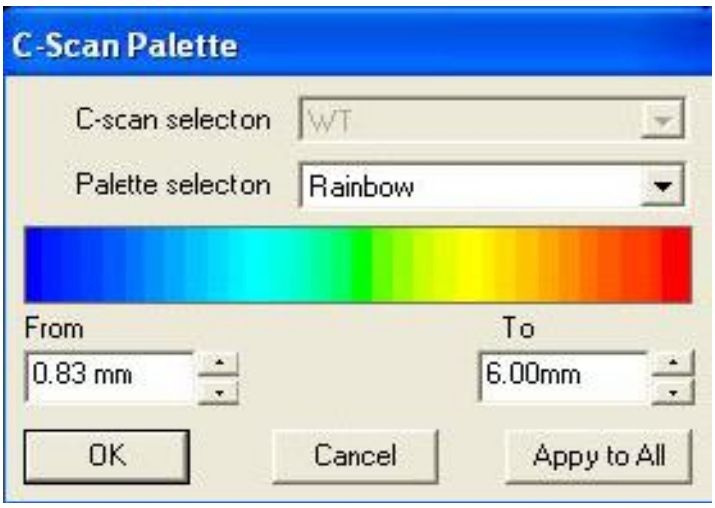
5.1. Calibration Tube

The following calibration tube had been used:

- Innospection Calibration Tube
  Dimensions : Ø 31.75 mm x WT 1.65mm
  Calibration standard with reference to ASME V Sec. 8

5.2. Sensitivity Setting

The general overview of the inspected areas and its inspection results are presented in the attached colour scan reports, with the wall loss represented in colour classes as depicted in the colour palette below.



5.3. Calibration Control

The general setting and calibration was performed at the beginning of the inspection, and after any interruption or break according to the technical procedure. All calibration data is further stored digitally.

Calibration can be achieved by selecting the correct material sound velocity for the tube under inspection, reference samples are then used for the initial set-up and for a check on the sensitivity settings.

6. Tube Identification

In order to be able to identify and locate each tube and create full traceability, a set of grid co-ordinates consisting of Pass, Row and Tube was used.

7. Inspection Procedure

The inspection was performed according to the following valid procedure:

Innospection Procedure No. InnoTIRIS-001-09 – Current Issue

8. Comments to Inspection

IRIS inspection was requested by the client, for the examination of this tube bundle.

However due to the tube material specification being “Nickel Alloy 200 - ASTM SB162”, Innospection would have preferred to have utilised an Eddy Current DC Magnetic Biased technique, supported by Remote Field Eddy Current for this particular type of tube inspection.

In discussion with FMC, there primary concern was also noted to be the detection of small diameter holes. IRIS is not suited particularly well to the resolution of such small through wall defects, and this was explained to the client. It is understood that the single tube found previously plugged out, was indeed the result of a through wall hole.

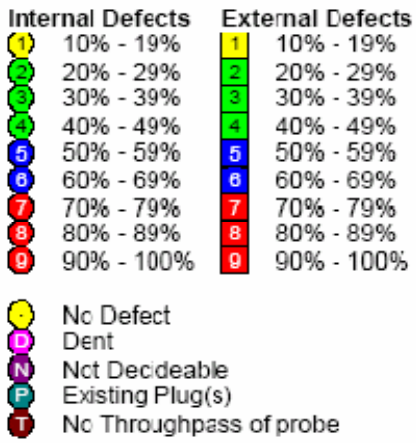
Of note and clearly seen within the appendices, was the detection and resolution of external tube wall damage at the support plates.

9. Result Overview

9.1. Result Information

The following documentation shows in detail the inspection results. In the defect picture, the deepest evaluated defect found in a particular tube is given a number.

Tubes were classified as the following legend:-



9.2. Result Overview

Number of tube identified with main internal indications:

10% - 19% internal wall loss	:	0 tubes
20% - 29% internal wall loss	:	0 tubes
30% - 39% internal wall loss	:	0 tubes
40% - 49% internal wall loss	:	0 tubes
50% - 59% internal wall loss	:	0 tubes
60% - 69% internal wall loss	:	0 tubes
70% - 79% internal wall loss	:	0 tubes
80% - 89% internal wall loss	:	0 tubes
90% - 100% internal wall loss	:	0 tubes

Number of tube identified with main external indications:

10% - 19% external wall loss	:	30 tubes
20% - 29% external wall loss	:	5 tubes
30% - 39% external wall loss	:	4 tubes
40% - 49% external wall loss	:	0 tubes
50% - 59% external wall loss	:	0 tubes
60% - 69% external wall loss	:	0 tubes
70% - 79% external wall loss	:	0 tubes
80% - 89% external wall loss	:	0 tubes
90% - 100% external wall loss	:	0 tubes

A summary of the inspection findings is given below:

Total number of tubes	:	60
Total number of tubes inspected	:	59
Number of tubes with no through pass	:	0
Number of tubes with existing plug	:	1

10. Inspection Summary

General external tube wall damage was noted at the support plates, being in a selection of the tubes examined. This is depicted within appendix 1 which shows an overall defect picture, taken at the tube-sheet identifying (per legend) the maximum wall losses per tube.

Below is one of the actual `C-Scan' images taken from an inspected tube within Unit 123, this clearly showing a reduction to the external tube wall at the support plate positions.

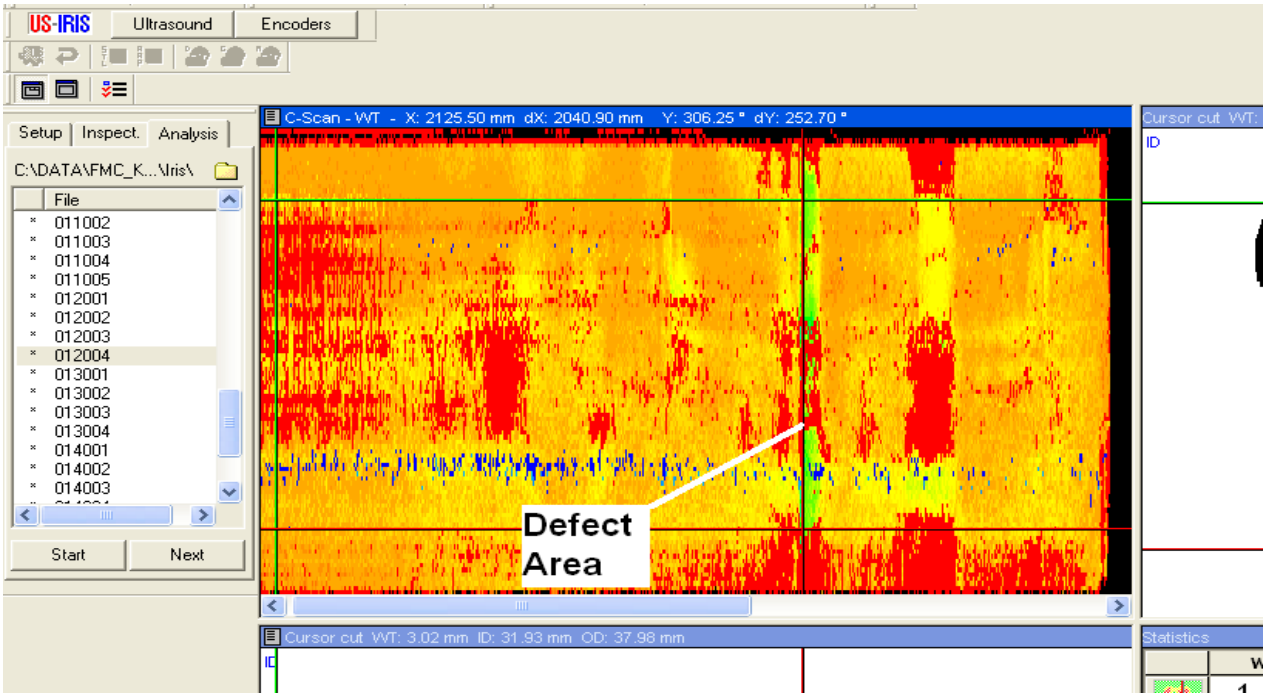


Figure 1

Actual IRIS Scan taken from Unit 123 depicting wall loss at the support plate

11. Documentation

The inspection result, parameters and data are stored in the Innospection Limited archive database system.

12. Signature

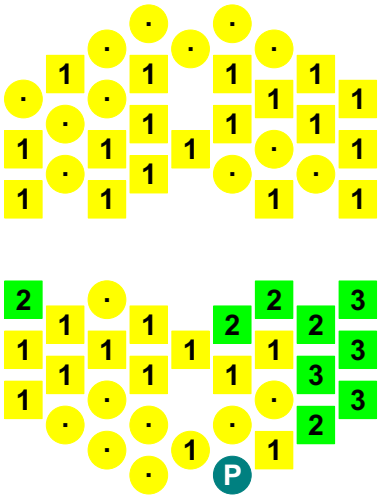
Technician a
Inspection Engineer
Innospection Limited

APPENDIX 01

Defect Picture

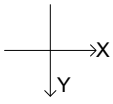
123
Defect Picture
final result

Unit 123



internal defects	external defects
1 10 % - 19 %	1 10 % - 19 %
2 20 % - 29 %	2 20 % - 29 %
3 30 % - 39 %	3 30 % - 39 %
4 40 % - 49 %	4 40 % - 49 %
5 50 % - 59 %	5 50 % - 59 %
6 60 % - 69 %	6 60 % - 69 %
7 70 % - 79 %	7 70 % - 79 %
8 80 % - 89 %	8 80 % - 89 %
9 90 % - 100 %	9 90 % - 100 %

view : North



- No defect
- D Dent
- N Not decideable
- P Plug
- T No throughpass

- Tube not to be inspected
- Tube to be inspected

subject : Unit 123
page(s) : 1 from 1
client : Client a
site : Site b
order-no. : xx22
K.-No. : K0xx-15
Date : 01/01/2015
Material : Nickel Alloy 200
Tube length : 3570 mm
Ø External : 31.75 mm
Ø Internal : 28.45 mm
Wall thickness : 1.65 mm

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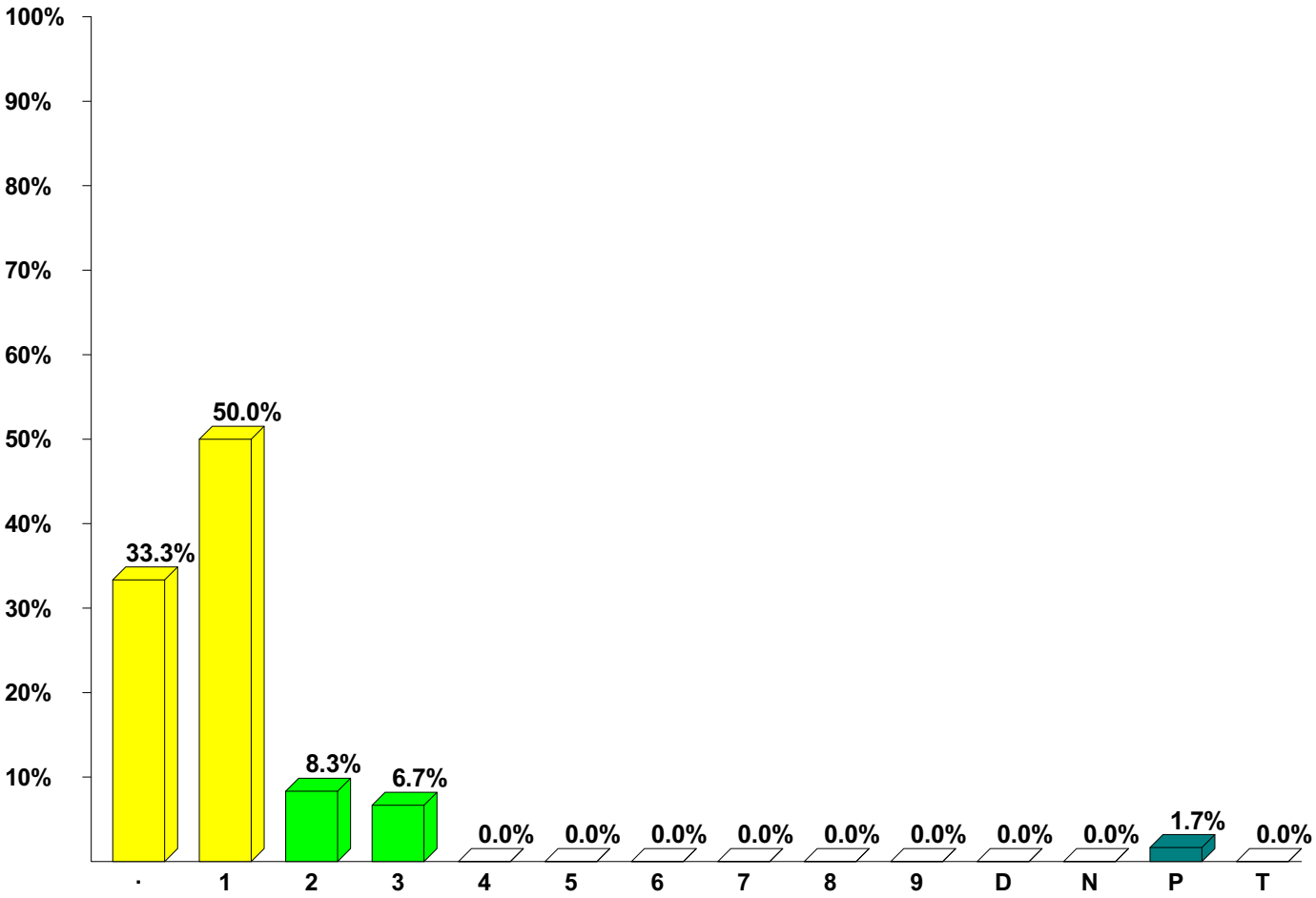
APPENDIX 02

Statistical Overview

Unit 123 - Statistic
final result - all section
(100% = all tubes)



[1] : all tubes		**60**		
[2] : all tubes with indication		**39**	**65.0% from [1**	
[3] : all inspected tubes		**59**	**98.3% from [1**	
internal defects	**number**	**% [1]**	**% [2]**	**% [3]**
1 10 % - 19 %	0	0.0	0.0	0.0
2 20 % - 29 %	0	0.0	0.0	0.0
3 30 % - 39 %	0	0.0	0.0	0.0
4 40 % - 49 %	0	0.0	0.0	0.0
5 50 % - 59 %	0	0.0	0.0	0.0
6 60 % - 69 %	0	0.0	0.0	0.0
7 70 % - 79 %	0	0.0	0.0	0.0
8 80 % - 89 %	0	0.0	0.0	0.0
9 90 % - 100 %	0	0.0	0.0	0.0
external defects	**number**	**% [1]**	**% [2]**	**% [3]**
1 10 % - 19 %	30	50.0	76.9	50.8
2 20 % - 29 %	5	8.3	12.8	8.5
3 30 % - 39 %	4	6.7	10.3	6.8
4 40 % - 49 %	0	0.0	0.0	0.0
5 50 % - 59 %	0	0.0	0.0	0.0
6 60 % - 69 %	0	0.0	0.0	0.0
7 70 % - 79 %	0	0.0	0.0	0.0
8 80 % - 89 %	0	0.0	0.0	0.0
9 90 % - 100 %	0	0.0	0.0	0.0
	number	**% [1]**	**% [2]**	**% [3]**
· No defect	20	33.3		33.9
D Dent	0	0.0	0.0	0.0
N Not decideable	0	0.0	0.0	0.0
T No throughpass	0	0.0	0.0	0.0
P Plug	1	1.7		
Tube not to be inspected	0	0.0		
Tube to be inspected	0	0.0		
V To be plugged	0	0.0		
X Extra to be plugged	0	0.0		

subject : Unit 123
section : all
client : Client a
site : site b
order-no. : xx22
K.-No. : K0xx-15
Date : 01/01/2015
Material : Nickel Alloy 200
length of leg : 3570 mm
Ø External : 31.75 mm
Ø Internal : 28.45 mm
Wall thickness : 1.65 mm
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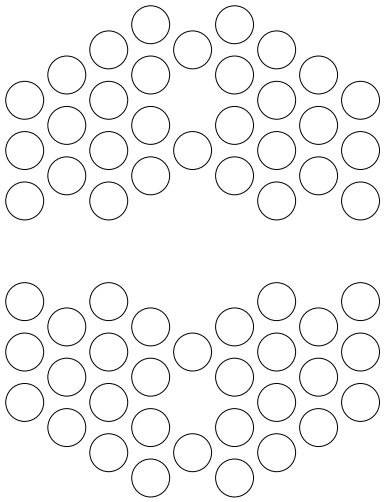
test parameter
Operator : Technician a
equipment : MS5800
Probe type : IRIS

APPENDIX 03

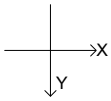
Tube Array

Unit 123
Tube Array

Unit 123



view : North



subject	: Unit 123
page(s)	: 1 from 1
client	: Client a
site	: Site b
order-no.	: xx22
K.-No.	: K0xx-15
Date	: 01/01/2015
Material	: Nickel Alloy
Tube length	: 3570 mm
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Wall thickness	: 1.65 mm

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