

EddyMax and IRIS Tube Inspection

Client

Client

Facility

Offshore Platform

Item Inspected

**Glycol Contactor Inlet Trim
Cooler Tubes**

Inspection Method

**Magnetic Biased Eddy Current
Remote Field Eddy Current
IRIS**

Date Commenced

17th Sept 2011

Date Completed

20th Sept 2011

Type of Report

Final

Report Number

K-XXX-11



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Appendix 1 : Tube Array

Appendix 2 : Coloured Defect Picture

Appendix 3 : Statistical Overview

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1.0) **Test Object Data**

Object Identification : Glycol Contactor Inlet Trim Cooler

Location of Object : Offshore Platform (North Sea UK Sector)

Orientation of Object : Horizontal

Tube Dimensions : OD : 19.05 mm
Wall Thickness : 2.11 mm
Length : 4100 mm

Material : Duplex

No. of tubes / legs : Straight tubes 414 Legs

2.0) **Inspection Task**

As requested by Client; Multiple Frequency Eddy Current and Ultrasonic IRIS tube inspections were carried out on the Glycol Contactor Inlet Trim Cooler, located on the Offshore Platform from 17th 09/2011 to 20th 09/2011.

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

The inspection was carried out as a general inspection during the plant shutdown.

3.0) **Inspection Personnel**

Inspection Supervisor : Alen Ennis PCN Level 2 ET, PT

Inspection Operator : Ryan Foster PCN Level 2

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4.0) **Magnetic Bias Inspection Equipment**

4.1) **Equipment**

The inspection equipment consists of the following:

- Multiple Frequency Eddy Current System
- Beltronic Serial No: EMC 07/08.02
- Type : eddyMax
- Software Version : eddyMax
- 4 Differential Channels
- 4 Absolute Channels
- 16 Mixed Channels
- Automatic Analysis in Differential Mode

4.2) **Magnetic Biased DC Power Supply**

Amperage used 25.1V / 1.07A

4.3) **Probes**

The following types of probes have been used:

Magnetic Biased Eddy Current probe Serial No: 08/058
Type : D-B-ID MA
Diameter : Ø 13.5 mm with fill factor 83.1%

4.4) **Calibration Tube**

The following calibration tube has been used:

Calibration Innospection Identification Serial No: 6059-1 & 6059-2
Ø 19.05 mm x WT 2.11mm
Material: Duplex
Calibration standard with reference to ASME V Sec. 8

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5.0) Magnetic Bias Equipment Setting & Calibration

5.1) Settings

- **Differential Channel CH1 ****
Frequency : 20 KHz
LP Filter : 300 Hz
HP Filter : Off
- **Differential Channel CH2 ****
Frequency : 10 KHz
LP Filter : 300 Hz
HP Filter : Off
- **Mixed Channels “low gain”*****
Provide reason for the mix e.g. low gain, high gain, etc
Source: CH 1 / CH 1

5.2) Calibration Setting

Differential Channel
40% external FBH (Flat Bottom Hole)
4.0 divisions peak to peak
Signal phase direction: vertical

5.3) Analysis Threshold Settings

The differential channels were set on a signal evaluation threshold of 1.0 division.

All absolute channels were set on a signal evaluation threshold of 1.0 division.

5.4) Calibration Data Storage

The calibration data, calibration signals and calibration check signals were stored within the project data test folder.

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6.0) **Remote-Field Inspection Equipment**

6.1) **Equipment**

The inspection equipment consisted of the following:

- Multiple Frequency Eddy Current System
- Beltronic Serial No: EMC 07/08.02
- Type : eddyMax
- Software Version : eddyMax
- 4 Differential Channels
- 4 Absolute Channels
- 16 Mixed Channels
- Automatic Analysis in Differential Mode
- Automatic / Manual Analysis in Absolute Mode

6.2) **Remote Field Eddy Current System**

EddyMax C-MEC Booster Unit

6.3) **Probes**

The following types of probes had been used:

Remote Field Eddy Current Probe Serial No: 07/024
Type : DA-T-ID.2S
Diameter : Ø 13.5mm with fill factor 83.1%

6.4) **Calibration Tube**

The following calibration tube had been used:

Calibration Innospection Identification Serial No: 6059-1 & 6059-2
Ø 19.05 mm x WT 2.11mm
Material: Duplex
Calibration standard with reference to ASME V Sec. 8

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7.0) Remote-Field Equipment Setting & Calibration

7.1) Settings

- **Differential Channel CH1 ****
Frequency : 600 Hz
LP Filter : 300 Hz
HP Filter : Off
- **Differential Channel CH2 ****
Frequency : 300 Hz
LP Filter : 300 Hz
HP Filter : Off
- **Absolute Channel CH3 ****
Frequency : 600 Hz
LP Filter : 300 Hz
HP Filter : Off
- **Absolute Channel CH4 ****
Frequency : 300 Hz
LP Filter : 300 Hz
HP Filter : Off
- **Mixed Channels “low gain”*****
Provide reason for the mix e.g. baffle, dent, low gain, high gain, etc
Source: CH 1 / CH 2

7.2) Calibration Settings

- **Differential Channel**
Through Wall Hole Ø : typically 2.5mm
Signal Amplitude : 4.0 divisions peak to peak
Signal phase in line with 100% defect depth
phase of the calibration curve
- **Absolute Channel**
External gradual thinning from 0% to 80%, 0 to amplitude 8 division from
bottom right corner moving in direction towards top left corner

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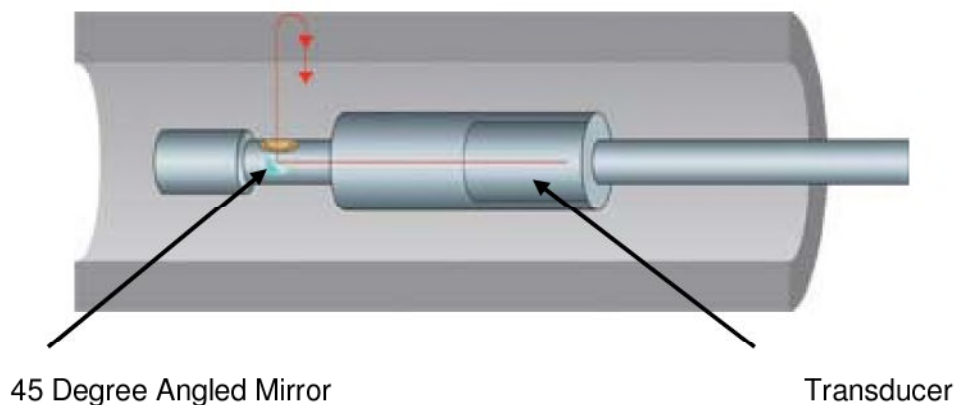
8.0) IRIS Inspection Equipment

8.1) Equipment

The inspection equipment consists of the following:

- RD Tech MultiScan MS5800U or TC5800 IRIS System, Serial No: 814818
- Software Version : Multi-view 6.0R4
- Data Storage : Laptop Hard drive

8.2) 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 off 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.

8.3) Probes & Turbine

The following types of probes and turbines had been used:

Probe Type : 15 MHz Serial No: 0802809

Turbine Diameter : 18mm etc Ø

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8.4) Calibration Tube

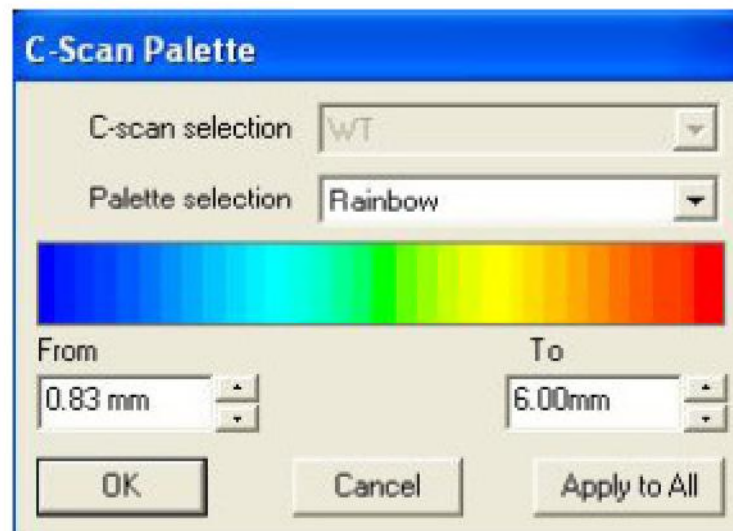
The following calibration tube had been used:

Calibration Innospection Identification Serial No: 6059-1 & 6059-2
 Ø 19.05 mm x WT 2.11mm
 Material: Duplex
 Calibration standard with reference to ASME V Sec. 8

The calibration was achieved with a similar section of tubing with eccentric artificial defects orientated at 180 degrees, with steps of wall thickness loss at 20%, 40%, 60% & 1.5mm hole. These artificial defects best simulated the type of wall loss that would be affecting these tubes.

9.0) IRIS 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.



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10.0) Inspection Procedures

The inspection was performed according to the following valid procedures:

EddyMax™ Tube Inspection;

In accordance with procedure No: InnoTEdmFMB-001-09-Rev-2.

Remote Field Inspection;

In accordance with procedure No: InnoTEdmRFR-001-09-Rev-2.

IRIS Ultrasound Inspection;

In accordance with procedure No: InnoTIRIS-001-09-Rev-2.

11.0) Inspection Performance

The inspection was performed with a manual probe drive.

Each individual test was performed with the bobbin probe being pushed along the straight ligament of the tube. The inspection data was received and analysed when the probe was withdrawn.

The inspection and related reporting software used a coordinate system where X runs from left to right across the rows and Y is the row number.

The tubes were inspected for localised defects and corrosional damage (this is with the exception of the tube ends within the tube plates that could not be inspected with this technique).

12.0) Analysis

The inspection was set up to inspect the tube ligaments except the tube ends in the expansion zones.

The Magnetic Biased Eddy Current technique focuses on the analysis of localised defects such as pitting or general corrosion and is limited in the detection of gradual defects such as general thinning. For the detection of gradual defects, the Remote Field Eddy Current technique is used.

The analysis of indications was done online through the software system with the final confirmation done by the Operator. The confirmed results were transferred straightaway to the reporting system.

Typically, indications displaying wall loss of above 10% are analysed and reported.

It is to be noted that Eddy Current inspection is an evaluation method of non-destructive testing. All settings and results obtained are based on a comparison to the results obtained from accurate calibrated samples of similar material and dimensions. These samples are machined with artificial defects to the actual type sought.

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13.0) Comments to Inspection

Entrance to all 414 tubes of the E-2046 was accessible with no restrictions.

100% of the tubes were clean and possible for inspection; all tubes were inspected by single size probes.

14.0) Result Overview

14.1) 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.

For example, where “6” appears, it means that a defect depth in the range from 60% to 69% of the tube wall thickness was the maximum defect located in that tube. Circles represent the maximum internal defects while the rectangles represent the maximum external defects.

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%
0 No Defect	
D Dent	
N Not Decideable	
P Existing Plug(s)	
T No Throughpass of probe	

The following Windevos™ results are included in this documentation:

1. Defect picture “Final Results” : This picture shows the individual final result of each tube, located at the deepest evaluated defect depth in that inspection run
2. Statistics : Overall graphic representation of the Data received
3. Plugging Plan : Graphic plugging diagram (if required)
4. Tube Array : Display of tube sheet view for reference

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14.2) Result Overview

A summary of the inspection findings is given below:

Total number of tubes : 414

Total number of tubes inspected : 414

Number of tubes with no through pass : 0

Number of tubes with existing plug : 0

Number of tubes with indications
other than defects : 0

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 : 0 tubes

20% - 29% external wall loss : 0 tubes

30% - 39% external wall loss : 0 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

Plugging Criteria:

Based on the following plugging criteria, the displayed number of tubes would have to be plugged:

Internal Loss	Wall	External Loss	Wall	Other Criteria	No. of tubes to be plugged
0 %		0 %		0	0 tubes

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15.0) Inspection Summary

No defects indications were found within the E-2046 Glycol Inlet Trim Cooler. Minor indications were noticed with Magnetic-Bias inspection; however for confirmation these were not confirmed by using the Remote Field and IRIS inspection techniques.

These indications have not been reported and are deemed spurious only.

For more information refer to appendix 1-3

16.0) Documentation

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

17.0) Signature

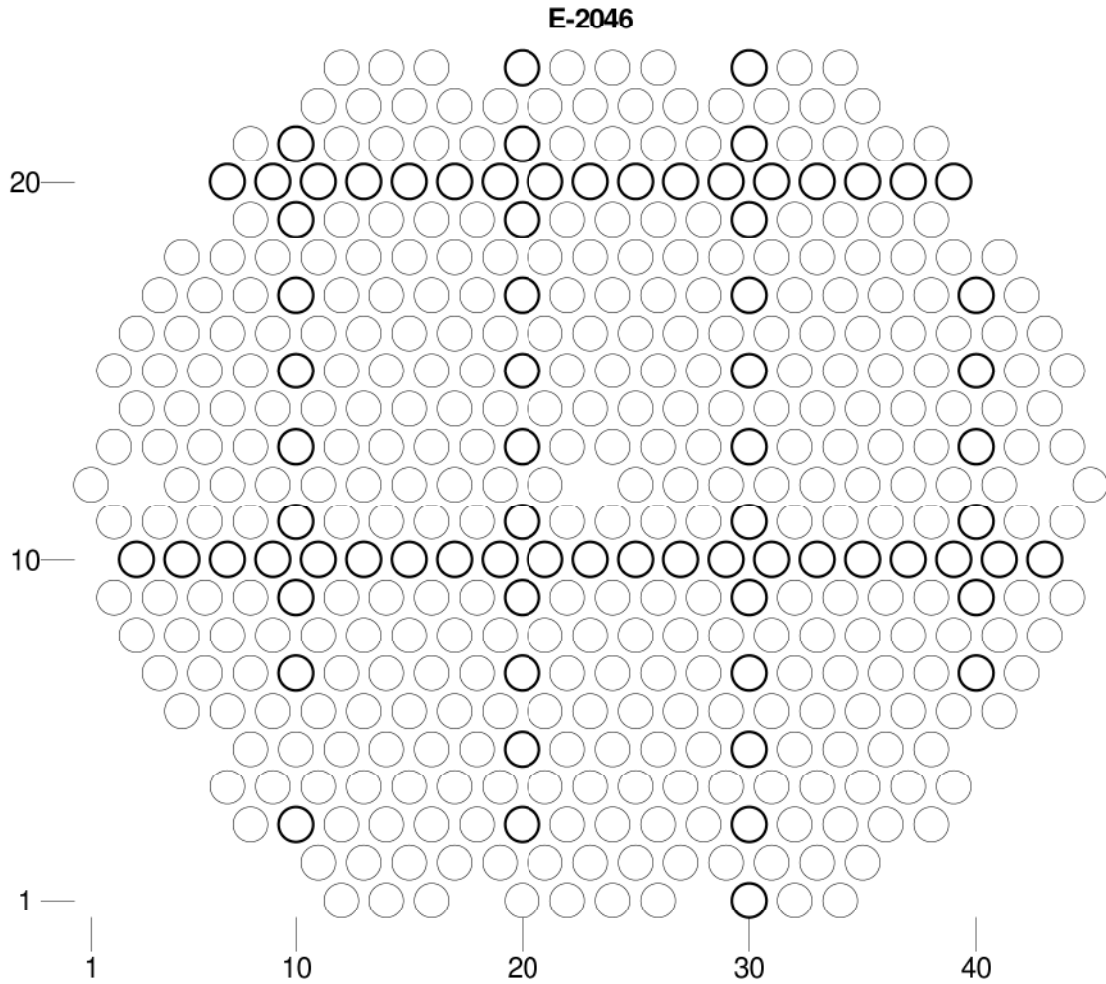
Innospection Limited
 Alen Ennis PCN Level 2 ET, PT
 Advanced Inspection Technician

Innospection Limited
 Mr. M. Churchill, Senior Engineer
 ET PCN Level 3 (200046)

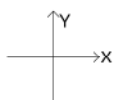




APPENDIX 01



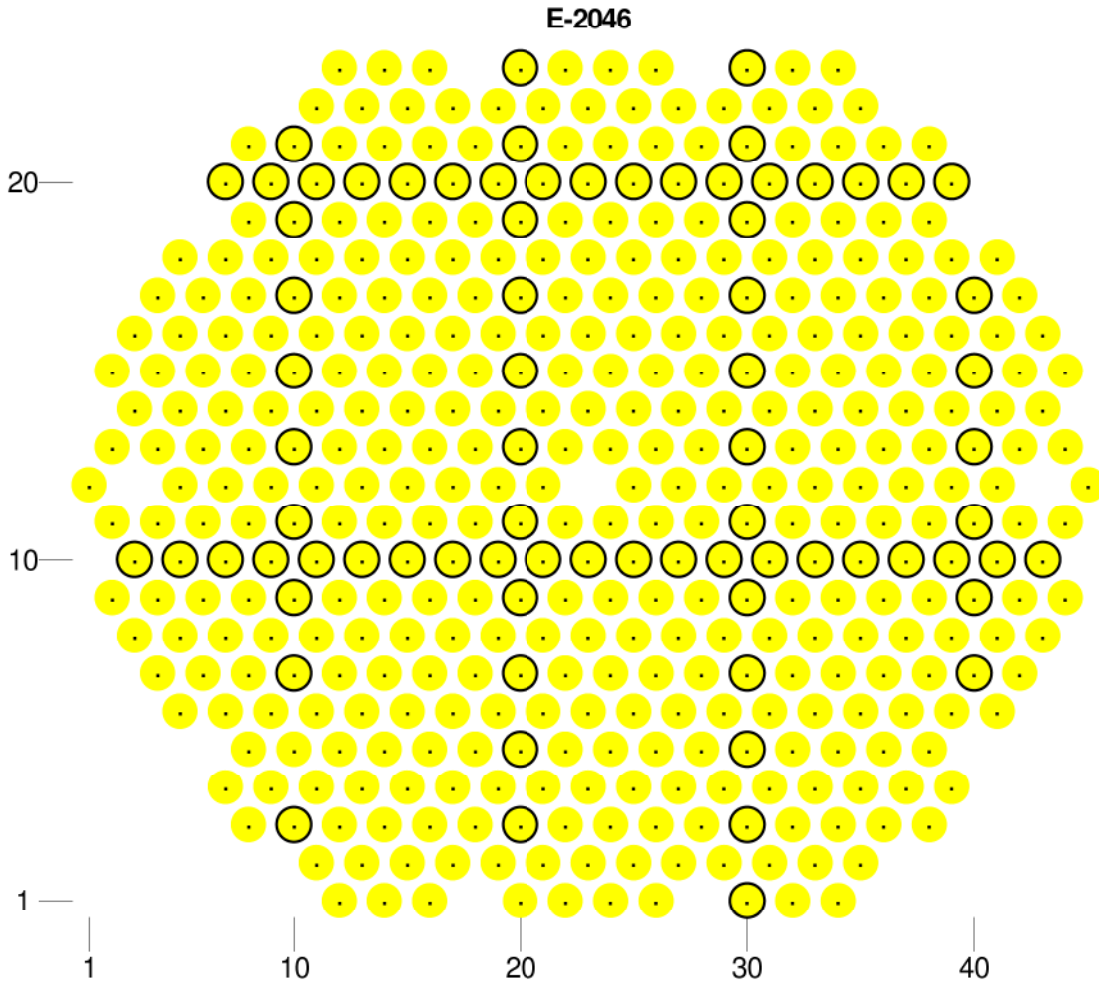
view : Outlet



subject : E-2046
page(s) : 1 from 1
client : Shell UK
site : Gannet Alpha Platform
order-no. : 1698
K.-No. : K055-11
Date : 17:09:2011
Material : Duplex
Tube length : 4100 mm
Ø External : 19.05 mm
Ø Internal : 14.83 mm
Wall thickness : 2.11 mm
WinDevos Ver. 2.09.1120 build 2323



APPENDIX 02



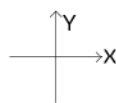
internal defects

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

external defects

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

view : Outlet



- No Defect
- Dent
- Not Decideable
- Existing Plug(s)
- No Throughpass of Probe

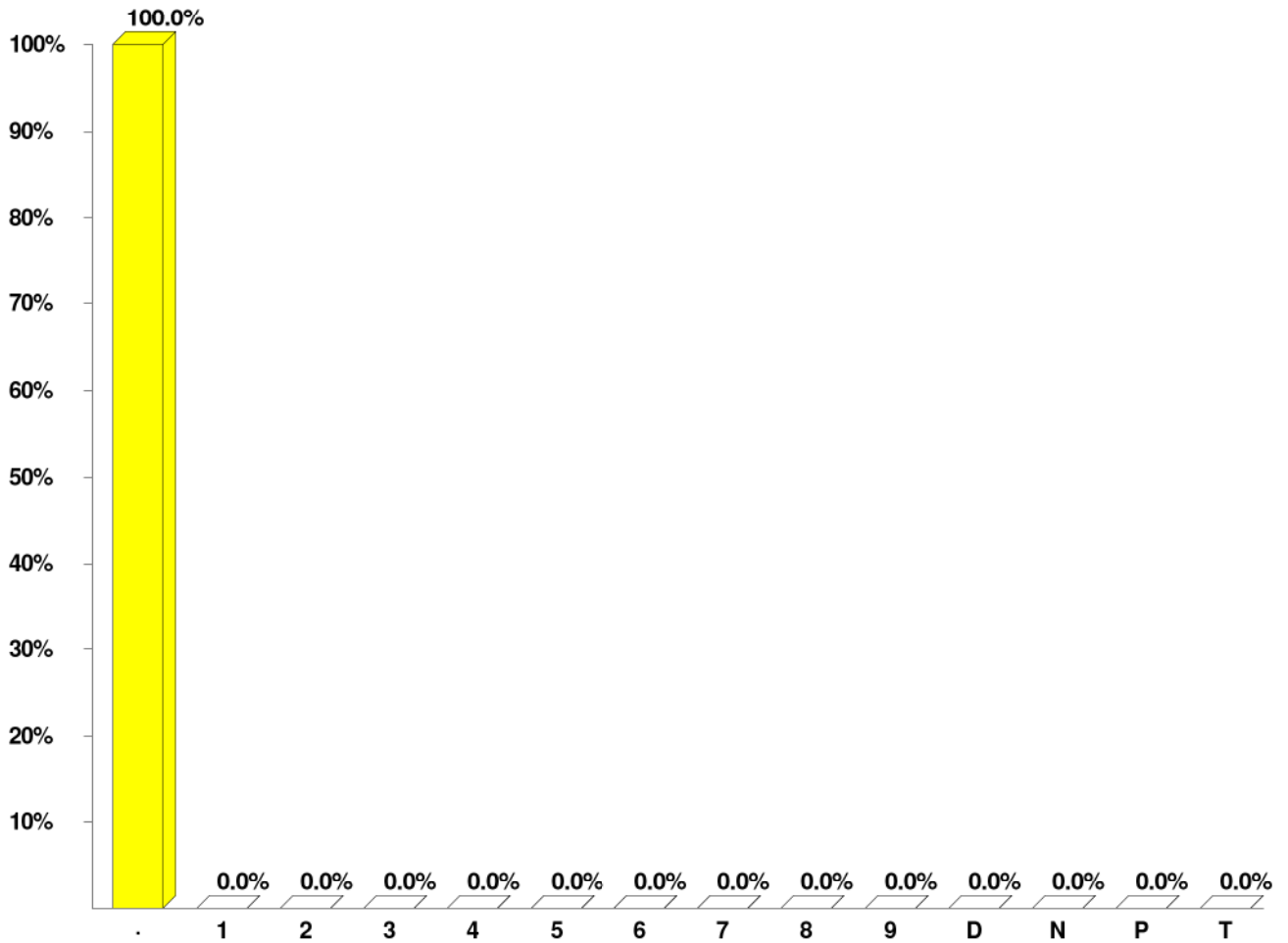
- Tube Not To Be Inspected
- Tube To Be Inspected

subject : E-2046
 page(s) : 1 from 1
 client : Shell UK
 site : Gannet Alpha Platform
 order-no. : 1698
 K.-No. : K055-11
 Date : 17:09:2011
 Material : Duplex
 Tube length : 4100 mm
 Ø External : 19.05 mm
 Ø Internal : 14.83 mm
 Wall thickness : 2.11 mm
 WinDevos Ver. 2.09.1120 build 2323



APPENDIX 03

**E-2046 - Statistic
final result - all section
(100% = all tubes)**



[1] : all tubes	414		
[2] : all tubes with indication	0	0.0% from [1]	
[3] : all inspected tubes	414	100.0% from [1]	
internal defects	number	% [1]	% [2] % [3]
1 10 % - 19 %	0	0.0	0.0
2 20 % - 29 %	0	0.0	0.0
3 30 % - 39 %	0	0.0	0.0
4 40 % - 49 %	0	0.0	0.0
5 50 % - 59 %	0	0.0	0.0
6 60 % - 69 %	0	0.0	0.0
7 70 % - 79 %	0	0.0	0.0
8 80 % - 89 %	0	0.0	0.0
9 90 % - 100 %	0	0.0	0.0
external defects	number	% [1]	% [2] % [3]
1 10 % - 19 %	0	0.0	0.0
2 20 % - 29 %	0	0.0	0.0
3 30 % - 39 %	0	0.0	0.0
4 40 % - 49 %	0	0.0	0.0
5 50 % - 59 %	0	0.0	0.0
6 60 % - 69 %	0	0.0	0.0
7 70 % - 79 %	0	0.0	0.0
8 80 % - 89 %	0	0.0	0.0
9 90 % - 100 %	0	0.0	0.0
	number	% [1]	% [2] % [3]
- No Defect	414	100.0	100.0
D Dent	0	0.0	0.0
N Not Decidable	0	0.0	0.0
I No Throughpass of Probe	0	0.0	0.0
P Existing Plug(s)	0	0.0	0.0
○ Tube Not To Be Inspected	0	0.0	0.0
● Tube To Be Inspected	0	0.0	0.0
V Additional plug(s) required	0	0.0	0.0
X Extra Plugging Requested	0	0.0	0.0

subject : E-2046
 section : all
 client : Shell UK
 site : Gannet Alpha Platform
 order-no. : 1698
 K.-No. : K055-11
 Date : 17:09:2011
 Material : Duplex
 length of leg : 4100 mm
 Ø External : 19.05 mm
 Ø Internal : 14.83 mm
 Wall thickness : 2.11 mm
 WinDevos Ver. 2.09.1120 build 2323

test parameter
 Operator : Alen Ennis
 equipment : TMT.eddyMax
 Probe type : MagBias
 Cal. Tube : 6059-1&2 Inno
 Cal. Defect : 40% @ 4 S.Div
 frequency : 20 kHz

Plug criteria
 internal defects : From: 40%
 external defects : From: 40%
 D, T

updated:
 plugged tubes: 0 0.0%
 available tubes: 414 100.0%