Haizea Wind S.L.
Muelle AZ-2.
48508 Zierbana – Bizkaia (Spain).

Fecha: 22/07/2019
Su ref: Renexia OWF Taranto.
Ntr. ref: ERR

Subject: Renexia Offshore Wind Farm, Taranto.

RFQ-2019-1074 HWB-18042-REN : Hempel's Systems.

Hereby, it is informs about the specified Hempel's systems for the above project based on the new ISO 12944:2018.

"AERIAL ZONE".

System nº 1 of Norsok M 501-Rev.6:2012 std. or CX (ISO 12944-9:2018):

- 1 x 60µ – HEMPADUR AVANTGUARD 750 – 1736G Grey 19840.
- 1 x 160µ – HEMPADUR 47300 Grey 12170.
- 1 x 60µ – HEMPEL'S PRO-ACRYLIC 55883-27230 (OTC free), instead of HEMPATHANE HS
- 55610-27230.
- Total: 280 microns.

- Test made for the above system:

- 4200 hours of Cyclic Ageing Test according to Annex B of ISO 12944-9:2018.

- ***According to the report "RDK1916609 LAB19-0058-REP Rev. 1 CX (1)" made by COT lab, it can see that the system fulfils the requirements for CX (ISO 12944-9:2018) also equivalent to System nº 1 of Norsok M 501-Rev.6:2012 (ISO 20340:2009).***

"SPLASH ZONE".

System 7A of Norsok M 501-Rev.6:2012 o C5-M and Im2 (ISO 20340:2009) / CX and Im4 (ISO 12944-9:2018):

- 1 x 350µ – HEMPADUR MS 35840 Grey 17380 (Glass Flake Epoxy).
- 1 x 350µ - HEMPADUR MS 35840 Yellow 27230 (Glass Flake Epoxy).

- Tests made for the above systems:

- 4200 hours of Cyclic Ageing Test according to ISO 20340:2009 (Annex A) standard. This test is exactly the same as ISO 12944-9:2018 (Annex B). The criterions to do the tests and the evaluation methods are exactly the same. There only is a change to evaluate the adhesion strength before doing the tests: The minimum value if from 3 MPa to 5 MPa.

- 4200 hours of Sea Water Immersion test according to ISO 2812-2 (ISO 20340:2009). In the new ISO 12944-9:2018, the method to do the test has not changed and based in the same ISO 2812-2, but weather the maximum corrosion from the scribe line: The new requirement is up to ≤ 6.0 mm, and before this value was up to ≤ 8.0 mm.

- 4200 hours of “Cathodic Disbonding Test” according to ISO 15711 (ISO 20340:2009). In this case and for the new ISO 12944-9:2018, the method and requirements are exactly the same.

- ***According to the report “LAB16-0034-REP Rev. 3B S8” made by COT lab, the system fulfils with requirements for “C5-M and Im2” (ISO 20340:2009) and at the same time with requirements for “CX and Im4” (ISO 12944-9:2018).***

“SUBMERGED ZONE”.

Sysstem 7B of Norsok M 501-Rev.6:2012 or Im2 (ISO 20340:2009) / Im4 (ISO 12944-9:2018):

- 1 x 175µ – HEMPADUR MS 45703 Grey 19880.
- 1 x 175µ – HEMPADUR MASTIC 45880 White 10170.

- Tests made for the above systems:

- 4200 hours of Sea Water Immersion test according to ISO 2812-2 (ISO 20340:2009). In the new ISO 12944-9:2018, the method to do the test has not changed and based in the same ISO 2812-2, but weather the maximum corrosion from the scribe line: The new requirement is up to ≤ 6.0 mm, and before this value was up to ≤ 8.0 mm.

- 4200 hours of “Cathodic Disbonding Test” according to ISO 15711 (ISO 20340:2009). In this case and for the new ISO 12944-9:2018, the method and requirements are exactly the same.

- ***According to the report “3410-04-0086 Mt06 Rev.A” made by Teknologisk Institute, the system fulfils the requirements for Im2 (ISO 20340) and at the same time for Im4 (ISO 12944-9:2018).***

Yours faithfully.

Enrique Romero Ruiz.

Protective, Industrial and Marine Division - Technical Sales Manager.

Pinturas Hempel, S.A.U.

PD.: This document are two pages and it shall be joined to the test reports mentioned for each case.

COT bv
Independent advice, research and management for construction and industry

Consultancy
Laboratory

Jan Tademaweg 40
2031 CV Haarlem
P.O. Box 2113
2002 CC Haarlem
The Netherlands
T +31 23-5319544
F +31 23-5277229
E info@cot-nl.com
I www.cot-nl.com

REPORT

Testing coated samples with COT sample number 20-16-18/0420 according to ISO 12944-9 CX

Haarlem, April 2nd, 2019

Client	:	Hempel A/S Lundtoftegårdsvej 91 DK-2800 KGS Lyngby Denmark Contact person: Mrs. V. Stendal Larsen
Project number	:	20180208
Report number	:	LAB19-0058-REP Revision 1
Handled by	:	Mr. P. Grootveld

CONTENTS

1 INTRODUCTION

1.1 Order

By order of Hempel in Lyngby, Denmark, the Centrum voor Onderzoek en Technisch advies (COT bv) in Haarlem, The Netherlands, has tested the samples with COT sample number 20-6-18/0420 according to ISO 12944-9 CX.

The order has been confirmed by email correspondence on 14-06-2018.

Tests marked with 'Q' are under accreditation according to ISO/IEC 17025 with registration number L535.

1.2 General information

Table 1: Received samples

COT sample number	Sample	Received
20-6-18/0420	12 coated steel panels, colour grey, dimensions 75 x 150 x 5 mm, numbered 97 - 108*	20-06-2018

*) numbered by the client.

COT sample number 20-06-18/	Products	Type	Name	Shade	Batch number	Received
0391	Avantguard 750 1736G	base	1736U	19830	048042596	20-06-2018
0392		Curing agent	97043	00000	048030495	
0400	Hempadur 47300	base	47309	12170	047102648	
0401		Curing agent	97301	00000	047121704	
0398	Hempel´s pro acrylic 55883	base	55889	10170	225061003	
0399		Curing agent	97883	00000	045081994	

The coating system has been applied to the test panels by the client. The following information has been received from the client.

Substrate
Steel panels.

Surface preparation
Blasted to Sa 2.5 grade cleanliness according to ISO 8501-1.
Surface roughness Medium (G) according to ISO 8503-1.

Coating system build up and specified dry film thickness
Hempadur Avantguard 750 1736G 19830 : 60 µm
Hempadur 47300 : 160 µm
Hempels pro acrylic 55883 : 60 µm
Total nominal dry film thickness (nDFT) : 280 µm

Test specification : ISO 12944-9
Corrosivity category : CX

2 PROCEDURE

2.1 Determination of the dry film thickness using a magnetic induction gauge, ISO 17025 Scope number 1 (Q)

Before starting the tests the total dry film thickness of the coating system has been measured according to ISO 2808:7C, COT Instruction 30.01.12-2 with a magnetic dry film thickness meter (COT E004). On each panel 5 measurements have been carried out; the minimum, the maximum, the average and the standard deviation have been reported.
and corrected for surface roughness (C = correction value) according to ISO 19840. On each panel 5 measurements have been carried out.

2.2 Adhesion

Before testing the panels have been conditioned for 7 days at 23 ± 2 °C and 50 ± 5 % R.H., the test has been performed under the same conditions. All individual values have been reported.

Depending on the uncorrected DFT of the coating system, the following methods are used:
- If lower or equal to 250 micrometers: cross-cut method according to ISO 2409,
- If higher than 250 micrometers; pull-off method B according to ISO 4624.
-

2.3 Pull-of adhesion according to ISO 4624-method B

On each panel three trials have been performed.

The coating surface and the dolly (diameter 20 mm) have been sanded lightly and the epoxy adhesive has been applied. After curing of the adhesive and prior to testing, the coating and the adhesive have been scribed around the dolly down to the bare metal.
Testing is performed using an automatic hydraulic adhesion tester (COT A004).

The fractures of the adhesion test have been evaluated according to this scheme:
A/B Fracture between the steel surface and 1st coat (adhesion failure).
B Fracture in the 1st coat (cohesion failure).
B/C Fracture between the 1st and 2nd coat (adhesion failure).
C Fracture in the 2nd coat (cohesion failure).
C/D Fracture between the 2nd and 3rd coat (adhesion failure).
D Fracture in the 3rd coat (cohesion failure)
-/Y Fracture between the outer coat and the glue (adhesive failure).

2.4 Cyclic Ageing test

Three test panels have exposed to the cyclic ageing test according to ISO 12944-9 Annex B for 4200 hours.The fully cured coating system has been scribed horizontal down to the steel substrate, the scribe line being 2 mm wide and 50 mm long.

The panels have been exposed to the following cycle:

72 hours	QUV test cabinet with UV-A 340 nm lamps in accordance with ISO 16474-3 Method A, cycle 1 (4 hours UV-light at 60 ± 3 °C / 4 hours condensation at 50 ± 3 °C)
72 hours	Salt Spray test according to ISO 9227 5.2 NSS
24 hours	Exposure to low temperature (-20 ± 2 °C)

Immediately after exposure the panels were evaluated for visual surface defects according to ISO 4628-2, -3, -4 and -5.
The corrosion at the scribe has been determined within 8 hours after the end of the exposure.
The corrosion at the scribe is calculated from the equation: M=(C-W)/2, where
M = corrosion creep (mm)
C = average of the nine measurements (mm)
W = the original width of the scribe (mm)

The adhesion has been determined after 7 and 14 days conditioning according to ISO 4624.

2.5 Fingerprints

The following parameters according to ISO 12944-9 Annex C have been determined of both the base and the curing agent of the wet paint samples.

Main parameters

Infrared spectra	
Non-volatile matter by mass	ISO 3251
Density	ISO 2811
Ash	ISO 14680-2

Infrared spectra in Annex II.

3 REQUIREMENTS

Only one of the three panels shall be allowed not to comply with the requirements.

3.1 Reference adhesion before tests

Table 2: Adhesion before tests

Adhesion ISO 4624		**Requirements**
ISO 4624	Individual values	≥ 2.5 MPa
	Break Area	No A/B break unless ≥ 5 MPa

3.2 Assessment after Cyclic Ageing test

Table 3: Assessment after Cyclic Ageing test

Cyclic ageing ISO 12944-9 Annex B, 4200 hours		**Requirements**
ISO 4628-2	Blistering	0(S0)
ISO 4628-3	Rusting	Ri 0
ISO 4628-4	Cracking	0(S0)
ISO 4628-5	Flaking	0(S0)
Corrosion from scribe	- CX (other)	≤ 3.0 mm
	- high impact	≤ 8.0 mm
ISO 4624	Individual values	≥ 2.5 MPa
	Break Area	0% adhesive failure between steel or metalized steel and the first coat unless ≥ 5 MPa

4 RESULTS

4.1 Dry film thickness

Table 4: Dry film thickness test panels. (ISO 17025 Scope number 1)
Test date: 09-07-2018

Q	Dry film thickness ISO 2808-7C (C = 25 µm)	COT sample number 20-06-18/0420				
		Panel 97	**Panel 98**	**Panel 99**	**Panel 100**	**Panel 101**
	Readings (n=5)	393 392 440 435 433	375 362 404 409 405	380 385 343 326 369	399 377 362 365 376	310 312 313 330 320
	Min. - Max. (µm) Average, SD (µm)	392 - 440 419 ± 24	362 - 409 391 ± 21	326 - 385 361 ± 25	362 - 399 376 ± 15	310 - 330 317 ± 8
		Panel 102	**Panel 103**	**Panel 104**	**Panel 105**	**Panel 106**
	Readings (n=5)	288 297 298 286 274	284 290 285 283 289	286 290 274 269 257	267 276 274 271 269	292 287 281 255 284
	Min. - Max. (µm) Average, SD (µm)	274 - 298 289 ± 10	283 - 290 286 ± 3	257 - 290 275 ± 13	267 - 276 271 ± 4	255 - 292 280 ± 14
		Panel 107	**Panel 108**			
	Readings (n=5)	269 265 280 294 262	278 296 284 265 277			
	Min. - Max. (µm) Average, SD (µm)	262 - 294 274 ± 13	265 - 296 280 ± 11			

4.2 Assessment before tests

Table 5: Reference assessment of coating adhesion.
Test date: 10-07-2018

Reference Adhesion ISO 4624 Method B No exposure		COT sample number 20-06-18/0420		
		Panel 106	**Panel 107**	**Panel 108**
Adhesion strength	(MPa)	20.1	20.5	18.8
Break area	(%)	15% C/D, 75% D, 10% Y	5% B, 15% C, 75% C/D, 5% Y	15% C, 55% C/D, 30% Y
		14.6	16.7	17.1
		30% C, 60% C/D, 10% Y	25% C, 60% C/D, 15% Y	15% C, 55% C/D, 30% Y
		13.4	13.9	13.3
		15% C, 70% C/D, 15% Y	20% C, 70% C/D, 10% Y	5% B, 10% C, 50% C/D, 35% Y

4.3 Assessment after Cyclic Ageing test

Table 6: Assessment after Cyclic Ageing test
Test date: 17-07-2018 till 08-01-2019, Adhesion: 15-01-2019

	Cyclic Ageing ISO 12944-9 Annex B Exposure 4200 hours		**COT sample number 20-06-18/0420**		
			Panel 101	**Panel 102**	**Panel 103**
Q	ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)
Q	ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0
Q	ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)
Q	ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)
	Corrosion from scribe (mm)		6.6	6.5	6.3
	ISO 4624	Adhesion (MPa)	8.1	8.3	7.8
		Break area (%)	60% A/B, 40% D	60% A/B, 40% C/D	65% A/B, 35% C/D
			7.2	7.7	6.6
			95% A/B, 5% C/D	55% A/B, 40% C/D, 5% Y	60% A/B, 40% C/D
			7.3	9.0	7.1
			95% A/B, 5% Y	60% A/B, 40% C/D	70% A/B, 30% C/D

Table 7: Assessment after Cyclic Ageing test
Test date: Adhesion: 22-01-2019

Cyclic Ageing ISO 12944-9 Annex B Exposure 4200 hours		**COT sample number 20-06-18/0420**		
		Panel 101	**Panel 102**	**Panel 103**
ISO 4624	Adhesion (MPa)	8.3	8.1	9.7
	Break area (%)	90% A/B, 10% C/D	85% A/B, 15% C/D	100% A/B
		7.8	8.0	7.1
		60% A/B, 40% C/D	95% A/B, 5% C/D	100% A/B,

4.4 Fingerprints

Table 8: Results Fingerprint according to ISO 12944-9 Annex C

COT Sample number	20-06-18/0391 + 0392		
Name of paint	Avantguard 750 1736G		
Name of manufacturer	Hempel	**Base material**	**Curing agent**
Colour		1736U-19830 grey	97043-00000
Batch number		048042596	048030495
Main parameters	**Test method**	**Test result**	
Infrared spectra		Epoxy	Polyaminoamide Adduct
Non-volatile matter (% by mass)	ISO 3251	89 ± 2	44 ± 2
Density (g/cm³)	ISO 2811	2.63 ± 0.05	0.94 ± 0.05
Ash (% by mass)	ISO 14680-2	79 ± 3	1
Optional parameters		NA	NA

Table 9: Results Fingerprint according to ISO 12944-9 Annex C

COT Sample number	20-06-18/0400 + 0401		
Name of paint	Hempadur 47300		
Name of manufacturer	Hempel	**Base material**	**Curing agent**
Colour		47309-12170 green/grey	97301-00000
Batch number		047102648	047121704
Main parameters	**Test method**	**Test result**	
Infrared spectra		Epoxy	Poly Amine
Non-volatile matter (% by mass)	ISO 3251	90 ± 2	67 ± 2
Density (g/cm^3)	ISO 2811	1.69 ± 0.05	0.95 ± 0.05
Ash (% by mass)	ISO 14680-2	60 ± 3	3 ± 3
Optional parameters		NA	NA

Table 10: Results Fingerprint according to ISO 12944-9 Annex C

COT Sample number	20-06-18/0398 + 0399		
Name of paint	Hempel's pro acrylic 55883		
Name of manufacturer	Hempel	**Base material**	**Curing agent**
Colour		55889-10170 white	97883-00000
Batch number		225061003	045081994
Main parameters	**Test method**	**Test result**	
Infrared spectra		Polyester	Epoxy-Tri-methoxy Silan
Non-volatile matter (% by mass)	ISO 3251	71 ± 2	2 ± 2
Density (g/cm^3)	ISO 2811	1.35 ± 0.05	1.06 ± 0.05
Ash (% by mass)	ISO 14680-2	37 ± 3	1
Optional parameters		NA	NA

5 SUMMARY

Table 11: Summary of the test results (COT sample number 20-06-18/0420).

Test method	**Test duration**	**Pass / Fail**
Reference adhesion	N.A.	Pass
Cyclic Ageing ISO 12944-9 Annex B	4200 hours	Pass

6 CONCLUSION

The coated samples with COT sample number 20-06-18/0420 meet the requirements of ISO 12944-9 CX (high impact areas).

CENTRUM VOOR ONDERZOEK
EN TECHNISCH ADVIES (COT bv)

P. Grootveld
Laboratory Technician

J.R.S. Brakenhoff
Technical Manager Laboratory

ANNEX I

Photographs

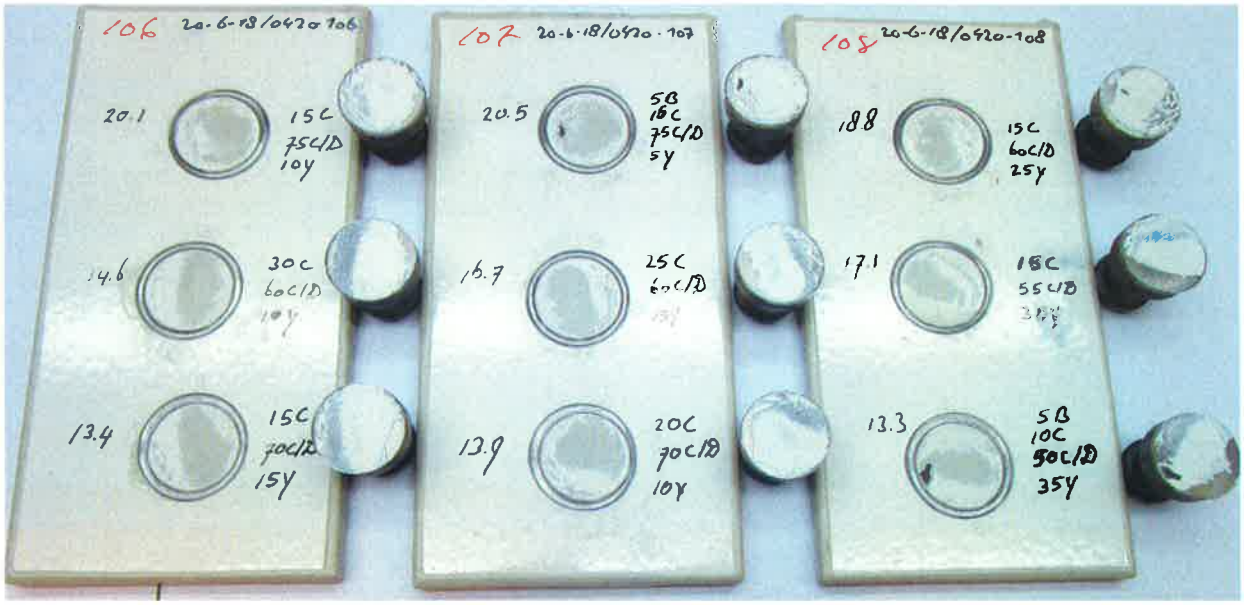


Photo 1: Panels 106, 107 and 108 Reference adhesion.

Photo 2: Panels 101, 102 and 103 after 4200 hours Cyclic Ageing test.

Photo 3: Panels 101, 102 and 103 including adhesion after 14 days conditioning.

ANNEX II

Infrared spectra

Figure 1: Avantguard 1736U-19830, grey Base

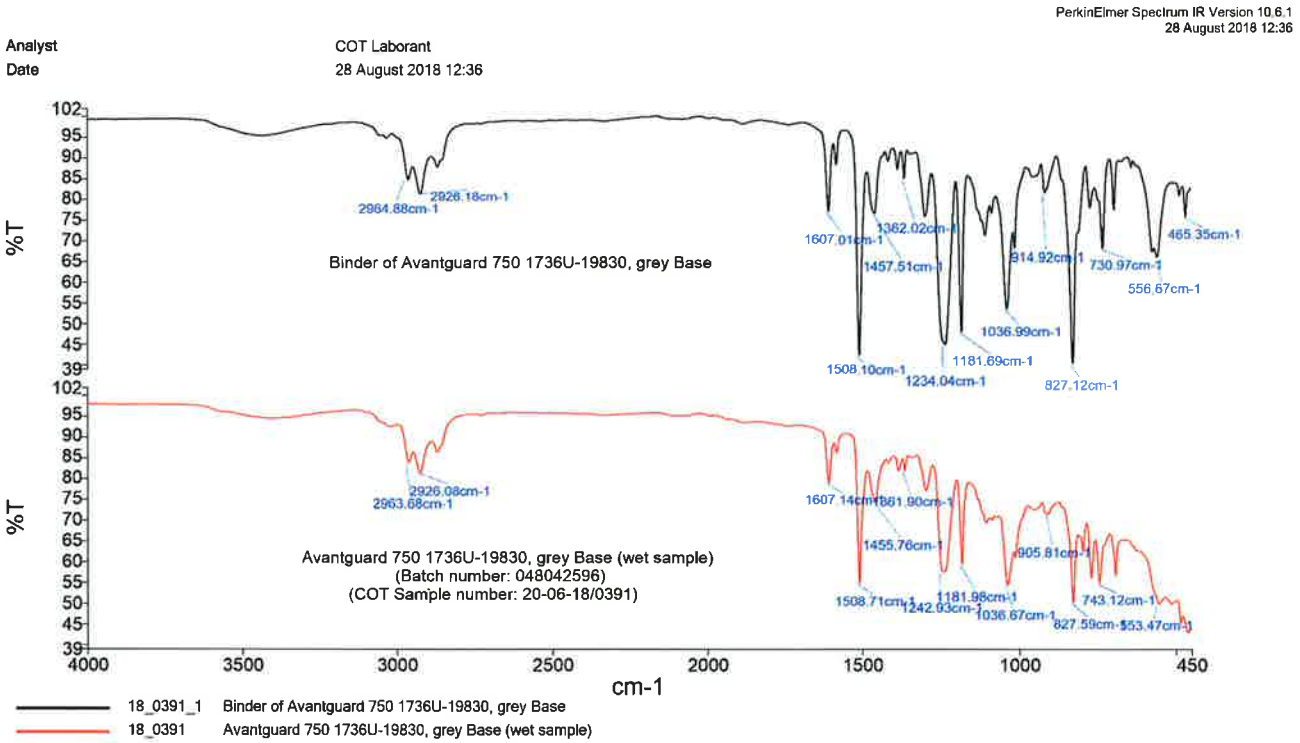


Figure 2: Hempel's Curing Agent 97043-00000

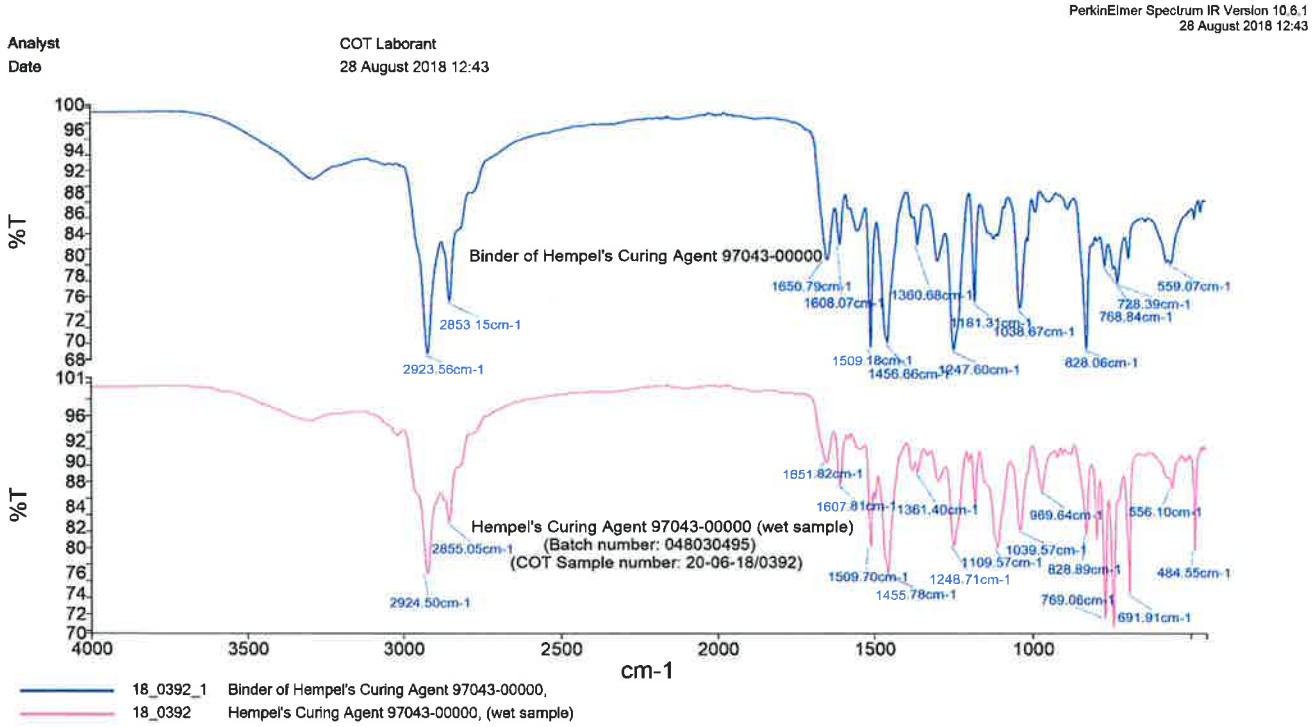


Figure 3: Hempadur 47309-12170, green/grey, Base

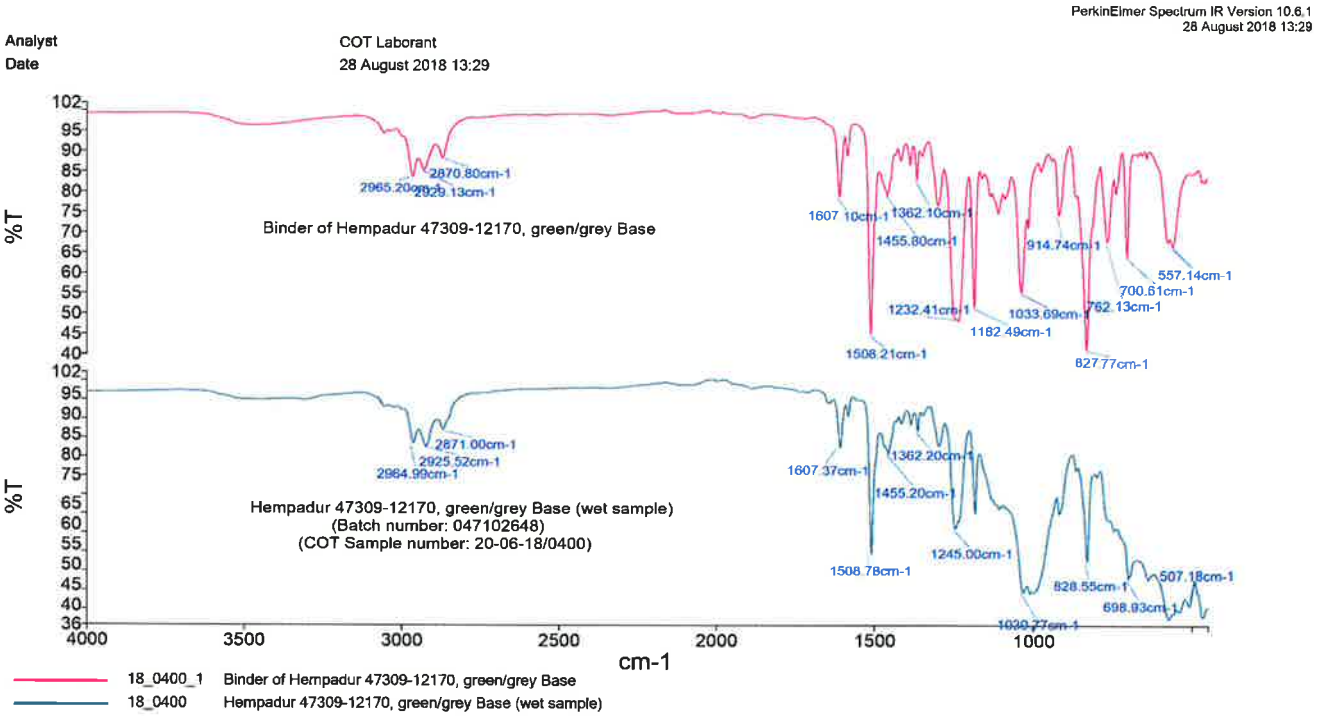


Figure 4: Hempel's Curing Agent 97301-00000

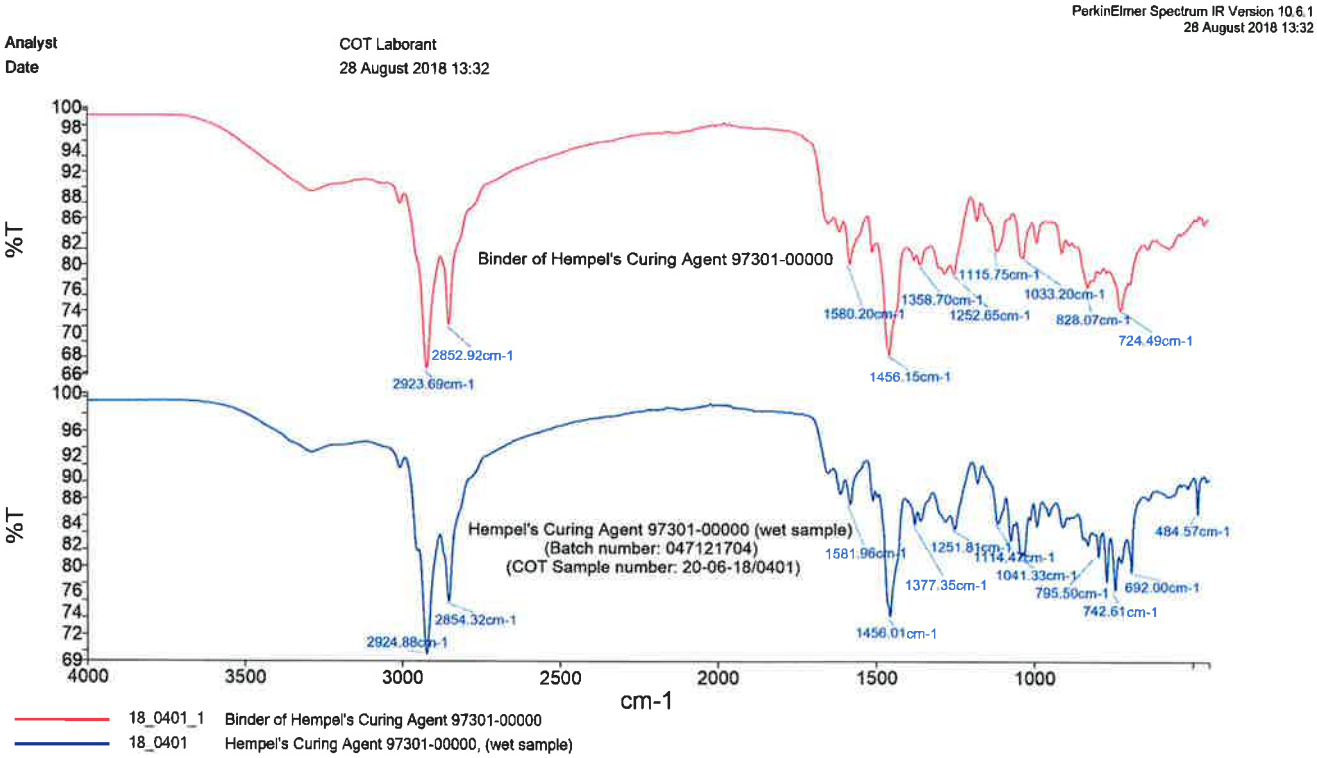


Figure 5: Hempel's pro acrylic 55889-10170, white Base

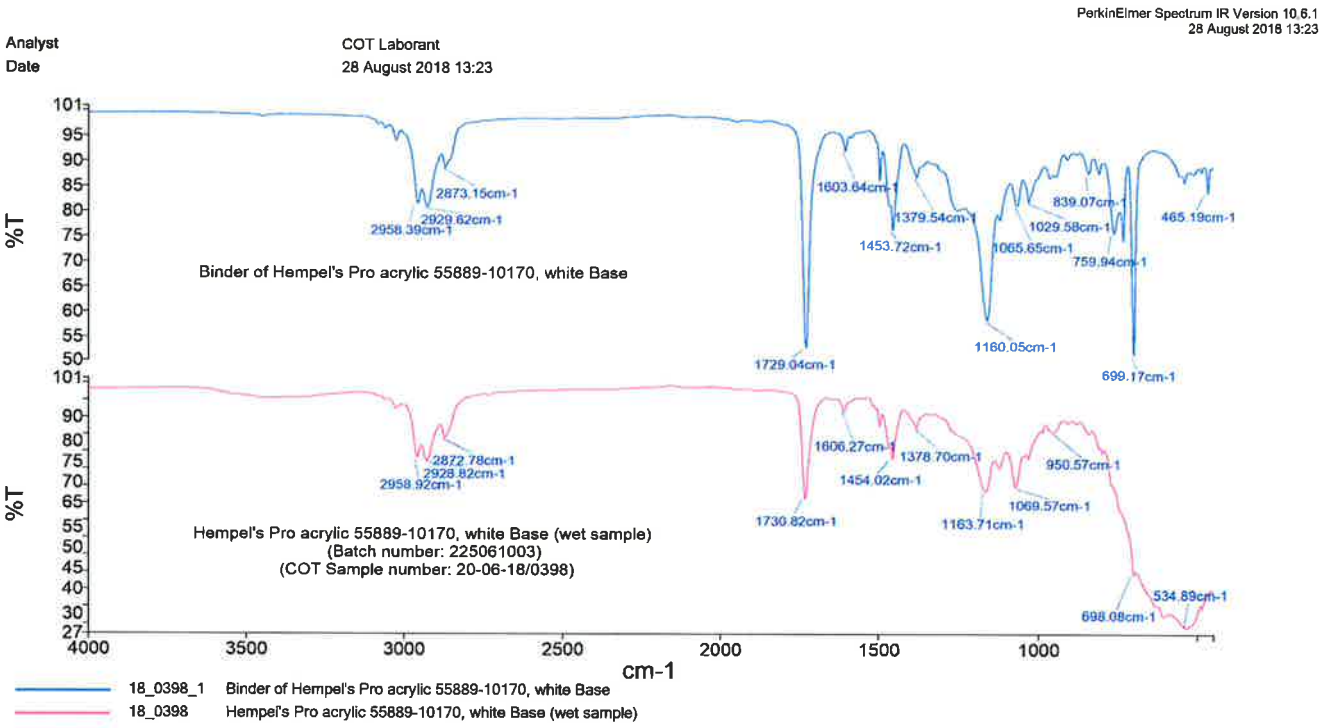
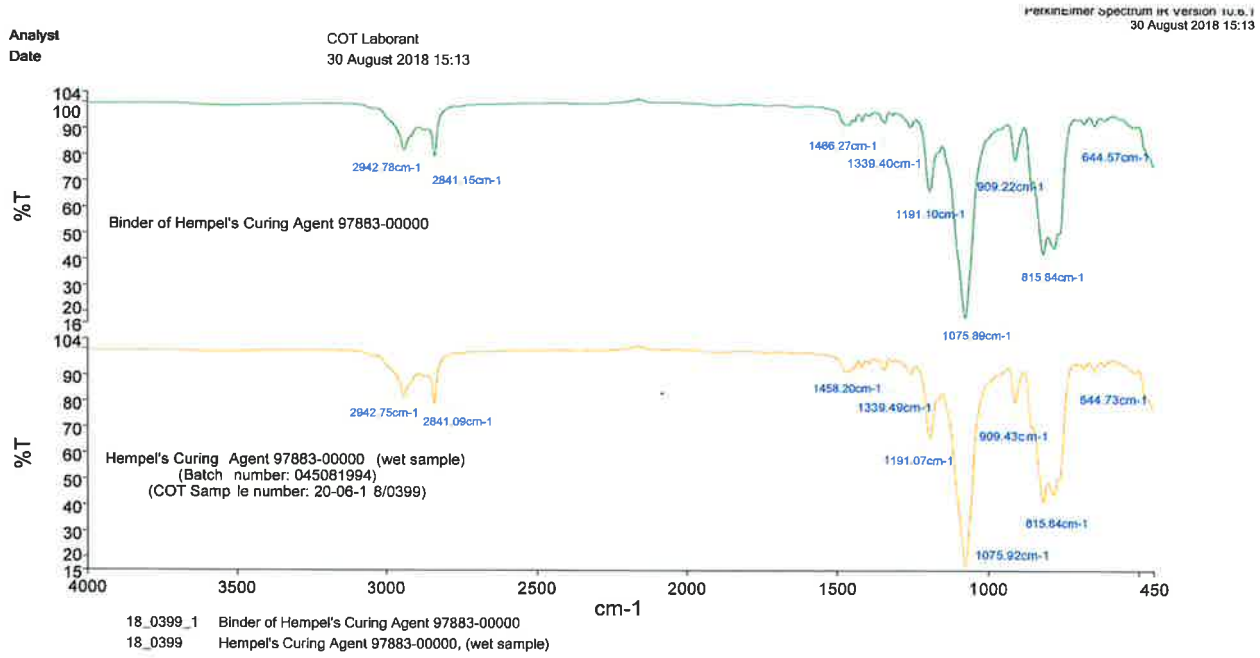


Figure 6: Hempel's Curing Agent 97883-00000



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Civil projects
Corrosionprotection
Laboratory

Jan Tademaweg 40
2031 CV Haarlem
P.O. Box 2113
2002 CC Haarlem
The Netherlands
T +31 23-5319544
F +31 23-5277229
E info@cot-nl.com
I www.cot-nl.com

REPORT

Testing of the system
HEMPADUR MULTI-STRENGTH 35840/ HEMPADUR MULTI-STRENGTH 35840
(DFT 300 / 300 µm)
according to NORSOK M-501, Edition 6, System 7A

Haarlem, April 5th, 2017

Client	:	Hempel A/S Lundtoftegårdsvej 91 2800 Kgs. Lyngby Denmark Contact person: Mrs. J. Dyring Carlsen
Project number	:	20140346
Report number	:	LAB16-0034-REP Revision 3
Handled by	:	Mr. K. Coppoolse

CONTENTS

1 INTRODUCTION

1.1 Order

By order of Hempel A/S, Lyngby, Denmark, the Centrum voor Onderzoek en Technisch advies bv (COT) in Haarlem, The Netherlands, has tested the system Hempadur Multi-Strength 35840 / Hempadur Multi-Strength 35840 (DFT 300 / 300 µm), according to NORSOK M-501, Edition 6, System no. 7A.

The order has been given in the email correspondence dated October 6th, 2014.

1.2 General information

Table 1: Samples

COT Sample number	Samples	Received
24-04-15/0263	21 Coated steel panels, coloured red, numbered 114 – 134*, size 70x150x5 mm	24-04-2015

* numbered by the client

1.3 Information received from the client

The system has been applied to the test panels by Hempel and controlled by COT. The following information has been confirmed by COT.

Table 2: Products

Coating product	Component	Batch number
Hempadur Multi-Strength 35840	Base Lab. produced	-
	Curing agent 95620	Lab. produced

Substrate
Hot-rolled mild steel, Rust grade A (ISO 8501-1).

Surface preparation
All panels have been abrasive-blasted with iron grit (G070 according to ISO 11124) to a cleanliness degree equivalent to Sa 2.5 (ISO 8501-1). The surface roughness has been randomly checked by COT according to ISO 8503-4 by means of a portable surface finish measuring instrument. The roughness was in the range 75 – 90 µm.

System and specified dry film thickness
Hempadur Multi-Strength 35840 : 300 µm
Hempadur Multi-Strength 35840 : 300 µm

2 PERFORMANCE TESTS

2.1 Dry film thickness

Before starting the tests the dry film thickness of the coating system has been measured according to ISO 19840 with a magnetic dry film thickness meter (COT E004). On each panel 5 measurements have been carried out, which have been corrected with a value of 25 µm to account for surface roughness. The minimum, the maximum, the average and the standard deviation have been reported. In deviation of the report procedure of ISO 2808, individual measurements are not reported.

2.2 Ageing resistance

The fully cured coating system has been scribed horizontal down to the bare metal. The scratch line is 2 mm wide and 50 mm long. The panels have been exposed to the following cycle according to ISO 20340 Annex A:

72 hours	QUV test cabinet with UV-A 340 nm lamps in accordance with ISO 11507 Method A (4 hours UV-light at 60 ± 3 °C / 4 hours condensation at 50 ± 3 °C)
72 hours	Salt Spray test according to ISO 9227 NSS
24 hours	Exposure to low temperature (-20 ± 2 °C)

The total exposure time is 4200 hours.
The start of the ageing test was 19 June 2015; the test has been ended on 11 December 2015.

After the ageing test part of the panels was overcoated with Hempathane HS 55610 without mechanical treatment to test for overcoatability.

2.3 Seawater immersion

The fully cured coating system has been scribed horizontally down to the bare metal, the scribe line being 2 mm wide and 50 mm long. The panels have been immersed in synthetic seawater (according to ISO 15711) at 40 °C during 4200 hours according to ISO 2812-2.

The start of the immersion was 15 June 2015, and ended on 7 December 2015.

2.4 Cathodic Disbonding

Cathodic disbonding has been determined according to ISO 15711: method A – impressed current, using a cathode potential of -1.10 volt relative to a saturated KCL silver/silverchloride reference electrode. Three panels have been prepared by drilling an artificial holiday with a diameter of 6 mm through the coating unto the bare metal. Prior to the exposure the panels have been checked with a low voltage holiday detector. The three panels have been partially submerged in the electrolyte (synthetic seawater) for 4200 hours (25 weeks), after which the maximum disbonding has been measured.

The start of the cathodic disbonding test was 22 June 2015; the test has been ended on 21 December 2015.

2.5 Adhesion test

The adhesion before and after the seawater immersion and after the ageing test has been determined by a pneumatic adhesion tester (COT A006) in accordance with ISO 4624.
The coating surface and the dolly (diameter 20 mm) have been sanded lightly prior to the application of an epoxy adhesive. After curing of the adhesive and prior to testing, the coating and the adhesive have been drilled around the dolly down to the bare metal. Two trials on each of the tested panels have been performed, the average and standard deviation has been reported.

The adhesion of the coating system after the tests has been determined the first half of January 2016 under ambient laboratory conditions.

The fractures of the adhesion test have been evaluated according to the scheme underneath:

A/B Fracture between the steel surface and 1st coat (adhesion failure).
B Fracture in the 1st coat (cohesion failure).
B/C Fracture between the 1st and 2nd coat (adhesion failure).
C Fracture in the 2nd coat (cohesion failure).

-/Y Fracture between the outer coat and the glue (adhesive failure).

3 REQUIREMENTS

3.1 Ageing resistance

After exposure to the specified time, the test panels shall comply with the following requirements:

Method		Requirements
--	Corrosion creep from scribe*	≤ 8.0 millimetres
--	Overcoat ability	Minimum 5.0 MPa adhesion
ISO 4628-2	Blistering	0(S0)
ISO 4628-3	Rusting	Ri 0
ISO 4628-4	Cracking	0(S0)
ISO 4628-5	Flaking	0(S0)
ISO 4628-6	Chalking	maximum rating 2
ISO 4624	Adhesion	minimum 5.0 MPa and maximum 50 % reduction from original value

* The corrosion creep is calculated from the equation: M=(C-W)/2, where
M = corrosion creep (mm)
C = average of the nine measurements (mm)
W = the original width of the scribe (mm)

3.2 Seawater immersion test

After exposure to the specified time, the test panels shall comply with the following requirements:

Method		Requirements
--	Corrosion creep from scribe*	≤ 8.0 millimetres
ISO 4628-2	Blistering	0(S0)
ISO 4628-3	Rusting	Ri 0
ISO 4628-4	Cracking	0(S0)
ISO 4628-5	Flaking	0(S0)
ISO 4624	Adhesion	minimum 5.0 MPa and maximum 50 % reduction from original value

* The corrosion creep is calculated from the equation: M=(C-W)/2, where
M = corrosion creep (mm)
C = average of the nine measurements (mm)
W = the original width of the scribe (mm)

3.3 Cathodic disbonding

After exposure for the specified amount of time, the equivalent diameter of the disbonded area shall be not more than 20 mm.

4 RESULTS

4.1 Original adhesion value

Method		COT Sample Number 24-04-15/0263	
		Panel 128	Panel 131
ISO 19840	Min – max dry film thickness (µm)	521 – 606	607 – 671
ISO 19840	Average dry film thickness (µm)	553 ± 34	639 ± 30
ISO 4624	Adhesion (MPa)	16.7 ± 0.6	17.8 ± 3.7
	Percentage area and type of fracture	100 % -/Y	100 % -/Y

4.2 Ageing resistance

Exposure time: 4200 hours

Method		COT Sample Number 24-04-15/0263		
		Panel 123	Panel 127	Panel 132
ISO 19840	Min – max dry film thickness (µm)	559 – 607	573 – 642	573 – 620
ISO 19840	Average dry film thickness (µm)	585 ± 20	603 ± 30	595 ± 18
ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)
ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0
ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)
ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)
ISO 4628-6	Chalking	0(S0)	0(S0)	0(S0)
--	Corrosion creep from scribe (mm)	5.2	6.5	6.1
ISO 4624	Adhesion (MPa)	11.7 ± 1.2	12.6 ± 1.2	11.6 ± 0.5
	Percentage area and type of fracture	100 % C	100 % C	100 % C
ISO 4624	Overcoatability adhesion (MPa)	8.6 ± 1.0	8.7 ± 0.2	5.6 ± 0.9
	Percentage area and type of fracture	100 % C/D	100 % C/D	100 % C/D

4.3 Seawater immersion

Exposure time: 4200 hours

Method		COT Sample Number 24-04-15/0263		
		Panel 125	Panel 126	Panel 130
ISO 19840	Min – max dry film thickness (µm)	603 – 658	567 – 659	577 – 642
ISO 19840	Average dry film thickness (µm)	623 ± 21	610 ± 37	606 ± 30
ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)
ISO 4628-3	Rusting	Ri 0	Ri 0	Ri 0
ISO 4628-4	Cracking	0(S0)	0(S0)	0(S0)
ISO 4628-5	Flaking	0(S0)	0(S0)	0(S0)
--	Corrosion creep from scribe (mm)	1.3	1.3	2.0
ISO 4624	Adhesion (MPa)	6.2 ± 0.6	5.1 ± 0.5	7.3 ± 0.8
	Percentage area and type of fracture	100 % A/B	100 % A/B	100 % A/B

4.4 Cathodic Disbonding

Exposure time: 4200 hours

Method		COT Sample Number 24-04-15/0263		
		Panel 129	**Panel 133**	**Panel 134**
ISO 19840	Min – max dry film thickness (µm)	560 – 602	590 – 644	560 – 615
ISO 19840	Average dry film thickness (µm)	578 ± 18	612 ± 22	587 ± 24
ISO 15711	Equivalent diameter disbonding (mm)	3.9	4.2	3.9
ISO 4628-2	Blistering	0(S0)	0(S0)	0(S0)

5 CONCLUSION

The system Hempadur Multi-Strength 35840 / Hempadur Multi-Strength 35840, DFT 300 / 300 µm, (COT sample number 24-04-15/0263), meets the requirements of NORSOK M-501, Edition 6, System no. 7A.

CENTRUM VOOR ONDERZOEK
EN TECHNISCH ADVIES (COT bv)

K. Coppoolse
Laboratory Technician

Dr. B.P. Alblas
Manager Laboratory

Rapport
Report

Teknologisk Institutt

Oppdragsgiver *Client*	**Utførende enhet/lab.** *Department/laboratory responsible*
Hempel's Marine Paints AS Lundtoftevej 150 DK-2800 Lyngby Denmark	The National Institute of Technology Materials Technology Pb 2608 St.Hanshaugen NO - 0131 OSLO

Rapportnr. *Report no.*

3410-04-0086 Mt06 Rev.A

Tittel *Title*

Pre-qualification testing in accordance with NORSOK M-501, rev.5, system no.7 of Hempel no. H-03/N7 2005 in the submerged area.

Dato *Date*	**Utarbeidet av** *Prepared by*	**Godkjent av** *Approved by*	**Innleveringsdato for prøve** *Date of receipt of test object*
27/10-2005	Kristian A. Kaltenborn	Hege Krogh	November 2004
Revisjonsnr. *Revision no.*	**Konfig.kont.** *Config.contr.*	**Antall sider** *No. of pages*	**Ant. vedlegg** *No. of append.*
A	[X] Ja *Yes* [ ] Nei *No*	4	5
Kopi nr. *Copy no.*	**Akkred. test** *Accredited test*	**Kundens ref.** *Client's ref.*	**Bestillingsnr.** *Order no.*
	[ ] Ja *Yes* [X] Nei *No*	Gert Simonsen	

Fordeling *Distribution*

Teknologisk Institutt as

Akersveien 24C	Kongsberg Næringspark	Hillevågsveien 99	Kystbasen Ågotnes	Televeien 3	Teknologiveien 22	firmapost@teknologisk.no
Pb 2608 St. Hanshaugen, NO-0131 Oslo	Pb 1019, NO-3601 Kongsberg	NO-4016 Stavanger	Pb 23, NO-5346 Ågotnes	Pb 44, NO-8551 Lødingen	NO-2815 Gjøvik	www.teknologisk.no
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Faks +47 22 86 51 37	Faks +47 32 28 87 37	Faks +47 51 88 02 18	Faks +47 56 31 28 01	Faks +47 76 93 10 64	Faks +47 61 14 58 99	

1. Summary

This new revision A has the correct name of the topcoat.

The following paint system from Hempel's Marine Paints AS has been tested in accordance with NORSOK M-501, rev. 5, NORSOK system no 7:

Hempel system no. H-03/N7 2005:

Substrate	Steelpanels, blast-cleaned to Sa 2½
Hempadur Multi-Strenght 45703	1 x 175 µm
Hempadur Mastic 45880	1 x 175 µm

The Cathodic Disbonding test was performed from February 7th 2005 to August 1st 2005.
The Sea Water Immersion test test was performed from January 31st 2005 to July 25th 2005.

The system passed the requirements for Sea Water Immersion and Cathodic Disbonding according to ISO 20340, adhesion on unexposed and exposed panels and overcoatability after the Sea Water Immersion test.

The paint system is in full accordance with the requirements in NORSOK M-501, rev. 5, system no 7 in the submerged area.
The paint system is not in full accordance with the requirements in NORSOK M-501, rev. 5, system no 7 in the splash zone / tidal zone.

2. Reference documents

The National Institute of Technology, Materials Technology has tested the following product:

Client: **Hempel's Marine Paints AS**
Product type: **Paint system according to NORSOK system no. 7**

Paint system: Hempel-03/N7 2005

Substrate	Steelpanels, blast-cleaned to Sa 2½		
Hempadur Multi-Strenght 45703	1 x 175 µm	Part A	Batch no: CS001-001
		Part B	Batch no: 0140 96068
Hempadur Mastic 45880	1 x 175 µm	Part A	Batch no: 0140 84847
		Part B	Batch no: 0140 84820

Comments to the measured DFT:
The roughness of the panels is 50-85 µm .
The laboratory interprets that the requirement in the NORSOK standard for the dry film thickness to be within ± 20 % of the NDFT is referring to the total system.

The total system: The measured DFT of the total system was OK for all the exposed panels.

3. Test methods

The pre-qualification tests have been executed in accordance with the standard NORSOK M-501, rev. 5, NORSOK system no 7.

All test standards are either ISO- or ASTM-standards and the testing has been executed in full accordance with the requirements given in these standards and with the quality system of the laboratory.

3.1 Cathodic disbonding test procedures acc.to ISO 20340

- Total time artificial sea water — ISO 15711 — 4200 h
- Acceptance criteria — Maximum disbond — 10 mm

3 parallel panels shall be tested. Two of three panels shall fulfil the requirements.
The Cathodic Disbonding test was performed from February 7th 2005 to August 1st 2005.
The Sea Water Immersion test was performed from January 31st 2005 to July 25th 2005.

3.2 Sea water immersion test procedures acc.to ISO 20340

Total time artificial sea water — ISO 2812 — 4200 h

Acceptance Criteria

1. Corrosion creep from scribe: less than 3,0 mm (average of 9 point measured across the scribe)
2. Blistering ISO 4628-2 Rating 0
3. Rusting ISO 4628-3 Rating 0
4. Cracking ISO 4628-4 Rating 0
5. Adhesion ISO 4624 Min 5,0 MPa, max 50% reduction from original value
6. Overcoatable without mechanical treatment obtain minimum adhesion of 5 MPa.

3 parallel panels shall be tested. Two of three panels shall fulfil the requirements.

Panels dried for minimum 14 days after exposure tests before adhesion tests were executed.

For the exposure test 3 parallel panels were used. The pull off testing in acc. with ISO 4624 was executed with 5 parallels. Dollies 1,57 cm^2 was used.

The uncertainty of the methods (the pull off test) is 10% for adhesion values less then 20 MPa and 15% for adhesion value more than 20 MPa.

The scratches were made mechanically with a machine Sajo VRF 52 M.
The Cathodic Disbonding test was performed from February 7th 2005 to August 1st 2005.
The Sea Water Immersion test was performed from January 31st 2005 to July 25th 2005.

4. Results

All test results are given in annex 1 and 2.
Corrosion creep is calculated from the average of 9 measurements of the maximum width of the corrosion across the scribe. The maximum width is measured in the middle of the scribe, and in four points on each side of the middle, 5mm between each point. Corrosion creep (M = (C-W)/2, where C is the average of the 9 maximum widths of corrosion across the scribe, and W is the original width of scribe.

Photographs of the tested panels are given in annex 5.
Application details are given in annex 3 and 4.

The results from fingerprinting will be given in a separate report.

5. Comments and conclusion

- The cathodic disbonding test was in accordance with the requirements.
- The sea water immersion test was in accordance with the requirements.
- The overcoatability after the cyclic test was in accordance with the requirements.
- Adhesion test results on all exposed panels were in accordance with the requirements.
- Adhesion test results on unexposed panels were in accordance with the requirements.

The paint system is in full accordance with the requirements in NORSOK M-501, rev. 5, system no 7 in the submerged area.
The paint system is not in full accordance with the requirements in NORSOK M-501, rev. 5, system no 7 in the splash zone / tidal zone.

NORSOK M-501, rev. 5
Coating System No.7

Test results, each parallel. After exposure in Sea Water Immersion

Report no.: 3410-04-0086 Mt06
Client: Hempel
Paint system code: H-03/N7 2005
Paint system: Substrate Steelpanels blast-cleaned to Sa 2 1/2
Hempadur Multi-Strenght 45703 175 µm
Hempadur Mastic 45880 175 µm

Test parameter	Standard	Parallel	Disbonding		Blistering		Rusting		Cracking		Chalking		Adhesion *)		Overcoatability *)		Result
			NORSOK-std.		ISO 4628-2		ISO 4628-3		ISO 4628-4		ISO 4628-6		ISO 4624		ISO 4624		
			mm		Density(Size)		Ri		Density(Size)		Rating		MPa		MPa		Acc./Not acc.
		Panel no.	Req.	Res.	Req.	Res.	Req.	Res.	Req.	Res.	Req.	Res.	Req.	Mean res.	Req.	Mean res.	
Sea Water Immersion	ISO 20340	91	3,0	0,0	0(S0)	0(S0)	0	0	0(S0)	0(S0)	2	0	5	21,7	5	18,1	Accepted
		92	3,0	0,0	0(S0)	0(S0)	0	0	0(S0)	0(S0)	2	0	5	-	5	-	Accepted
		95	3,0	0,0	0(S0)	0(S0)	0	0	0(S0)	0(S0)	2	0	5	-	5	-	Accepted
Cathodic Disbonding	ISO 15711	82	10,0	6,9	0(S0)	0(S0)	0	0	0(S0)	0(S0)	2	0	5	-	5	-	Accepted
		83	10,0	7,3	0(S0)	0(S0)	0	0	0(S0)	0(S0)	2	0	5	-	5	-	Accepted
		84	10,0	7,4	0(S0)	0(S0)	0	0	0(S0)	0(S0)	2	0	5	-	5	-	Accepted
Adhesion test, unexposed	ISO 4624	Mean	-	-	-	-	-	-	-	-	-	-	5	17,2	-	-	Accepted
TOTAL EVALUATION																	**Accepted**

*) The adhesion result in the table is a mean value of 5 parallels from the 3 or 2 parallel test panels

Rapport Report

Rapportnr. *Report no.* 3410-04-0086Mt06 rev.A
Vedlegg *Appendix* 1
Dato *Date* 27/10-2005

Teknologisk Institutt

NORSOK M-501, rev. 5

Coating System No.7

Adhesion test results after exposure in Sea Water Immersion

Report no.: 3410-04-0086 Mt06
Client: Hempel
Paint system code: H-03/N7 2005
Paint system: Substrate Steelpanels blast-cleaned to Sa 2 1/2
Hempadur Multi-Strenght 45703 175 µm
Hempadur Mastic 45880 175 µm

Test parameter	Standard	Panel no.	Adhesion after exposure	Overcoatability
			ISO 4624	ISO 4624
			MPa	MPa
Sea Water Immersion	ISO 20340	**Mean**	**21,7**	**18,1**
		Par. 1	22,0	17,2
		Par. 2	22,4	19,0
		Par. 3	21,2	18,6
		Par. 4	21,2	17,0
		Par. 5	21,8	18,6
Adhesion test, unexposed	ISO 4624	**Mean**	**17,2**	**Not tested**
		Par. 1	17,0	-
		Par. 2	17,0	-
		Par. 3	17,4	-
		Par. 4	17,0	-
		Par. 5	17,4	-

Remarks: Cohesion failure in the recoated topcoat on all 3 exposed panels.
100% Glue failure on all unexposed panels

NORSOK M-501, rev. 5
Coating System No.7

APPLICATION OF TEST PANELS

Client	Hempel	System no	H-03/N7 2005
Report no	3410-04-0086 Mt06	Panel no	

Surface Preparation:

Degreasing	Alkaline	Date	23.11.2004
Blast-cleaning	Sa 2½	Roughness	50-85 µm
Abrasive	Grit	Date	23.11.2004

Paint system:

Paints	1. coat	2. coat	3. coat
	Hempadur Multi-Strenght 45703	Hempadur Mastic 45880	
DFT,	175	175	
Batch no.Part A	CS001-001, 45705, 19880	0140 84847, 45889, 12340	
Batch no.Part B	0140 96068, 98750	0140 84820, 95880	
	Thinner - 1. coat	Thinner - 2. coat	
Type	-	-	
Volume	-	-	

Conditions during application and curing:

Paint	1. coat	2. coat	3. coat
Date of application	30.11.2004	01.12.2004	
Method of application	Airless	Airless	
Pump	El. membran	El. membran	
Inlet pressure, bar	200 bar	200 bar	
Nozzle orifice	5.21	5.19	
Thinning	5%	-	
Ambient temperature, °C	21	21,0	
Relative humidity, %	29	28	
Steel temperature, °C	-	-	
Curing condition of 1. coat	-	-	

NORSOK M-501, rev. 5
Coating System No.7

DFT OF COATED TEST PANELS (n = 5, no. of readings)

Client:	Hempel				**System no**				H-03/N7 2005			
Report no	3410-04-0086 Mt06				**Panel no**							
Substrate:	Steel panels, blast-cleaned to Sa 2 1/2											
Paint	**1. coat**				**2. coat**				**3. coat**			
	Hempadur Multi-Strenght 45703				Hempadur Mastic 45880							
DFT	175				175							
Date of recording:	01.12.2004				18.01.2005							
Panel no	**Mean**	**Low**	**High**	**Std**	**Mean**	**Low**	**High**	**Std**	**Mean**	**Low**	**High**	**Std**
82	207	178	232	23,7	348	307	377	28,2				
83	217	201	229	12,0	340	310	348	21,3				
84	225	188	244	23,6	347	320	381	22,0				
91	211	185	227	20,4	377	333	424	36,9				
92	218	194	232	16,6	368	342	410	27,6				
95	213	186	235	22,6	374	333	400	26,4				
94	229	213	244	12,0	370	358	390	12,4				
99	213	201	232	12,4	345	321	370	19,5				
		175			350							
Accumulated DFT ± 20%		140 - 210			280 - 420							
Remarks:												

Photo no.1. Panels after the Sea Water Immersion test

Photo no.2. Panels after the Cathodic Disbonding test