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

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

Investigation of 9 coating systems on thermal insulation corrosion resistance, UV-resistance and impact resistance

Haarlem, May 16th, 2011

Client	:	GDF SUEZ E&P Nederland BV P.O. Box 84 1780 AB DEN HELDER Contact person : Mr. P. de Wit
Project number	:	20100034
Report number	:	LAB11-0381-RAP
Handled by	:	Mr. A. van Marion Mr. J.R.S. Brakenhoff

CONTENTS

1 INTRODUCTION 3
1.1 Order 3
1.2 Aim 3
1.3 General data 3

2 TESTS 5
2.1 Thermal insulation 5
2.2 Salt spray 5
2.3 UV-resistance 5
2.4 Impact resistance 5

3 RESULTS 6
3.1 Thermal insulation 6
3.2 Salt spray 8
3.3 UV-resistance 9
3.4 Impact 9

4 DISCUSSION 10

ANNEX I : Heat resistance test for heat insulating coating systems for use in petrochemical offshore applications, maximum temperature 140 °C

ANNEX II : Insulation test results

ANNEX III : Photos

1 INTRODUCTION

1.1 Order

By order of Mr. P.J. Dirks of GDF SUEZ E&P Nederland B.V. (shortly GDF) in Den Helder, The Netherlands, the Centrum voor Onderzoek en Technisch advies (COT bv) in Haarlem, The Netherlands, has performed several tests on 9 different coating systems.

The order to perform this test has been given by Mr. P.J. Dirks by sending a signed purchase order with number P-P2075-08500 dated 28 July 2010.
The order is based on the COT quotation with reference BA/MH LAB10-0087-OFF dated 13 January 2010.

During the performance of the tests an extra scope of work has been agreed, offered at 12 November 2010 by e-mail and ordered by GDF at 26 November 2010 with purchase order number P-P2075-08500-C01.

1.2 Aim

The aim of this test is to determine the thermal insulation, corrosion resistance, UV-resistance and impact resistance on 9 different coating systems.

1.3 General data

Samples	:	6 panels of 100 x 150 x 5 mm ("large") of each coating system 6 panels of 75 x 150 x 5 mm ("small") of each coating system
COT sample number	:	30-07-10/0534-1 till 9
Received	:	July 30th 2010

*Table 1: Coating systems according to client's specification**

Coating system number	Coating system description	DFT (µm)
1	Rustgrip Hot surface coating (4mm) Enamogrip	100 4 mm 100
2	Epoxy primer Epoxy sealer Hot surface coating (4 mm) Enamogrip	40 – 60 70 – 90 4 mm 40 – 60
3	Epoxy primer Epoxy sealer Hot surface coating Enamogrip	40 – 60 70 – 90 25 mm 40 – 60
4	Epoxy primer Epoxy sealer Top coat polyurethane	40 – 60 70 – 90 40 – 60
5	Zinc rich pimer HS epoxy coating Hot surface coating (4 mm) Enamogrip	65 – 85 2x100 – 250 4 mm 40 – 60
6	Zinc rich pimer Medium solid epoxy coating Hot surface coating (4 mm) Enamogrip	65 – 85 2x100 – 250 4 mm 40 – 60
7	Epoxy primer Epoxy sealer Top coat polyurethane Rustgrip Hot surface coating (4 mm) Enamogrip	40 – 60 70 – 90 40 – 60 100 4 mm 100
8	Zinc rich primer Medium solid epoxy coating Blasted front side Epoxy primer on 50% of testplate Epoxy sealer on 50% of testplate Hot surface coating (4 mm) Enamogrip	65 – 85 2x100 – 250 40 – 60 70 – 90 4 mm 40 – 60
9	Hotpipe coating on exhausts	10 – 20 mm

*) Based on visual observations, the various top layers are more different as indicated by the description. The systems 1, 4 and 7 have visually the same top layer. The insulation layer of system 3 is not 25 mm but about 4 mm.

2 TESTS

All measurements have been performed between 20 August 2010 and 10 April 2011.

2.1 Thermal insulation

The insulation of the coating systems has been determined in a heat resistance test for heat insulating coating systems as described in Annex I. Three (large) panels of each system have been used.
At the start, some preliminary measurements have been performed. After evaluation of the results it has been agreed to do the insulation test at 3 temperatures (70, 125 en 170 °C) for the coating systems 1, 3, 5 and 7. For system 9 the temperatures are 200, 250 and 325 °C. For the systems 2, 4, 6 and 8 the test has been performed at 125 °C.
All measurements have been done up to 60 minutes in steps of 10 minutes. For system 9 the test has been extended up to 120 minutes.

Results of the measured temperature of the top of the coating system are presented in tables and figures.

2.2 Salt spray

Three (small) samples of each coating system have been exposed in a neutral salt spray test according to ISO 9227 for 2000 hours. This means a continuous salt spray of 5 % NaCl at 35 °C with a pH of 7.
The panels have been scribed vertically down to the bare metal with a Stanley knife over a length of 70 mm.
The assessment of the panels has been done according to ISO 4628.

The panels of the impact resistance test (2.4) of the coating systems 1, 3, 5 and 7 have been placed after impact testing in the salt spray test for 2000 hours, with interim assessments every 500 hours.

Also the panels of the thermal insulation test (2.1) of the coating systems 1, 3, 5 and 7 have been placed after insulation testing in the salt spray test for 2000 hours, with interim assessments every 500 hours.

2.3 UV-resistance

The UV-resistance of the coating systems has been determined in a QUV test cabinet according to ISO 11507 with 3 small panels of each system. The cycle applied was 4 hours UV-A light (340 nm) at 60 °C and 4 hours water condensation at 50 °C. The total testing time was 1000 hours.
The assessment of the panels has been done visually.

2.4 Impact resistance

The impact resistance of the coating systems has been determined according to NEN 5335, the impact test with falling nuts. The test has been performed on 3 large panels of each coating system.

After the tests photos have been taken of which some are presented in Annex III.

3 RESULTS

3.1 Thermal insulation

The average values of the measurements are presented in Tables 2-4.
Figure 1 presents a graphical view of the data at a substrate temperature of 125 °C. Figures 2 and 3 present the data of the systems 3, 5 and 9 at all three substrate temperatures.

All individual measured data at the three substrate temperatures are enclosed in Annex II.

Table 2: temperature at the top of the coating system as a function of time at a substrate temperature of 125 °C

COT Sample number	Temperature T (°C) at the top of the coating system							
	Time (min)							
	0	5	10	20	30	40	50	60
30-07-10/0534-1	61.5	70.1	75.0	78.1	78.8	78.9	79.0	79.1
30-07-10/0534-2	67.1	73.6	77.2	80.8	81.5	81.8	81.8	81.7
30-07-10/0534-3	68.0	72.9	75.7	78.2	79.2	79.5	79.5	79.7
30-07-10/0534-4	80,2	89.5	93.3	95.2	96.2	96.8	97.1	97.3
30-07-10/0534-5	60.2	70.3	76.6	81.6	83.2	83.3	83.4	83.4
30-07-10/0534-6	70.0	75.6	78.6	80.8	81.1	81.3	81.4	81.5
30-07-10/0534-7	67.9	74.3	77.3	79.5	80.6	81.4	81.4	81.8
30-07-10/0534-8	61.5	70.3	74.7	78.2	79.2	79.8	79.8	80.1

Table 3: Temperature at the top of the coating system as a function of time at a substrate temperature of 70 °C

COT Sample number	Temperature T (°C) at the top of the coating system							
	Time (min)							
	0	**5**	**10**	**20**	**30**	**40**	**50**	**60**
30-07-10/0534-1	25.0	36.1	43.6	49.0	49.2	49.1	48.6	48.1
30-07-10/0534-3	28.7	37.0	42.4	46.2	46.4	46.9	46.9	46.9
30-07-10/0534-5	32.6	39.3	44.0	47.6	48.9	48.7	48.4	48.1
30-07-10/0534-7	33.3	39.1	44.3	48.5	49.1	48.8	48.3	47.9

Table 4: Temperature at the top of the coating system as a function of time at a substrate temperature of 170 °C

COT Sample number	Temperature T (°C) at the top of the coating system							
	Time (min)							
	0	**5**	**10**	**20**	**30**	**40**	**50**	**60**
30-07-10/0534-1	68.2	83.9	94.1	100.5	102.2	102.6	102.9	103.0
30-07-10/0534-3	84.7	94.2	98.8	103.0	104.1	104.3	104.6	104.6
30-07-10/0534-5	92.0	100.3	104.3	107.5	108.0	107.9	107.9	107.8
30-07-10/0534-7	87.0	96.7	100.9	104.4	104.6	104.5	103.8	103.4

Table 5: Temperature at the top of the coating system as a function of time at various substrate temperatures for coating system 9

COT Sample number	Sub-strate Temp (°C)	Temperature T (°C) at the top of the coating system								
		Time (min)								
		0	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**120**
30-07-10/0534-9	200	52.8	62.6	71.0	82.0	87.2	88.1	88.4	88.5	92.5
30-07-10/0534-9	250	59.2	75.1	89.6	108.8	115.4	114.8	115.7	117.6	118.2
30-07-10/0534-9	325	65.8	94.6	115.3	136.5	143.2	145.1	147.8	149.1	148.4

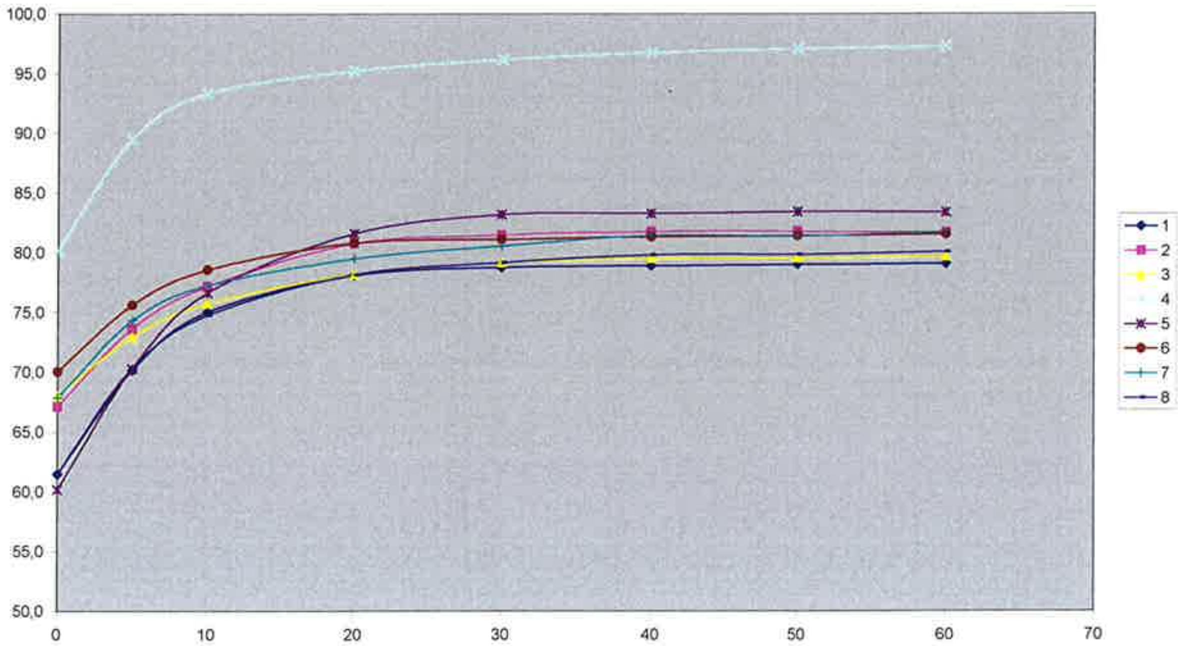
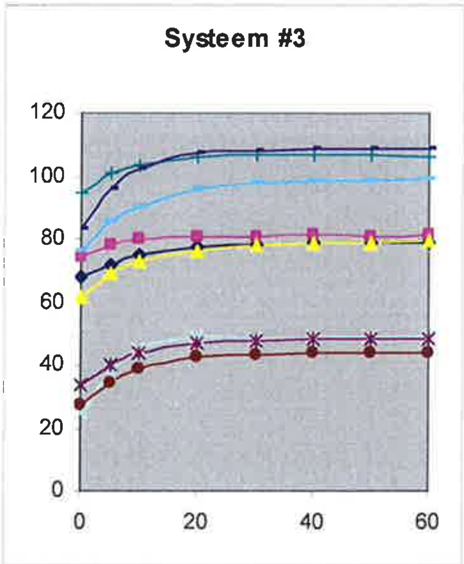


Figure 1: temperature (in °C) at the top at the coating system at a substrate temperature of 125 °C as a function of time (in minutes) for the coating systems 1-8



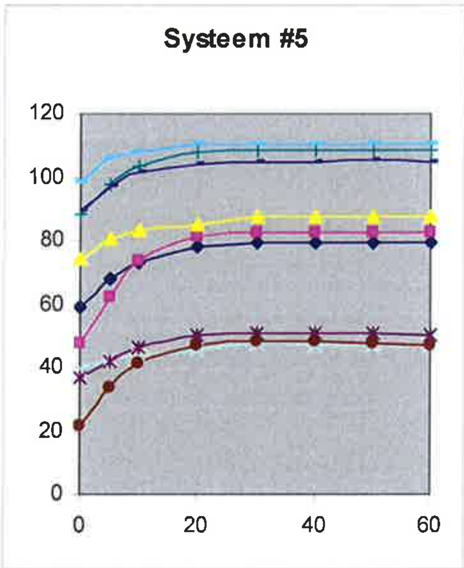


Figure 2: Temperature (in °C) at the top of the coating system at a substrate temperature of respectively 70, 125 and 170 °C as a function of time (in minutes) for the coating systems 3 and 5

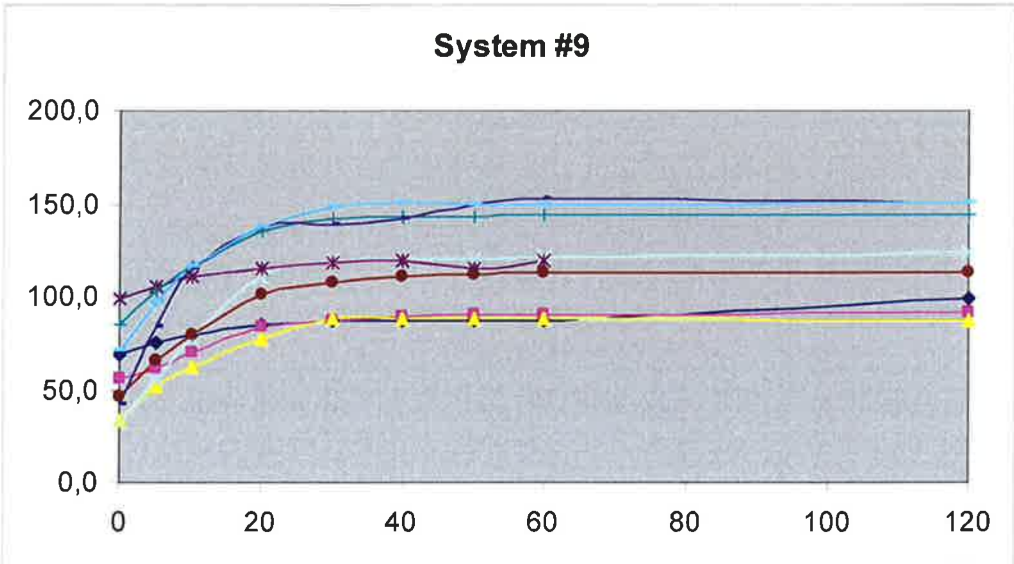


Figure 3: Temperature (in °C) at the top of coating system 9 at a substrate temperature of respectively 200, 250 and 325 °C as a function of time (in minutes)

3.2 Salt spray

Most samples showed a little corrosion from the scribe (creep). The results are presented in table 5. On the surface there was no corrosion at all.
The panels from the thermal insulation test and the panels from the impact test did not show any corrosion nor other defects.
Only some rust colored staining has been observed around pores and cracks in the top surface. Destructive examination after the test revealed that the corrosion did not originated from the substrate below.

Table 6:Results after salt spray-, QUV- and impact testing of the coating system

Coating system number	**Corrosion form the scribe (mm) after salt spray**	**Observations after QUV test**	**Defects after impact test**
30-07-10/0534-1	2	No defects	Cracking in top layer
30-07-10/0534-2	0.5	Strong loss of gloss	Cracking in top layer
30-07-10/0534-3	0	Strong loss of gloss	Cracking in top layer
30-07-10/0534-4	2	No defects	Some defects up to the steel surface
30-07-10/0534-5	0.5	Strong loss of gloss	Cracking in top layer
30-07-10/0534-6	0.5	No defects	Cracking in top layer
30-07-10/0534-7	0.5	No defects	Cracking in top layer
30-07-10/0534-8	0	Strong loss of loss	Cracking in top layer
30-07-10/0534-9	4-5	No defects	No defects

3.3 UV-resistance

The observed results after QUV testing are reported in Table 6, third column.

3.4 Impact

The observed results after impact testing are reported in Table 6, fourth column.

4 DISCUSSION

Table 6 summarizes the data of the insulation test of the systems 1, 3, 5, 7 and 9. The systems 1, 3, 5 and 7 all show about the same behavior: a relative temperature difference between top and bottom of the coating system of about 31 %, 35 % and 39 % at a substrate/bottom temperature of respectively 70, 125 and 170 °C.

Table 7: Substrate temperature (T1) and temperature of the top of the coating system (T2) and the difference (ΔT) for 5 coating systems measured in the thermal insulation test

COT Sample number	Substrate Temperature T1 (°C)	Top Coat Temperature T2 (°C)	T1 – T2 (°C)	(T1 - T2)* 100% / T1 (%)
30-07-10/0534-1	70	49	21	31
	125	79	46	37
	170	103	67	40
30-07-10/0534-3	70	47	23	34
	125	79	46	37
	170	104	66	39
30-07-10/0534-5	70	49	21	31
	125	83	42	33
	170	108	62	37
30-07-10/0534-7	70	49	21	30
	125	81	44	35
	170	104	66	39
30-07-10/0534-9	200	88	112	56
	250	116	134	54
	325	146	179	55

The systems 2, 6 and 8, only tested at 125 °C, show the same relative temperature difference of 35 %. Coating system 4, without a hot surface coating layer, shows a smaller relative ΔT (22 %). For system 9 the relative temperature difference is about 55 % for substrate temperatures between 200 and 325 °C.

The coating systems 3 and 8 show no corrosion form the scribe after salt spray testing; the systems 2, 5 and 7 show 0.5 mm creep, systems 1 and 4 2 mm creep and system 9 4-5 mm. Most systems have a good corrosion resistance.

All coating systems show a good impact resistance, except system 4. System 9 is the best.

The UV resistance of coating systems 1, 4, 7 and 9 is very good; the UV resistance of the other systems is less, all show a strong loss of gloss.

CENTRUM VOOR ONDERZOEK
EN TECHNISCH ADVIES (COT bv)

A.R. van Marion
Laboratory technician

Dr. B.P. Alblas
Manager Laboratory

ANNEX I

Heat resistance test for heat insulating coating systems for use in petrochemical offshore applications, maximum temperature 140 °C

Pending official tests (under development):
ISO/CD 12736, TC67 and ISO/CD 14288, TC107 (75.180.10/25.220.20)

Requirement
Test of heat insulating properties of several coating systems to a maximum of 140 °C.

Practical setup
Our current testing setup consists of a standard heating plate, regulated through an external probe, which is embedded in a solid steel block which is in contact with the uncoated side of the test sample. A second temperature sensor embedded in polystyrene (or polyurethane as PSF tends to deform at higher temperatures) foam is applied to the sample at the opposing side. The weight of a second block of steel ensures good contact of the sensors.
The HB is preheated using the stainless steel dummy.
The dummy is replaced with a sample once the desired temperature has been reached.

Considerations
Heating of the heating block (HB) tends to have a delay of several minutes, causing a significant overshoot which is less noticeable at higher temperatures.
Exchange of heat from the HB to a cool sample also causes fluctuation in the HB.
In order to avoid this noise, we propose preheating a sample to about half the target temperature.
External temperature will increase asymptotically up to a point where a balance is reached between diffusion of heat from the HB and to the surrounding air.

Interpretation
We can interpret several values for comparable results.
- Rate of heat transfer. Gradient of temperature over time during the period of linear heating.
- Difference in HB temperature and temperature on the outside, when equilibrium is reached.

Preliminary results
We have performed some exploratory measurements on some of the systems to be tested at a heater cut off temperature of 70 and 125 °C.
A sample with only a topcoat reaches a higher surface temperature than a RVS blank, likely due to the reduced area of bare metal.
Compared to topcoat only systems, foam insulated systems remain significantly cooler.

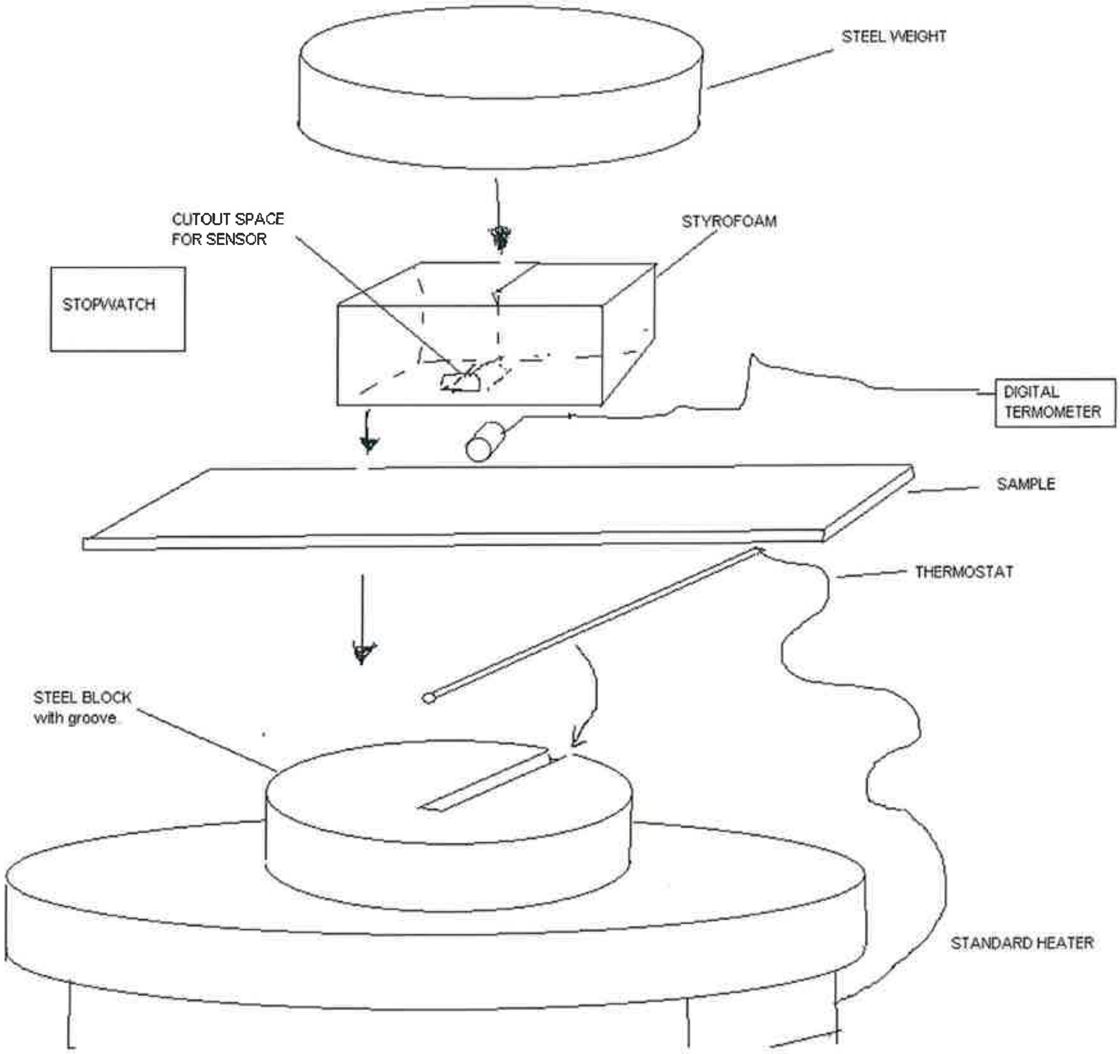


Figure 1: Quick doodle of experimental setup for determining insulation

ANNEX II

Insulation test results

T1 = substrate temperature (°C)
T2 = temperature (°C) at the top of the coating system
Panel code: **1-7**, means coating system 1 and panel number 7

125 °C

Time	1-7		1-8		1-9		2-7		2-8		2-9		3-7		3-8		3-9		4-7		4-8		4-9	
(min)	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
0	125,2	64,5	125,0	65,5	126,8	54,4	125,0	75,3	125,0	72,9	125,0	53,1	125,0	67,9	125,0	74,6	125,0	61,5	125,0	71,1	125,0	84,3	129,0	85,1
5	125,8	70,1	129,6	74,5	128,2	65,8	125,6	79,6	126,1	78,0	126,2	63,2	125,0	71,9	125,7	77,9	126,4	69,0	124,0	87,0	126,0	90,2	121,0	91,2
10	125,8	73,6	128,0	79,9	127,1	71,6	125,7	81,5	126,1	79,4	127,1	70,6	125,0	74,8	125,6	79,7	126,6	72,7	125,0	92,5	122,0	93,1	125,0	94,4
20	125,5	76,1	126,7	81,7	126,1	76,5	125,0	82,8	126,1	81,5	125,7	78,0	125,0	77,7	125,4	80,5	126,7	76,4	124,0	95,0	125,0	94,5	124,0	96,2
30	125,3	77,0	125,8	81,9	125,5	77,4	125,2	83,0	125,7	81,6	125,5	79,8	125,0	78,2	125,1	80,9	125,8	78,4	125,0	97,0	125,0	94,8	125,0	96,7
40	125,2	77,2	125,6	81,9	125,2	77,6	124,9	83,3	125,4	81,7	125,1	80,3	125,0	78,7	125,0	81,2	125,4	78,6	126,0	97,4	125,0	95,5	125,0	97,4
50	125,0	77,5	125,3	81,9	125,8	77,6	124,9	83,4	125,2	81,5	125,2	80,4	125,0	78,7	125,0	80,9	125,4	79,0	125,0	98,3	125,0	95,5	125,0	97,4
60	125,2	77,6	125,1	81,8	125,8	77,8	131,0	83,0	125,0	81,4	125,2	80,6	125,0	78,9	124,9	81,0	125,2	79,1	125,0	97,3				
□T	47,9		43,6		48,0		43,3		43,8		45,0		46,4		44,0		46,7		27,8		22,3		20,9	

125 °C

Time	5-7		5-8		5-9		6-7		6-8		6-9		7-7		7-8		7-9		8-7		8-8		8-9	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
0	127,1	58,9	127,5	47,4	128,0	74,2	125,0	66,7	125,6	68,6	125,3	74,8	125,2	75,2	125,2	75,4	125,0	53,0	128,0	46,8	125,5	70,4	125,0	67,2
5	126,8	67,7	126,5	62,5	126,6	80,6	126,4	72,4	126,7	75,5	125,9	78,9	125,7	79,0	125,7	78,9	124,0	65,0	121,0	62,3	126,2	75,5	125,3	73,1
10	125,9	72,8	125,6	73,7	125,7	83,4	126,0	75,6	126,7	79,1	126,7	81,0	125,6	80,7	125,9	80,4	124,0	70,7	125,0	70,3	125,8	77,8	125,5	76,1
20	126,1	78,3	124,9	81,2	126,2	85,3	125,6	77,8	126,3	81,5	125,9	83,1	126,7	82,0	125,5	81,5	125,0	75,0	124,0	76,1	125,7	79,6	125,5	78,8
30	124,9	79,4	124,9	82,5	125,0	87,6	125,4	78,3	125,5	81,6	125,2	83,4	125,7	82,6	125,3	81,8	125,0	77,3	125,0	78,2	125,3	80,0	125,4	79,3
40	125,0	79,6	124,9	82,8	124,7	87,4	125,0	78,5	125,5	81,9	125,1	83,6	125,3	82,6	125,3	81,8	125,0	79,9	125,0	79,5	125,2	80,1	125,1	79,8
50	125,0	79,6	125,1	82,8	124,7	87,8	125,0	78,5	125,3	82,0	125,1	83,7	125,2	82,6	125,3	81,6	125,0	79,9	125,0	79,5	125,1	80,0	125,1	80,0
60	125,0	79,6	125,1	82,8	124,8	87,7	125,0	78,5	125,2	82,3	125,1	83,8	125,1	82,6	125,9	81,4	125,0	81,3	125,0	80,2	125,3	80,1	124,9	79,9
□T	45,4		42,3		37,2		46,7		43,4		41,5		42,7		43,8		45,4		45,7		45,2		45,4	

70°C

Time	1-7		1-8		1-9		3-7		3-8		3-9		5-7		5-8		5-9		7-7		7-8		7-9	
(min)	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
0	70,0	23,6	70,0	19,5	70,0	31,9	76,0	25,0	70,0	33,5	70,0	27,6	70,1	39,4	70,0	36,6	70,0	21,8	70,0	29,2	70,0	38,5	71,3	32,3
5	73,0	40,0	72,2	32,8	74,1	35,6	85,0	37,0	70,3	39,8	70,2	34,3	70,9	42,7	70,9	41,7	72,8	33,6	75,7	34,4	72,4	41,6	70,6	41,2
10	77,4	48,8	70,7	40,4	71,5	41,7	79,0	45,0	70,2	43,7	70,1	38,5	70,5	44,0	70,5	46,6	71,5	41,3	72,0	40,8	70,7	46,2	70,1	45,8
20	72,8	54,5	69,9	45,5	70,0	47,1	69,0	49,0	70,3	47,1	70,0	42,5	69,7	45,8	70,4	50,0	70,6	46,9	70,2	46,3	69,8	49,8	69,9	49,4
30	71,4	53,5	69,9	46,3	70,2	47,8	71,0	48,0	70,1	47,9	70,2	43,2	70,3	47,4	70,3	51,1	70,3	48,2	69,8	47,3	69,8	50,2	69,8	49,9
40	70,9	52,4	70,1	46,7	69,9	48,1	71,0	49,0	70,1	48,1	70,1	43,6	70,3	47,2	70,0	50,8	70,1	48,0	68,9	47,8	69,9	49,8	69,9	48,9
50	70,5	51,5	70,0	46,7	70,0	47,7	71,0	49,0	70,1	48,1	70,0	43,6	70,1	47,0	70,0	50,6	70,1	47,5	68,9	47,3	69,9	49,4	69,9	48,3
60	70,2	50,4	70,0	46,5	70,1	47,5	71,0	49,0	70,0	48,0	70,1	43,8	70,0	46,9	70,1	50,2	70,0	47,1	70,0	47,0	70,0	49,0	69,8	47,6
□T	18,8		23,5		22,3		22,3		22,1		26,6		23,1		19,4		22,4		22,1		20,3		21,2	

170°C

Time	1-7		1-8		1-9		3-7		3-8		3-9		5-7		5-8		5-9		7-7		7-8		7-9	
(min)	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
0	170,0	91,6	174,1	36,1	170,0	76,8	170,0	94,4	170,0	83,3	170,0	76,3	170,0	88,4	170,9	89,3	170,0	98,4	170,0	93,4	170,8	86,1	170,0	81,5
5	170,9	99,3	174,7	64,0	172,6	88,3	170,7	100,8	171,2	96,0	171,4	85,9	171,7	97,7	171,1	97,3	171,0	106,0	171,5	105,0	171,4	92,7	172,8	92,4
10	170,6	105,8	172,2	81,5	171,4	95,0	171,0	103,7	171,3	102,3	171,5	90,3	172,2	103,6	171,0	101,4	170,5	107,9	171,7	109,1	171,4	96,0	172,0	97,6
20	170,3	107,1	170,6	93,7	170,6	100,6	170,7	106,2	170,7	107,3	171,1	95,6	171,8	107,9	170,5	104,2	171,0	110,5	171,2	110,7	171,0	99,3	171,2	103,1
30	170,2	107,9	170,2	96,9	170,4	101,9	170,6	106,4	170,4	108,2	170,3	97,7	171,1	108,7	170,5	105,0	170,3	110,4	171,0	109,3	170,6	100,4	170,8	104,2
40	170,2	108,2	169,9	97,5	170,4	102,2	170,5	106,5	170,3	108,4	170,4	98,1	170,4	108,4	170,7	105,0	170,3	110,2	170,8	108,4	170,5	100,8	170,4	104,2
50	170,0	108,5	170,1	97,9	170,3	102,3	170,4	106,4	170,2	108,7	170,2	98,7	170,3	108,5	170,2	105,1	170,2	110,2	170,5	106,3	170,2	100,9	170,4	104,1
60	170,2	108,6	170,1	98,0	170,2	102,3	170,2	106,2	170,1	108,5	170,3	99,2	170,0	108,4	170,1	104,9	170,5	110,2	170,6	105,1	170,0	101,0	170,2	104,0
□T	61,9		72,5		68,2		64,1		61,8		71,9		62,0		65,4		60,1		63,5		69,6		66,3	

Coating system 9

	200°C						250°C						300°C					
Time	9-7		9-8		9-9		9-7		9-8		9-9		9-7		9-8		9-9	
(min)	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
0	201,1	69,3	201,0	55,7	202,6	33,3	250,0	32,5	250,2	98,9	250,0	46,3	301,5	84,8	300,0	41,5	302,2	71,1
5	201,6	75,0	202,5	61,7	202,6	51,2	259,8	54,8	252,5	105,2	252,7	65,2	308,5	102,8	306,0	84,0	315,0	96,9
10	201,6	79,6	202,7	70,4	202,2	62,9	253,7	77,7	254,0	110,9	257,1	80,1	312,7	115,6	302,3	114,6	321,6	115,8
20	201,0	85,0	202,0	83,7	201,9	77,4	259,3	110,3	254,3	115,5	257,5	100,6	317,0	135,0	291,0	137,1	328,1	137,5
30	200,6	86,6	201,3	87,4	200,8	87,7	246,8	119,7	255,3	118,8	254,1	107,7	318,7	142,0	294,1	139,0	321,7	148,7
40	200,3	87,2	200,7	89,4	200,6	87,7			255,1	119,2	254,1	110,4	318,7	142,5	306,1	142,4	321,8	150,4
50	200,4	87,2	200,4	90,3	200,6	87,7	246,6	120,2	254,3	115,0	254,5	111,9	319,1	143,5	317,7	149,9	322,0	150,0
60	200,1	86,9	200,0	90,8	200,5	87,8	249,8	121,1	255,0	119,4	254,6	112,4	319,0	144,3	314,3	153,1	322,0	149,8
120	232,0	98,6	200,0	91,8	200,2	87,2	250,9	123,3			254,7	113,1	318,6	144,0	279,1	150,5	322,9	150,7

ANNEX III

PHOTOS

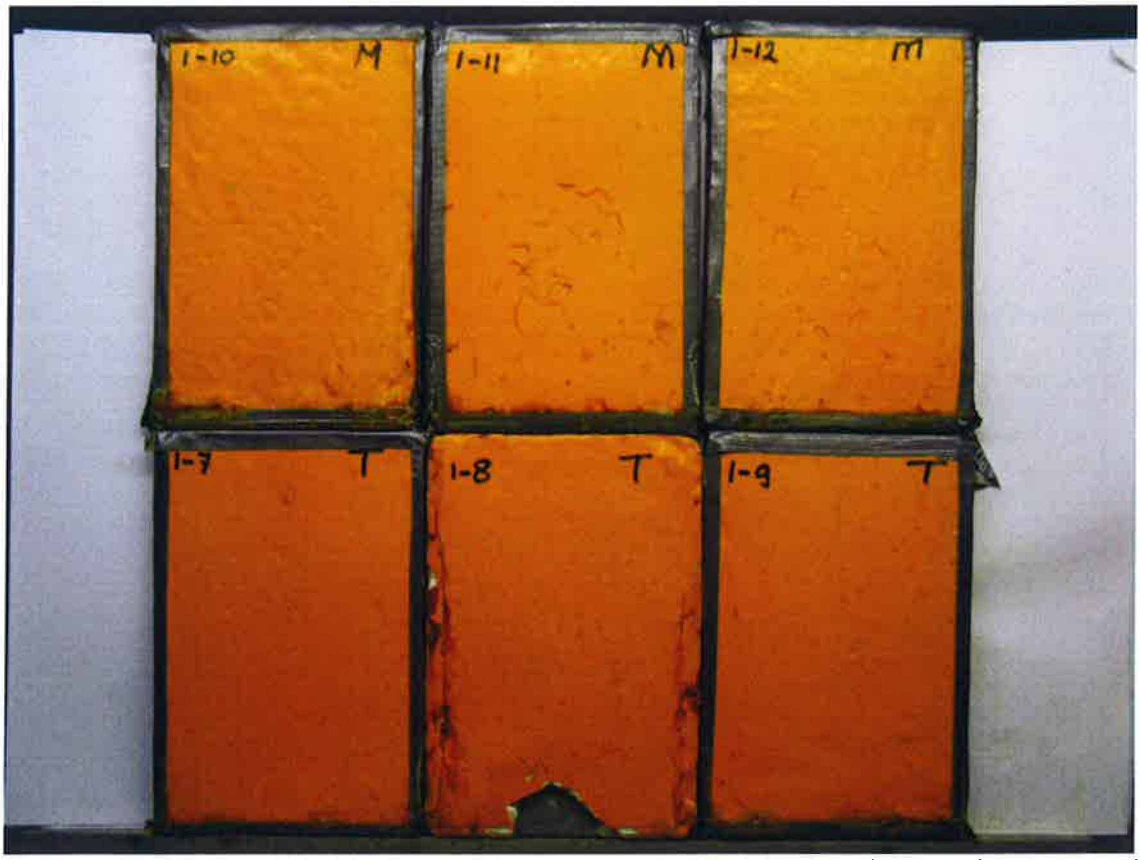


Photo 1. Panels of coating system 1 after Impact Resistance test, 2000 hours Salt spray test (M, top), after Thermal insulation and 2000 hours Salt spray test (T, bottom), both in 3-fold.

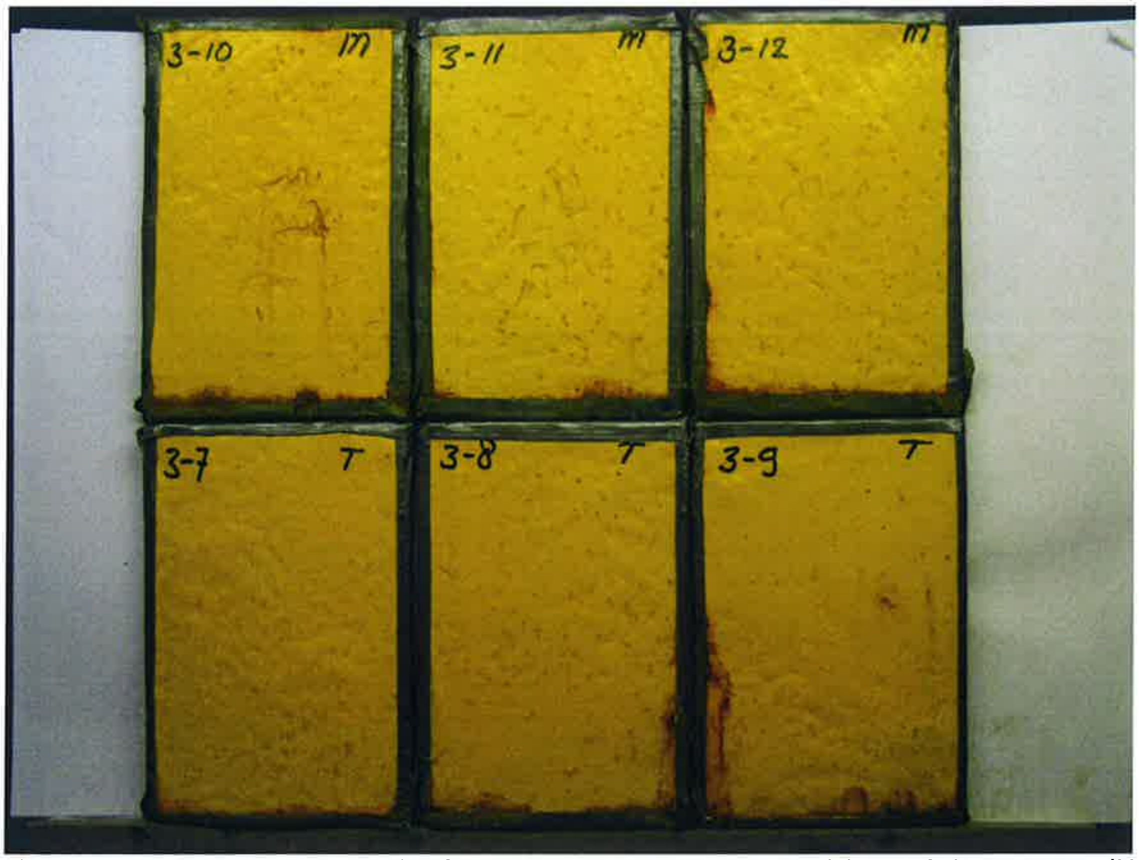


Photo 2. Coating system 3: Panels after Impact resistance test, 2000 hours Salt spray test (M, top), Thermal insulation and 2000 hours Salt spray test (T, bottom), both in 3-fold

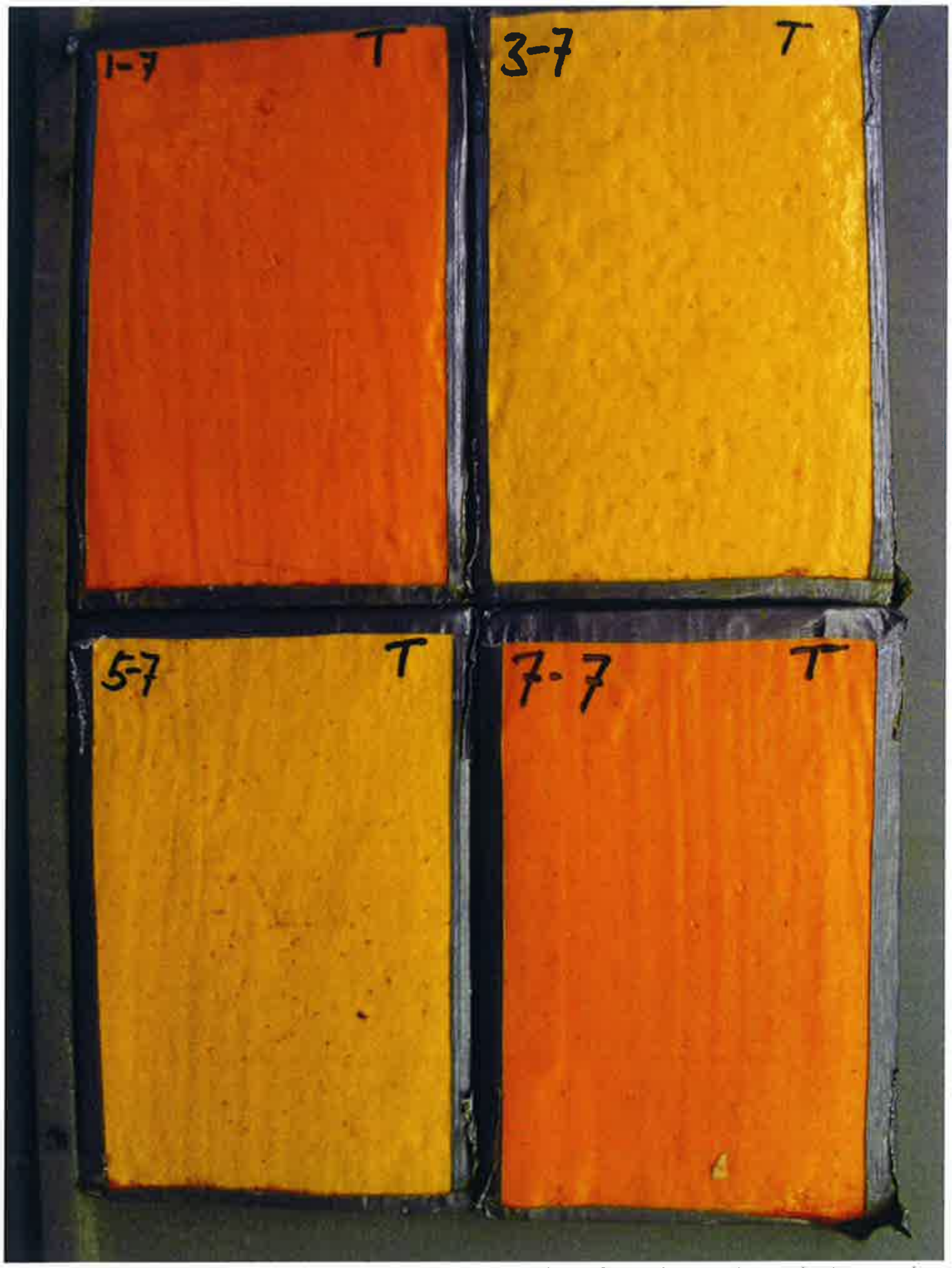


Photo 3. Panels of coating systems 1, 3, 5 and 7 after Thermal insulation and 2000 hours Salt spray test