DC Magnetic Biased Tube Inspection

Client:	**Client a**
Facility:	**site b**
Items Inspected:	**Cooler B** **Cooler C**
Inspection Method:	**DC Magnetic Biased Tube Inspection**
Commencement Date:	**28th September 2016**
Completion Date:	**17th October 2016**
Type of Report:	**Final**
Report Number:	**Kxx0-16**
Job Number:	**Jxx10**

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Fe TUBE INSPECTION REPORT

(DC Magnetic Biased Eddy Current)

Executive Summary

Innospection Ltd was requested by Client a to perform a DC Magnetic Biased Eddy Current Tube inspection, on the Coolers identified as B and C.

The inspection was conducted via two separate trips, made out to the Murdoch Platform.

The first trip for Cooler A from the 28th September and completed on the 05th October, with the second trip for Cooler B being made from the 12th October and completed on the 17th October.

This inspection report documents in detail the specific inspection that has been conducted; the individual technique and equipment utilised and the results obtained.

The DC Magnetic Eddy Current Tube inspection conducted indicated no significant and/or reportable indications within the inspected fin-fan tubing banks.

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1. Test Object Data

Object Identification : Cooler A
Cooler B

Location of Object : Site b

Orientation of Object : Horizontal

Tube Dimensions :
OD : 25.4 mm
Wall Thickness : 1.65 mm
Length : 9600 mm

Material : A789 Duplex

No. of Tubes / Legs : 1484 Fin Fan Tubes (6 Banks)

2. Inspection Task

As requested by Client a, a DC Magnetic Biased Eddy Current Tube Inspection was performed on Coolers A and B, these being located at site b and inspected from the 28th September 2016 to the 17th October 2016 in two separate visits.

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

The inspection was performed as a general inspection during the plant shutdown.

3. Inspection Personnel

Inspection Operator : Technician a
ET level 2 / 000000

Inspection Assistant : Technician b
ET level 2 / 000000

4. Inspection Equipment

4.1. EddyMax™ (DC Magnetic Biased) Equipment

The inspection equipment consisted of the following:

Inspection System :	Multiple Frequency Eddy Current System Type : EddyMax™ Beltronic Serial No EMC 04/11.01 Software Version EddyMaxV3
Differential Channels :	4
Absolute Channels :	4
Mixed Channels :	6
Analysis :	Manual analysis in differential mode

4.2. Magnetic Biased DC Power Supply

State amperage used 40V / 1.20A

4.3. Probes

The following probe was used:

- Magnetic Biased Eddy Current probe
  Serial No. : 09/021
  Type : D-B-ID MA
  Diameter : Ø 21 mm with fill factor 90 %

4.4. Calibration Tubes

The following calibration tube was used:

- Innospection Calibration Tube
  Serial No. : 6063
  Dimensions : Ø 25.4 mm x WT 1.65 mm
  Material : A789 Duplex
  Calibration standard with reference to ASME V Sec. 8

5. Equipment Setting & Calibration

5.1. Settings

- Differential Channel CH1
  Frequency : 30 KHz
  LP Filter : 300 Hz
  HP Filter : Off

- Differential Channel CH2
  Frequency : 15 KHz
  LP Filter : 300 Hz
  HP Filter : Off

5.2. Calibration Settings

- **Differential Channels**
  40% External Flat Bottom Hole
  Sensitivity set @ 4.0 screen divisions (peak to peak) downwards direction first.

5.3. Analysis Threshold Settings

The differential channels were set on 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.

6. Inspection Procedures

The inspection was performed according to the following valid procedure:

EddyMax™ Tube Inspection Equipment, according to DC Magnetic Biased Tube Inspection Procedure No. Inno TEdmFMB-001-09 – 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, and the zone directly adjacent to the tubesheet face, with exception to the tube material lying directly within the tube-plates.

The differential channels were used to detect and analyse any localised defects, such as pitting or general corrosion on both sides of the tube 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 wall loss of above 20%> 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.

9. Comments to Inspection

The inspection was split over two separate visits, whilst deposits were removed from all of the 6 banks.

Cooler B was inspected on the 1st visit, and Cooler C inspected on the 2nd visit.

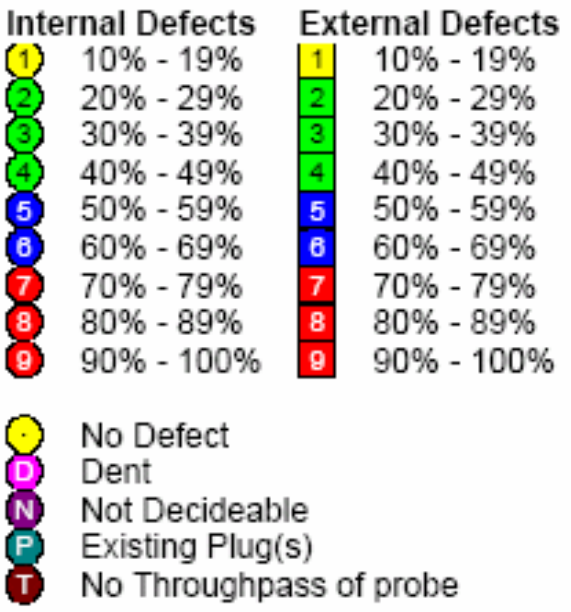
After issues with cleanliness in previous inspections, after cleaning the tubes were found to be clear from deposits and blockages enabling a 100% inspection of the tubes.

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 : 1472
Total number of tubes inspected : 1472
Total number of tubes with no through pass : 0
Number of tubes with existing plug : 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 : 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 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

Plugging Criteria

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

Internal Wall Loss	External Wall Loss	Other Criteria	No. of Tubes To be Plugged
0 %	0 %	0	0 tubes

11. Inspection Summary

During this inspection no significant indications were observed within each of the six banks inspected.

12. Documentation

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

13. Signature

Technician a
NDT Technician
Innospection Limited

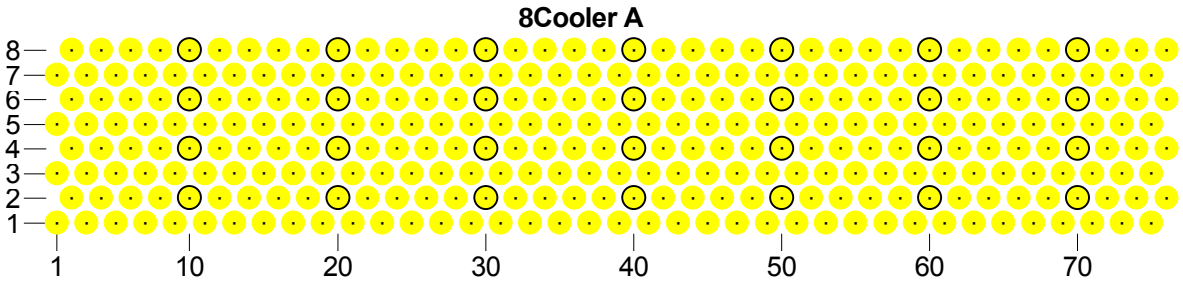
Level 3
Senior Inspection Engineer
Innospection Limited

APPENDIX 01

Defect Picture, Statistical Overview &Tube Array

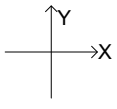
Cooler A

Cooler A
Defect Picture
final result



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 : Inlet



- No Defect
- D Dent
- N Note
- P Existing Plug(s)
- T No Through pass of probe

- Tube Not To Be Inspected
- Tube To Be Inspected

subject : Cooler A
page(s) : 1 from 1
client : Client a
site : Msite b
order-no. :
K.-No. : K-xx0-16
Date : 17.10.2016
Material : A789 Duplex
Tube length : 9600 mm
Ø External : 25.40 mm
Ø Internal : 22.10 mm
Wall thickness : 1.65 mm

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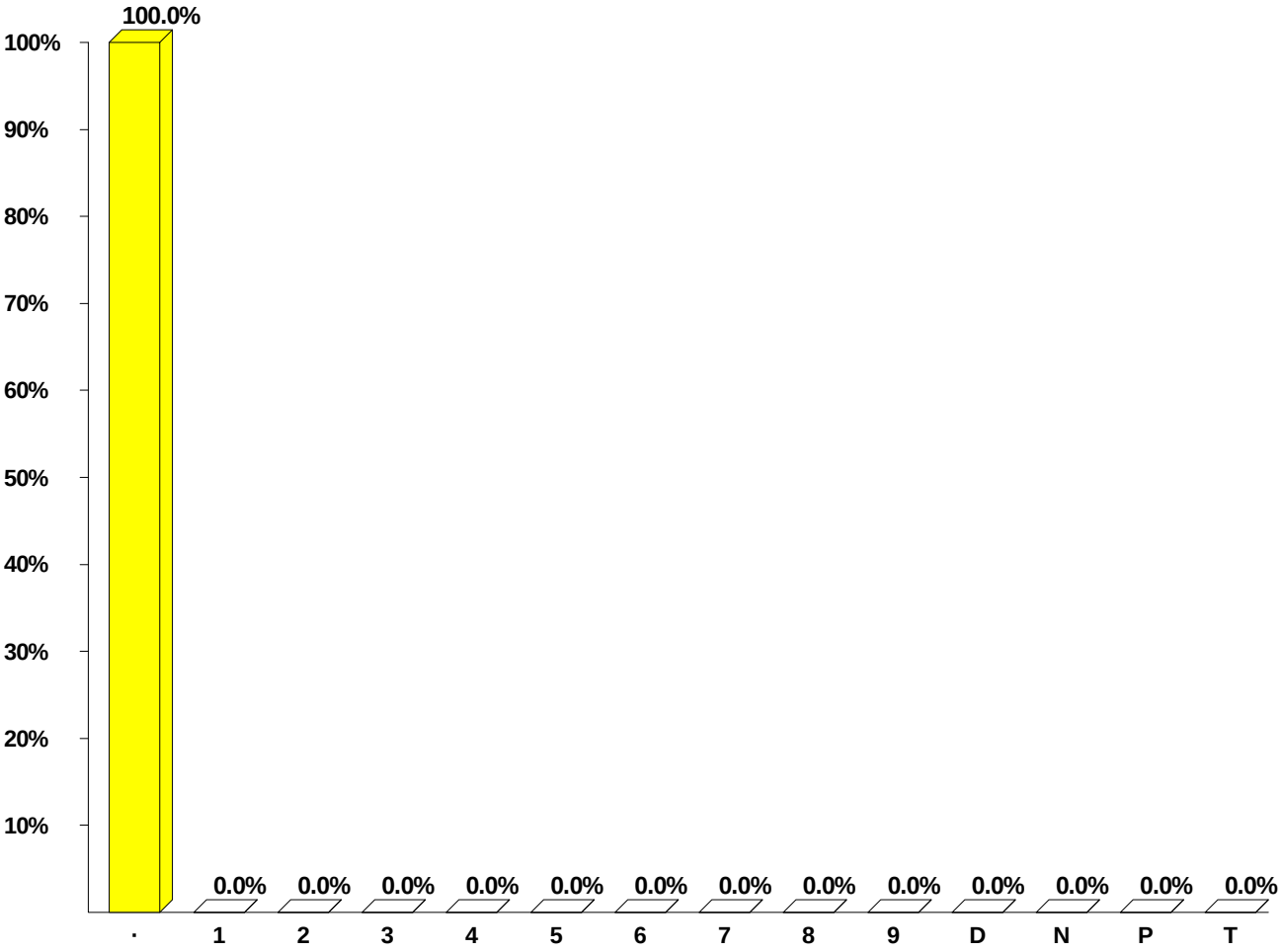
Cooler A - Statistic
final result - Cooler A
(100% = all tubes)



[1] :	**all tubes**		**304**		
[2] :	**all tubes with indication**		**0**	**0.0% from [1**	
[3] :	**all inspected tubes**		**304**	**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	304	100.0		100.0
D	Dent	0	0.0		0.0
N	Note	0	0.0		0.0
T	No Through pass of probe	0	0.0		0.0
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	: Cooller A
section	: Cooler A
client	: Client a
site	: site b
order-no.	:
K.-No.	: K-xx0-16
Date	: 17.10.2016
Material	: A789 Duplex
Tube length	: 9600 mm
Ø External	: 25.40 mm
Ø Internal	: 22.10 mm
Wall thickness	: 1.65 mm

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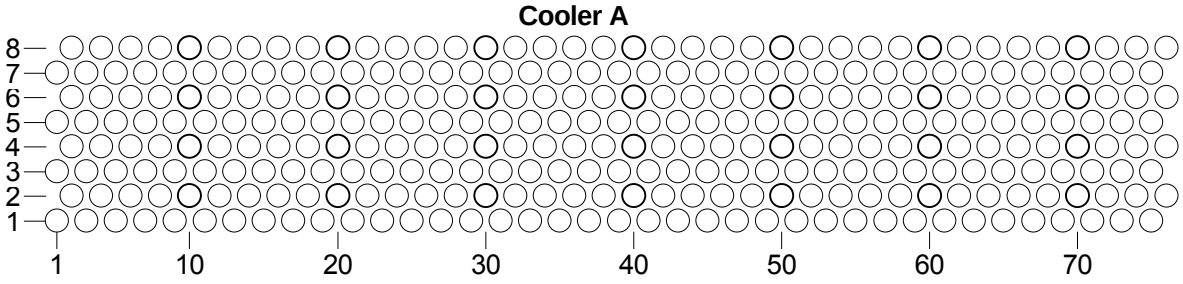
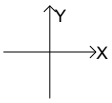
test parameter

Operator	: GN & LS
equipment	: TMT.eddyMax
Probe type	: MB
Cal. Tube	: Inno
Cal. Defect	: 40%@4SD
frequency	: 30 kHz

Cooler A
Tube Array



view : Inlet



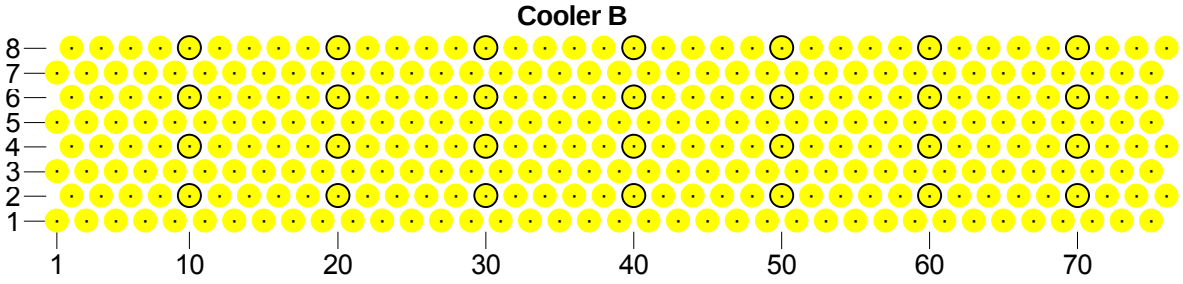
subject : Cooler A
page(s) : 1 from 1
client : Client b
site : site b
order-no. :
K.-No. : K-xx0-16
Date : 17.10.2016
Material : A789 Duplex
Tube length : 9600 mm
Ø External : 25.40 mm
Ø Internal : 22.10 mm
Wall thickness : 1.65 mm

APPENDIX 02

Defect Picture, Statistical Overview &Tube Array

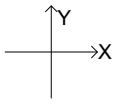
Cooler B

Cooler B
Defect Picture
final result



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 : Inlet



- No Defect
- D Dent
- N Note
- P Existing Plug(s)
- T No Through pass of probe

- Tube Not To Be Inspected
- Tube To Be Inspected

innospection

subject : Cooler B
page(s) : 1 from 1
client : Client a
site : site b
order-no. : Cooler B
K.-No. : K-xx0-16
Date : 17.10.2016
Material : A789 Duplex
Tube length : 9600 mm
Ø External : 25.40 mm
Ø Internal : 22.10 mm
Wall thickness : 1.65 mm

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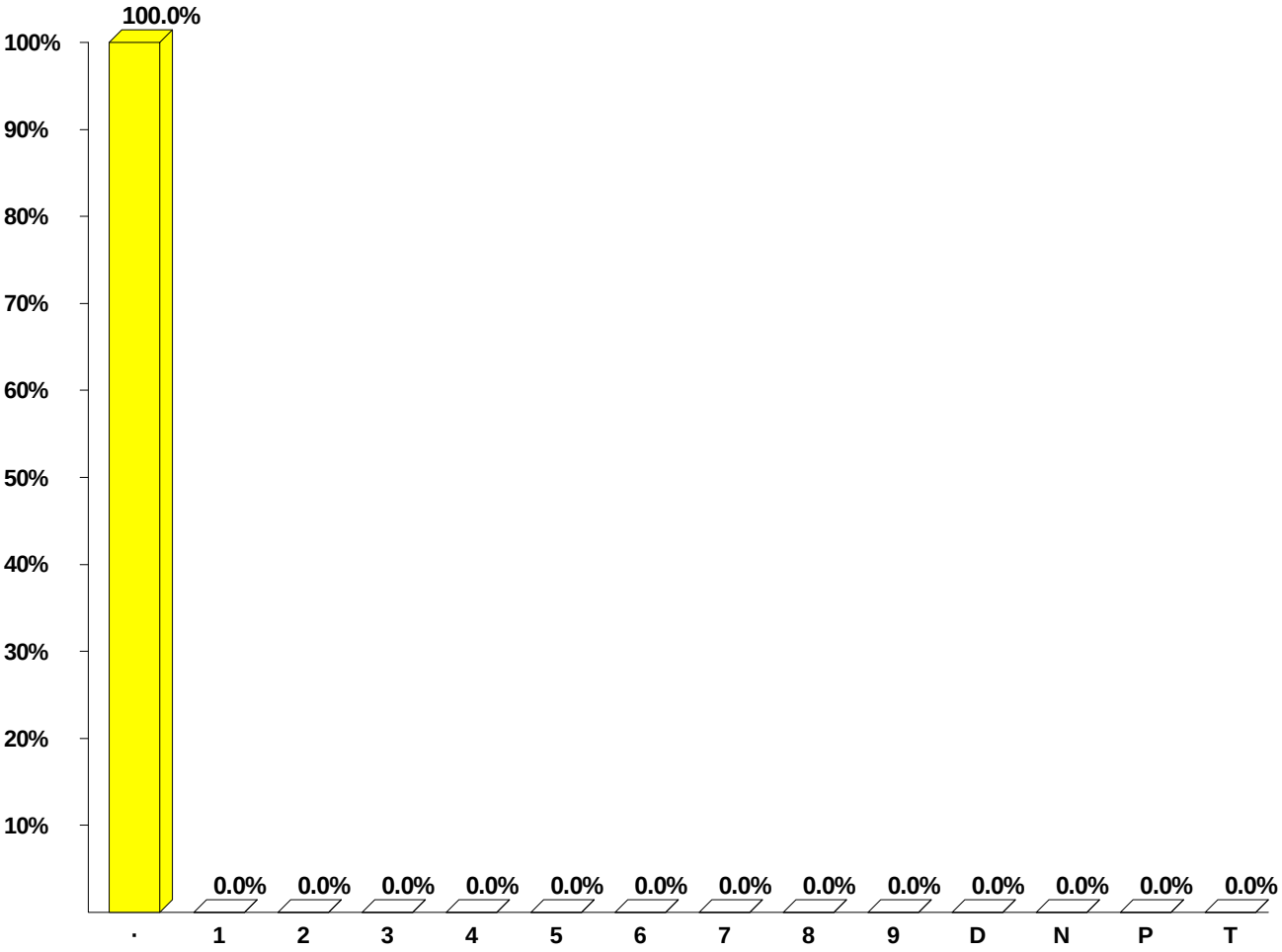
Cooler B - Statistic
final result - 83D-EB6201B
(100% = all tubes)



[1] : all tubes		**304**		
[2] : all tubes with indication		**0**	**0.0% from [1**	
[3] : all inspected tubes		**304**	**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	304	100.0		100.0
D Dent	0	0.0		0.0
N Note	0	0.0		0.0
T No Through pass of probe	0	0.0		0.0
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		

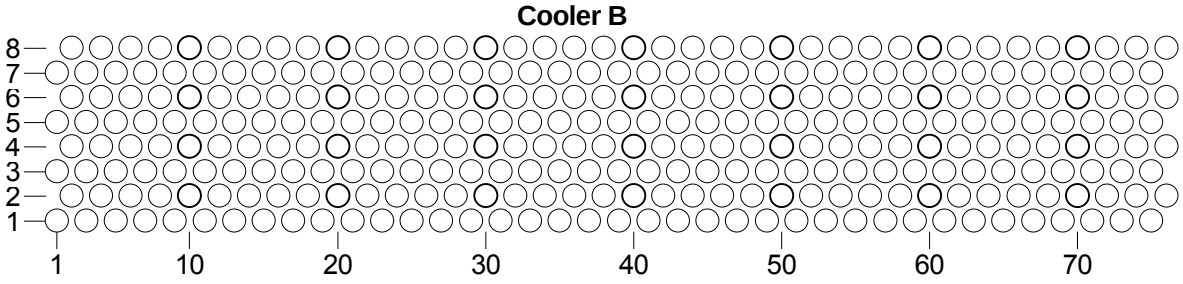
subject	: Cooler B
section	: Cooler B
client	: Client a
site	: site b
order-no.	: Cooler B
K.-No.	: K-110-16
Date	: 17.10.2016
Material	: A789 Duplex
Tube length	: 9600 mm
Ø External	: 25.40 mm
Ø Internal	: 22.10 mm
Wall thickness	: 1.65 mm

WinDevos Ver. 2.09.1120 build 2323

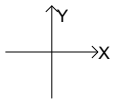
test parameter

Operator	: GN & LS
equipment	: TMT.eddyMax
Probe type	: MB
Cal. Tube	: Inno
Cal. Defect	: 40%@4SD
frequency	: 30 kHz

Cooler B
Tube Array



view : Inlet



subject : Cooler B
page(s) : 1 from 1
client : Client a
site : site b
order-no. : Cooler B
K.-No. : K-xx0-16
Date : 17.10.2016
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