EddyMax™ Tube Inspection

Client:	**Client a**
Facility:	**site b**
Items Inspected:	**Inlet Heater**
Inspection Method:	**Eddy Current Tube Inspection**
Commencement Date:	**28th June 2016**
Completion Date:	**29th June 2016**
Type of Report:	**Final Report**
Report Number:	**K078-xx**
Job Number:	**J20xx**

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Executive Summary

Innospection Ltd was requested by Client A, to perform a Multiple Frequency Eddy Current Tube inspection on the Inlet Heater.

The inspection was conducted at site b, on the 28th June 2016 and was completed by the 29th June 2016.

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

A reduced probe diameter was required for this inspection; with many of the tubes originally attempted, found to give a no-throughpass to the original bobbin probe selected (this with the best diameter suited for this dimension of tubing.

Despite the reduction in the probe diameter (and fill factor), it can be seen that a total of 188 tubes still refused to allow a successful bobbin probe through-pass.

The Multiple Frequency Eddy Current Tube inspection indicated 77 tubes, where internal pitting was detected.

Table of Contents

Appendix

1. Test Object Data

Object Identification : Inlet Heater

Location of Object : Site a

Orientation of Object : Horizontal

Tube Dimensions :
OD : 25.4 mm
Wall Thickness : 2.108 mm
Length : 2150 mm

Material : Stainless Steel (316L)

No. of Tubes / Legs : 1450 Straight tubes / 725 U-Bends

2. Inspection Task

As requested by Client a, a Multiple Frequency Nfe Eddy Current Tube Inspection was performed on the Inlet Heater, located onboard the site a on the 28th June 2016 until the 29th June 2016.

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

The inspection was performed as a general routine inspection.

3. Inspection Personnel

Inspection Supervisor : Name 1
PCN Level 2 / 000000.

Inspection Operator : Name 2
PCN Level 2 / 000000.

4. Inspection Equipment

4.1. EddyMax™ Equipment

The inspection equipment consisted of the following:

Inspection System :	Multiple Frequency Eddy Current System Type: EddyMax™ Beltronic Serial No. EMC02/07.01 Software Version EddyMax/Tube Max
Differential Channels :	4
Absolute Channels :	4
Mixed Channels :	6
Analysis :	Automatic analysis in differential mode Manual analysis in absolute mode

4.2. Probes

The following probe was used:

- Bobbin type probe
  Serial No. : YB07/076
  Type : TMT B-D-ID
  Diameter : Ø 18.5mm with a reduced Fill Factor of 76%

4.3. Calibration Tubes

The following calibration tubes had been used:

- Innospection Calibration Tubes
  Serial No. : 3038 -1 & 2
  Dimensions : Ø 25.4 mm x WT 2.108 mm
  Material : 316L
  Calibration standard with reference to ASME V Sec. 8

5. Equipment Setting & Calibration

5.1. Settings

- Differential Channel CH1**
  Frequency : 100 KHz
  LP Filter : 300 Hz
  HP Filter : Off

- Differential Channel CH2**
  Frequency : 50 KHz
  LP Filter : 300 Hz
  HP Filter : Off

- Absolute Channel CH3**
  Frequency : 100 KHz
  LP Filter : 30 Hz
  HP Filter : Off

- Absolute Channel CH4**
  Frequency : 50 KHz
  LP Filter : 30 Hz
  HP Filter : Off

- Mixed Channels CH5 **
  Source : example - CH1 / CH2
  Baffle Mix

5.2. Calibration Settings

- **Differential Channels**
  1.5mm Ø (TWH) through wall hole
  Sensitivity set @ 3.5 screen divisions (peak to peak) downwards direction first.

  100% through wall depth signal to be in line with the 100% depth indicated on the phase curve @ 45 degrees (ASME - standard).

- **Absolute Channels**
  Maximum internal and external thinning (usually 40%) set per channel @ 6.0 screen division's peak, in either the horizontal or vertical phase directions.

5.3. Analysis Threshold Settings

The differential channels were set to give an automated signal evaluation threshold of 1.0> divisions.

All absolute channels were set to give a manual signal evaluation threshold of >6.0 divisions peak.

5.4. Calibration Data Storage

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

6. Inspection Procedures

The inspection was performed according to the following valid procedure:

EddyMax™ Tube Inspection Equipment, according to Nfe Tube Inspection Procedure No. InnoTEdmNFE-001-08 – Current Issue

7. Inspection Performance

The inspection was performed with a manual probe drive.

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

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

The tubes were inspected for localised defects and corrosion / erosion damage (with the exception of the tube ends located within the tube end-plates that cannot be inspected with this technique).

8. Defect Analysis

The inspection was set up to inspect the straight tube ligaments, with the exception of the tube within the tube-plates.

The differential channels were used to detect and analyse localised defects, such as pitting or general corrosion on both sides of the tube wall.

The absolute channels were used to identify general wall loss, such as thinning or erosion on both sides of the wall.

The analysis of indications was done online through the software system, with the final confirmation completed by the technician. The confirmed results were transferred straightaway and automatically into the reporting system.

Typically, indications displaying a wall loss of above 10%> are analysed and reported on. Mixed channels were set up to identify possible defects at the baffle/support plates or to separate possible false calls from non-relevant indications.

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.

9. Comments to Inspection

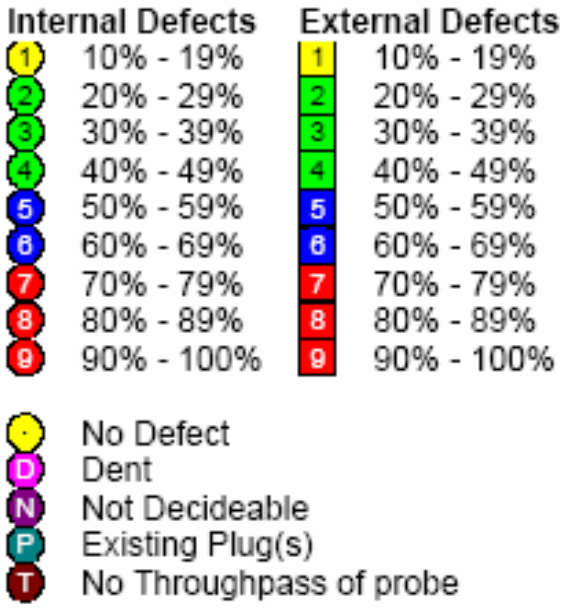
The probe diameter was reduced giving a fill factor of 76% thus to maximise the inspection possibility due to a significant hydrocarbon build up, found within these particular tubes.

10. Result Overview

10.1. Result Information

The following Windevos™ results are included in this documentation:

- **Defect picture "Final Results"**
  This diagram shows an overview of the whole tubesheet, with the inspection results indicated for each tube examined. The largest indication analysed in a particular tube, is highlighted by a number referencing to the below wall loss legend. For example where a "6" appears, an indication with a depth in the range of 60% to 69% of the tube wall thickness was the largest indication located in that particular tube. Furthermore circles represent internal indications, where squares represent external indications.



- **Statistics**
  This is an overall statistical representation of the total inspection data.

- **Tube Array**
  A display of the tube sheet layout provided for reference only.

10.2. Result Overview

A summary of the inspection findings is given below:

Total number of tubes	: 1450
Total number of tubes inspected	: 1450
Total number of tubes with no through pass	: 188
Number of tubes with existing plus	: 0
Number of tubes with indication other than defects	: 0

Number of tubes identified with main internal indications

10% - 19% internal wall loss	: 0 tubes
20% - 29% internal wall loss	: 38 tubes
30% - 39% internal wall loss	: 26 tubes
40% - 49% internal wall loss	: 13 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 tubes 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

11. Inspection Summary

The outlet tubes were noted to have suffered the most significant wall loss:-

38 tubes with 20-29% Internal Pitting
26 tubes with 30-39% Internal Pitting
13 tubes with 40-49% Internal Pitting

Although these tubes had been cleaned within the unit, hydrocarbon build had not been successfully removed causing many tubes to disrupt successful passage of the bobbin probe.

A probe diameter with a reduced fill factor was chosen for this particular inspection; with many of the tubes originally attempted, giving no-throughpass to the most suitable bobbin probe selected and suited for this dimension of tubing.

Despite the reduction in the probe diameter, it can be seen that a total of 188 tubes still refused to allow a successful bobbin probe through-passage.

The Multiple Frequency Eddy Current Tube inspection indicated 77 total tubes, where internal pitting was detected.

12. Documentation

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

13. Signature

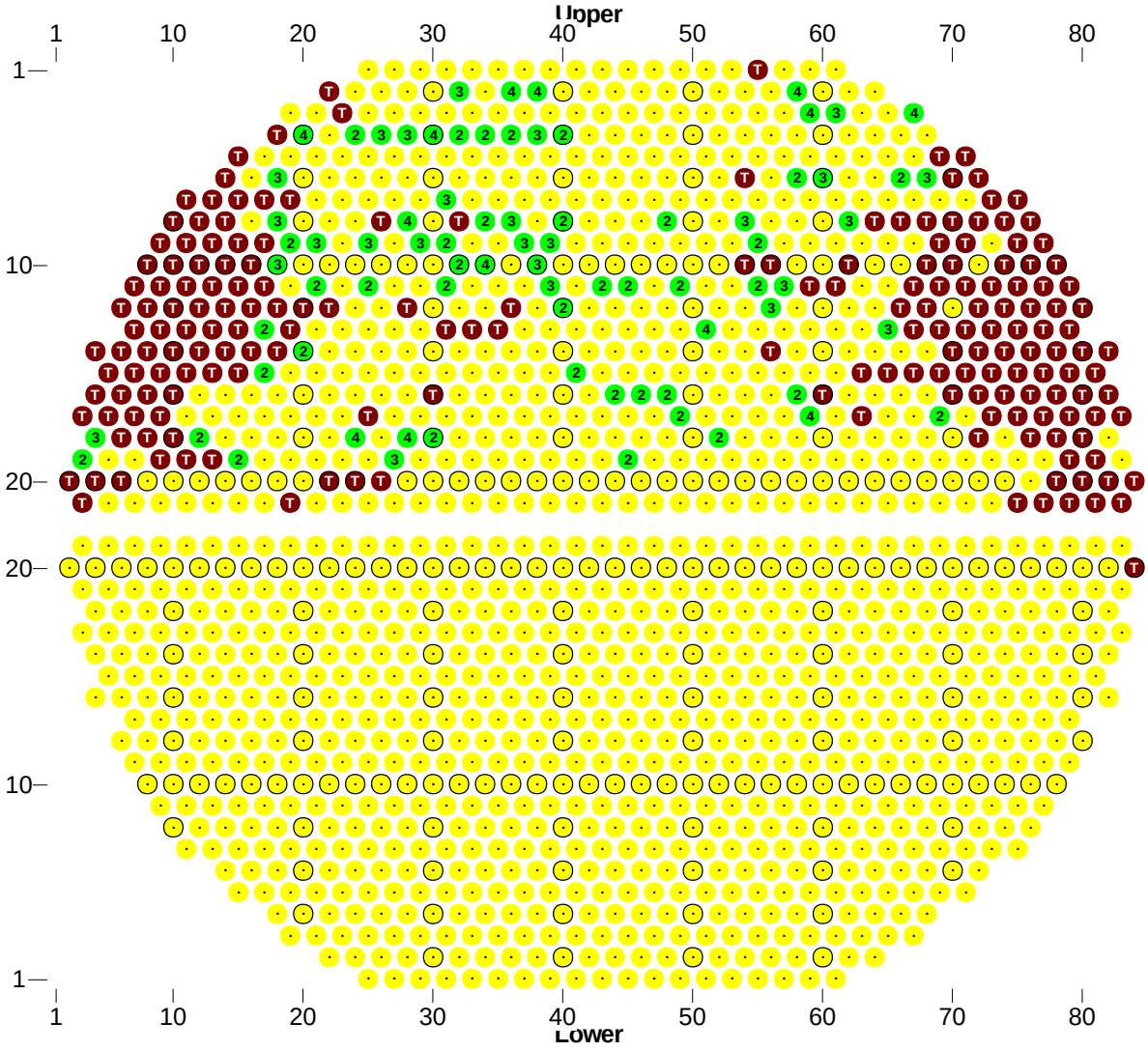
Name 1
NDT Tech
Innospection Limited

Name 3
Level 3 Inspection Engineer
Innospection Limited

APPENDICES

WinDevos Results

Abbot Inlet Heater
Defect Picture
final result - Diff/Abs



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 %

- No Defect
- D Dent
- N Not Decideable
- P Existing Plug(s)
- T No Throughpass of Probe

view : /tubeface

Y
X
Y

- Tube Not To Be Inspected
- Tube To Be Inspected

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subject	: Abbot Inlet Heater
page(s)	: all
client	: Client a
site	: Site b
order-no.	: 20xx
K.-No.	: 078-xx
Date	: 6/28/16
Material	: 316LS
length of leg	: 2150 mm
Ø External	: 25.40 mm
Ø Internal	: 21.18 mm
Wall thickness	: 2.11 mm

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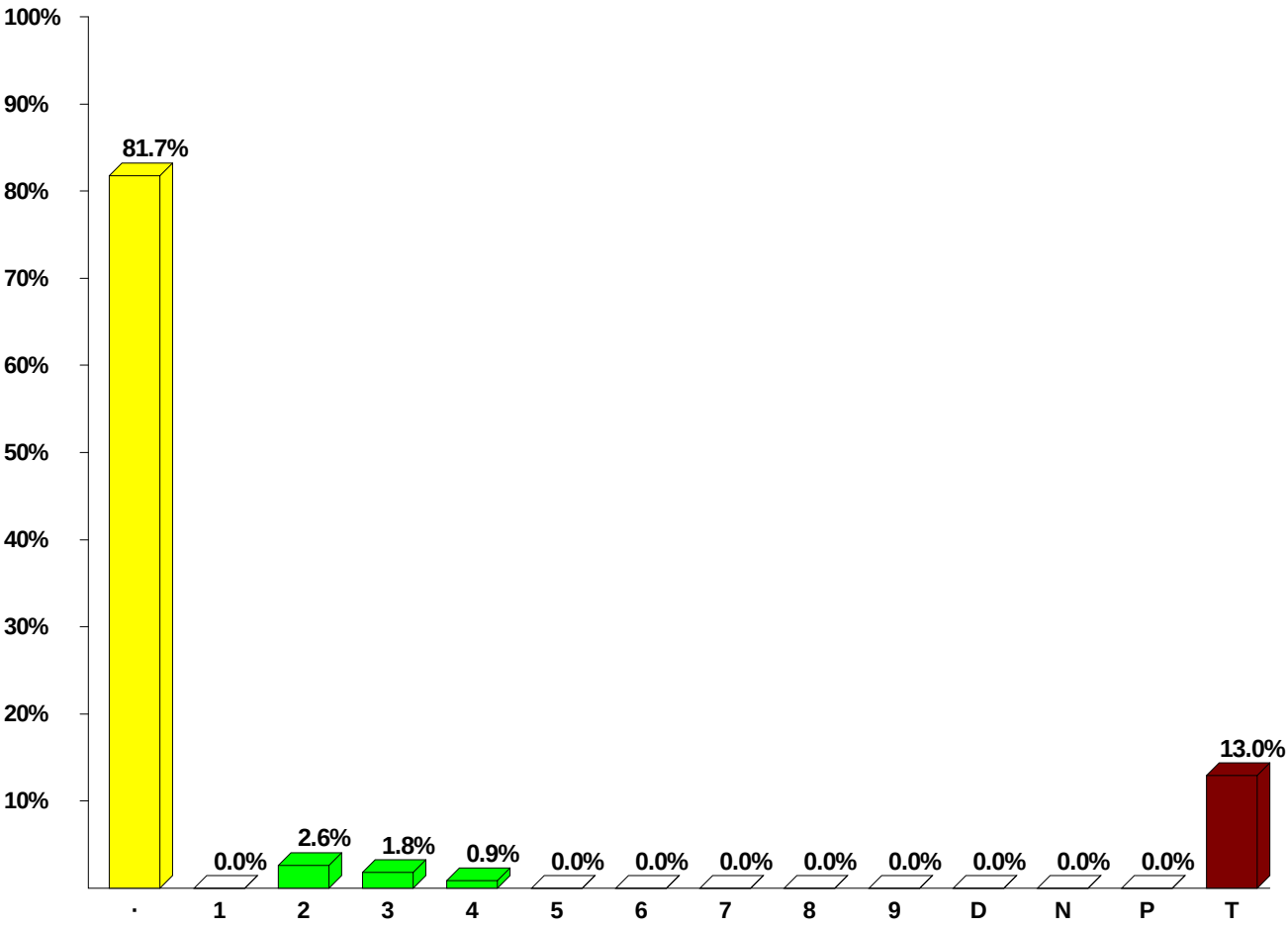
Abbot Inlet Heater - Statistic
final result - Diff/Abs - all section
(100% = all legs)



[1] : all legs		**1450**		
[2] : all legs with indication		**265**	**18.3% from [1**	
[3] : all inspected legs		**1450**	**100.0% from [1**	
internal defects	**number**	**% [1]**	**% [2]**	**% [3]**
1 10 % - 19 %	0	0.0	0.0	0.0
2 20 % - 29 %	38	2.6	14.3	2.6
3 30 % - 39 %	26	1.8	9.8	1.8
4 40 % - 49 %	13	0.9	4.9	0.9
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 %	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
	number	**% [1]**	**% [2]**	**% [3]**
· No Defect	1185	81.7		81.7
D Dent	0	0.0	0.0	0.0
N Not Decideable	0	0.0	0.0	0.0
T No Throughpass of Probe	188	13.0	70.9	13.0
P Existing Plug(s)	0	0.0		
Tube Not To Be Inspected	0	0.0		
Tube To Be Inspected	0	0.0		
V Additional plug(s) required	0	0.0		
X Extra Plugging Requested	0	0.0		

subject	: Inlet Heater
section	: all
client	: Client a
site	: Site b
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K.-No.	: 078-xx
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length of leg	: 2150 mm
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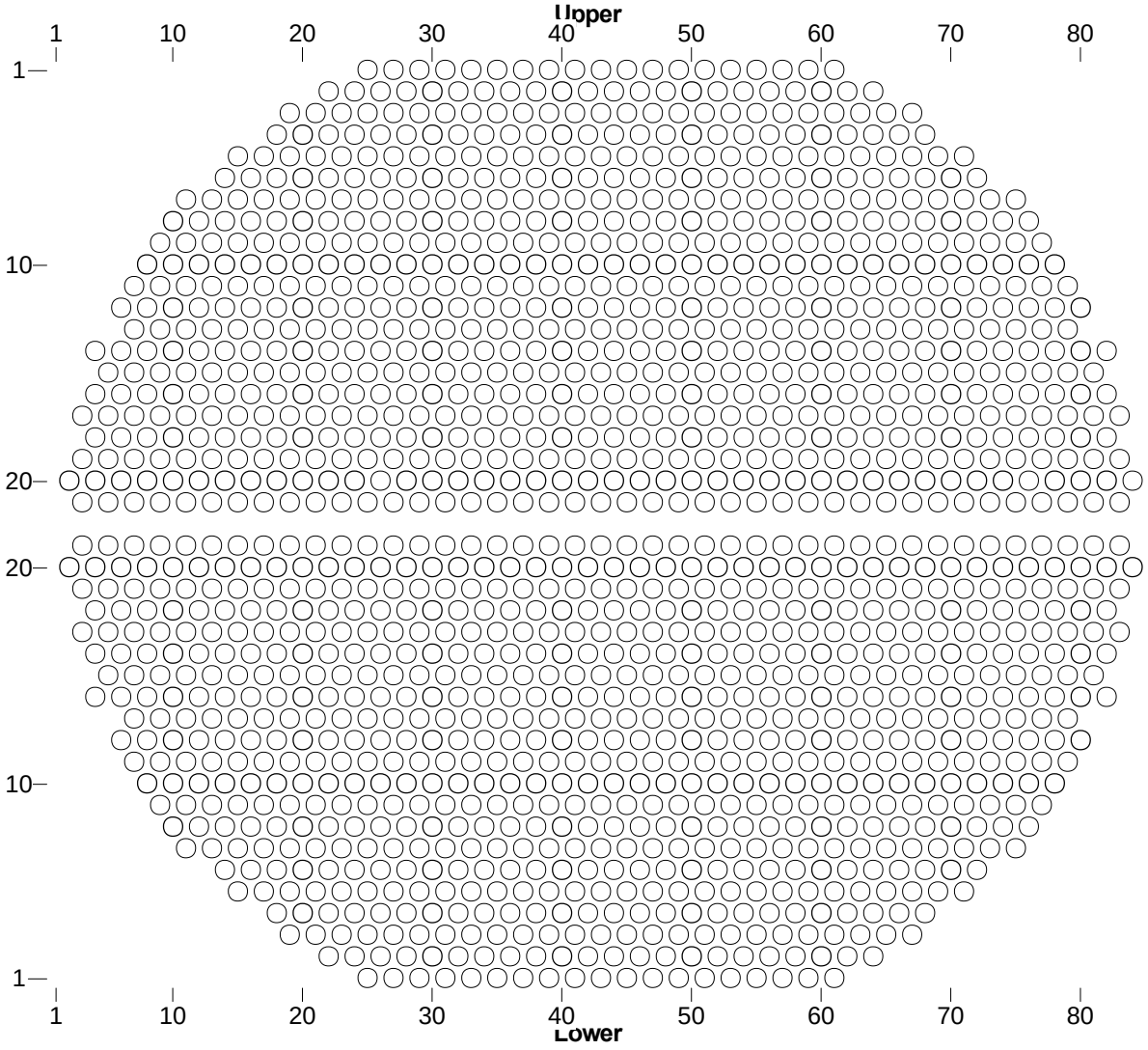
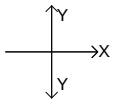
test parameter

Operator	: SA
equipment	: TMT.eddyMax
Probe type	: ET
Cal. Tube	: Inno Stock
Cal. Defect	: TWH@3.5Div
frequency	: 100 kHz

Abbot Inlet Heater
Tube Array



view : /tubeface



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