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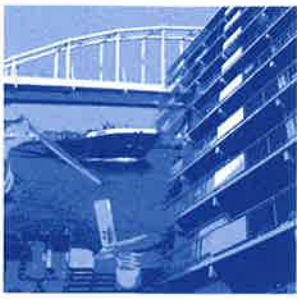

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REPORT

Testing of the system
MCU-ZINC + 2% MCU-QUICKCURE / MCU-MIOTOPCOAT (DFT: 200/100 µm)
according to Aramco 09-SAMSS-087

Haarlem, 15 September 2014

Client	:	MCU Coatings International Contact person: Mr. P. Lytens
Project number	:	20140158
Report number	:	LAB14-0540-REP
Handled by	:	Mr. K. Coppoolse

CONTENTS

1 INTRODUCTION

1.1 Order

By order of MCU Coatings International the Centrum voor Onderzoek en Technisch advies (COT bv) in Haarlem, The Netherlands, has tested the system MCU-Zinc + 2% MCU-Quickcure / MCU-Miotopcoat (DFT: 200/100 µm) according to Aramco 09-SAMSS-087.

The order has been confirmed by COT bv in the letter with reference LAB14-0226-BRF, dated 29 April 2014.

1.2 General information

Table 1: Received samples

COT Sample number	Product name	Batch number	Colour	Received
15-04-14/0213	MCU-Miotopocat	1302134-SI	RAL 7040 Grey	15 April 2014
15-04-14/0214	MCU-Quickcure	1302134-SI		
15-04-14/0215	MCU-Thinner 25	1004141-SI		
15-04-14/0212	MCU-Zinc	--		
23-04-14/0228	MCU-Zinc 8747	1604145-SI		23 April 2014

2 PAINT APPLICATION

The system has been applied to the test panels by COT from May 26th to May 28th, 2014 and after curing, the dry film thickness of the paint system has been measured by COT.

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 (COT R015). The roughness was in the range 57 – 66 µm.

Prior to the application of each layer, the panels were sprayed with a light mist of demineralized water, so that the application surface was visually damp.

System and specified dry film thickness
MCU-Zinc : 100 µm
MCU-Zinc : 100 µm
MCU Miotopcoat : 100 µm

For the application details refer to ANNEX I: Application data

3 PROCECURE

3.1 Dry film thickness

The dry film thickness of the coating has been measured in accordance with SSPC PA-2 (ASTM D 7091) using a type 2 digital gauge (COT E004) with magnetic induction probe. From a minimum of five measurements per panel, the minimum, maximum, average and corresponding standard deviation have been reported. In deviation of the standard the values of individual measurements have not been reported.

3.2 Adhesion

The adhesion of the coating system has been determined according to ISO 4624 (pull-off test) by a pneumatic adhesion tester (COT A006) on the unexposed reference panels and on the panels which have been exposed to maximum service temperature testing. The coating surface and the dolly have been sanded lightly and the epoxy adhesive has been applied. After the adhesive has been cured and prior to testing the coating and the adhesive have been drilled around the dolly down to the bare metal. On all panels two trials have been performed, the average and standard deviation has been reported.
The adhesion of the coating system has been determined at 23 ± 2 °C and 50 ± 5 % R.H..

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).
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).

3.3 Cyclic test

A cyclic test was conducted on three panels, as part of the performance tests described in the Aramco specification 09-SAMSS-087. In the coating system a vertical scribe mark has been made through the coating till the substrate in accordance with ASTM D 1654, using a sharp knife according to ISO 2409.
The panels were then exposed to alternately 100 hours in a Weather-O-Meter (COT S009) in accordance with ASTM G 155 cycle 1, and 200 hours in a salt fog cabinet in accordance with ASTM B 117, for a total period of 1500 hours.

Weather-O-Meter general data

Light intensity	:	550 ± 20 W/m^2.
Cycle	:	102 minutes light exposure (dry), Black Standard Temperature 65 ± 5 °C. 18 minutes water immersion.
Starting fase	:	dry
Exposition duration	:	500 hours, in 100 hour increments.

Salt Fog cabinet general data

Apparatus number	:	COT S006
Type of water	:	Demineralised water (< 1 µS)
Salt	:	Sodium chloride (NaCl) p.a.
Test temperature	:	35 °C
Collected salt solution	:	1.0 – 2.0 ml/hour/80 cm^2
pH of the collected salt solution	:	6.5 – 7.2
Salt concentration of the collected solution	:	50 ± 5 g/l
Exposition angle	:	approx. 20 ° from the vertical

The test was conducted from July 10th , 2014 to September 9th, 2014.

Immediately after the test, the panels have been examined for defects according to the requirements stated in 09-SAMSS-087 table 2. The corrosion creep from the scribe has been determined according to ASTM D 1654.

3.4 Maximum service temperature

Maximum service temperature testing was conducted on three panels, as part of the performance tests described in the Aramco specification 09-SAMSS-087. Three panels were exposed in an oven for 14 days, after which the adhesion was determined and compared to the adhesion results obtained from the unexposed reference panels.

The temperature by which the panels were exposed was 145 °C, as agreed with the client. The adhesion after exposure has been determined at 23 ± 2 °C and 50 ± 5 % R.H. on September 4th 2014.

4 RESULTS

4.1 Cyclic test

Table 2: Cyclic test results

		Cyclic test			Requirements
		Panel 5	**Panel 6**	**Panel 7**	
DFT (µm)	Min. - max.	271 – 311	246 – 341	238 - 309	
	Average ± STD	294 ± 15	293 ± 35	274 ± 30	
Blistering	ASTM D 714	No blistering	No blistering	No blistering	No blistering
Checking	ASTM D 660	No checking	No checking	No checking	No checking
Cracking	ASTM D 661	No cracking	No cracking	No cracking	No cracking
Rusting	ASTM D 610	None	None	None	9 or better
Corrosion from scribe (mm)	ASTM D 1654	9-10	9-10	9-10	9 or better

4.2 Maximum service temperature

Table 3: Maximum service temperature results

Maximum service temperature (145 °C)				
		Panel 1	**Panel 3**	**Requirements**
DFT (µm)	Min. - max.	245 – 294	255 – 343	
	Average ± STD	271 ± 18	282 ± 36	
Reference adhesion				
ISO 4624	Average ± STD	15.2 ± 0.9	9.5 ± 1.1	
Average adhesion (MPa)		12.3 ± 3.3		≥ 2.75 MPa
Adhesion after exposure				
ISO 4624	Average ± STD	12.5 ± 1.6	7.8 ± 0.4	
Average adhesion (MPa)		10.1 ± 2.9		≥ 90 % of reference adhesion (≥ 11.4 MPa)
Percentage of reference (%)		82		

5 CONCLUSION

The system MCU-Zinc + 2 % MCU-Quickcure / MCU-Miotopcoat (DFT 200/100 µm) was tested conform the performance tests detailed in the Aramco specification 09-SAMSS-087. The results can be surmised as follows:

- When tested at maximum service temperature of 145 °C, the adhesion of the system is 82 % of the value measured on the unexposed reference panels.

- When subjected to the cyclic test for the duration of 1500 hours, the system shows no defects, and a corrosion rating of 9-10 when evaluated according to ASTM D 1654, and therefore passes the requirements stated in Aramco specification 09-SAMSS-087 Table 2.

CENTRUM VOOR ONDERZOEK
EN TECHNISCH ADVIES (COT bv)

K. Coppoolse
Laboratory Technician

J.R.S. Brakenhoff
Technical Manager Laboratory

ANNEX I

Table 1: Application data

Paint Application Form				
Application data	**1st coat**	**2nd coat**		
Paint system:	MCU-Zinc + 2 % MCU-Quickcure	MCU-Miocoat RAL 7040		
Manufacturer: MCU-Coatings Middle East				
Surface roughness approx. 57-66 µm				
Date	May 26 2014	May 28 2014		
Time	10.15	8.00		
Surface preparation	Grit blasting	-		
Blasting standard	Sa 2½	-		
Abrasive used	A2	-		
Roughness	Medium	-		
Batch No. Comp. A	1604145-SI/ 1302134-SI	1004141-SI		
Batch No. Comp. B	--	--		
Equipment used	Airspray	Airless 66:1		
Nozzle pressure (bar)	2	165		
Size nozzle (mm)	2.0	0.017 (Inch)		
Fan width (--)	--	5		
Mixing ratio by mass	--	--		
Volume solid (% by volume)	72 ± 2	62 ± 2		
Theoretical wet film thickness (µm)	280	160		
Theoretical dry film thickness (µm)	200	100		
Thinner (% by volume)	0	0		
Air temperature (°C)	23	23		
Relative Humidity (%)	52	54		
Steel temperature (°C)	20	21		
Dew point (°C)	13	14		
Present at application: E. Huijsmans (COT)				

ANNEX II

Photographs of exposed panels

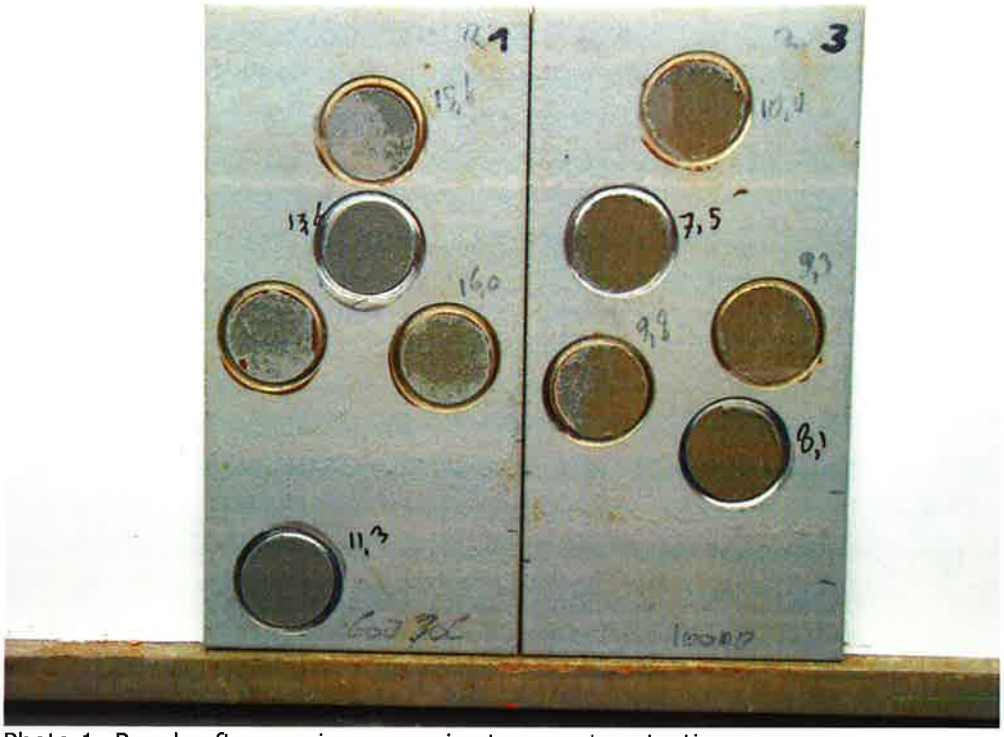

Photo 1: Panels after maximum service temperature testing

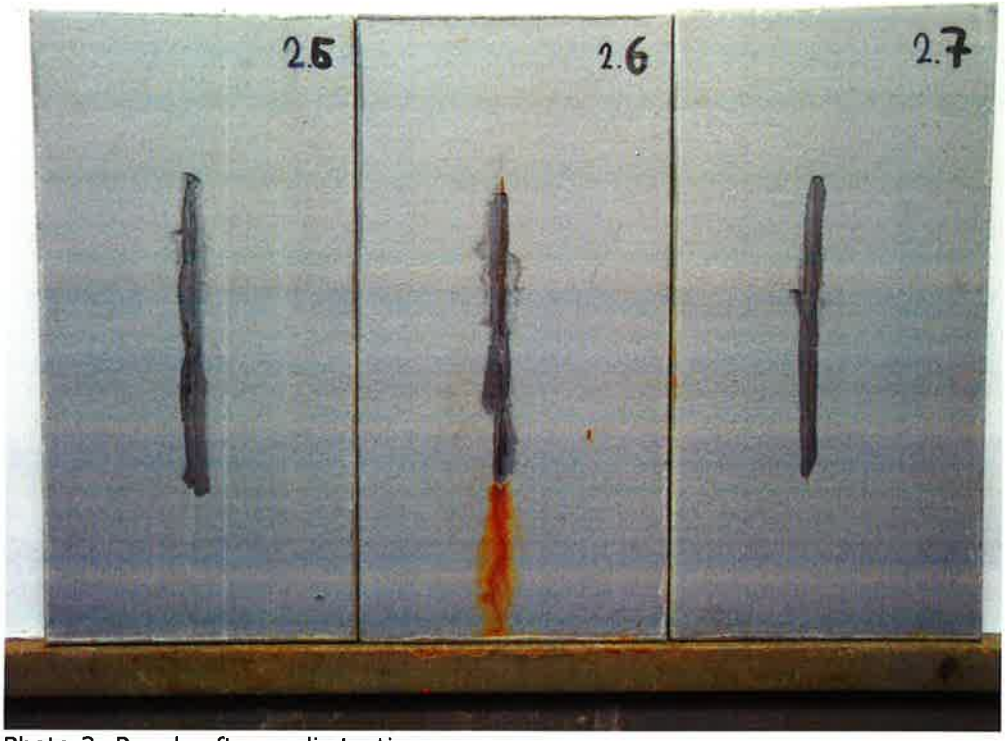

Photo 2: Panels after cyclic testing