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

REPORT

Investigation of a HSC coating system on thermal insulation and impact resistance

Civil projects
Corrosionprotection
Laboratory

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CONTENTS

1 INTRODUCTION

1.1 Order

By order of GDF SUEZ E&P Nederland B.V. (GDF) in Den Helder, The Netherlands, the Centrum voor Onderzoek en Technisch advies (COT bv) in Haarlem, The Netherlands, has performed several tests on a HSC coating system.

The order to perform this investigation has been given with the signed purchase order, number P-P2247-04501 dated 10 October 2011.
The order is based on the COT quotation with reference BA/MS LAB11-0432-OFF dated 26 May 2011.

1.2 Aim

The aim of this investigation is to determine the thermal insulation and impact resistance on a HSC coating system.

1.3 General data

Samples : 18 panels of 100 x 150 x 5 mm

COT sample number : 12-09-11/0606-1 till 18

Received : September 9th 2011

Table 1: Coating systems according to client's specification

Coating system number	Panel numbers	Coating system description	DFT (µm)
3a	1 – 6	Epoxy primer Epoxy sealer Hot surface coating Top coat polyurethane yellow RAL 1028	40 – 60 70 – 90 8 mm 40 – 60
3b	7 -12	Epoxy primer Epoxy sealer Hot surface coating Top coat polyurethane yellow RAL 1028	40 – 60 70 – 90 16 mm 40 – 60
3c	13 - 18	Epoxy primer Epoxy sealer Hot surface coating Top coat polyurethane yellow RAL 1028	40 – 60 70 – 90 25 mm 40 – 60

2 TESTS

All measurements have been performed between 15 September and 23 November 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 panels of each system have been used.

The insulation tests have been performed at 3 temperatures, 70, 125 and 170 °C.
All measurements have been done up to 60 minutes in steps of 5 minutes.

Results of the measured temperature and relative temperature reduction of the top of the coating system are presented in tables and figures. Experimental data are presented in Annex II for information.

2.2 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 panels of each coating system.

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

3 RESULTS

3.1 Thermal Insulation

The averaged values of the measurements are presented in Tables 2, 3 and 4.
Figure 1 presents a graphical view of the data for the three substrate temperatures and the three isolation thicknesses.

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

Table 2: Surface temperature and thermal isolation of the coating system as a function of time at a substrate temperature of 70 °C.

Coating system number	Isolation thickness (mm)	Temperature T (°C) at the top of the coating system							
		Time (min)							
		0	5	10	20	30	40	50	60
3a	8	28.8	34.5	39.3	44.0	44.9	45.0	44.9	44.7
3b	16	28.0	28.7	32.9	41.8	43.8	43.7	43.3	43.3
3c	25	29.9	26.8	28.3	31.7	34.6	36.3	37.0	37.4
		Thermal isolation (% temperature reduction)							
3a	8	59	52	44	37	36	36	36	36
3b	16	60	59	53	41	37	38	38	38
3c	25	58	63	60	55	51	48	47	47

Table 3: Surface temperature and thermal isolation of the coating system as a function of time at a substrate temperature of 125 °C.

Coating system number	Isolation thickness (mm)	Temperature T (°C) at the top of the coating system							
		Time (min)							
		0	5	10	20	30	40	50	60
3a	8	40.7	55.3	65.6	73.2	74.3	74.1	73.7	73.3
3b	16	37.9	46.1	51.6	58.9	61.8	62.3	62.1	61.7
3c	25	35.4	36.6	38.7	46.3	49.8	52.5	53.9	54.6
		Thermal isolation (% temperature reduction)							
3a	8	67	57	48	42	41	41	41	41
3b	16	70	64	59	54	51	50	51	51
3c	25	71	70	68	62	59	57	56	56

Table 4: Surface temperature and thermal isolation of the coating system as a function of time at a substrate temperature of 170 °C.

Coating system number	Isolation thickness (mm)	Temperature T (°C) at the top of the coating system							
		Time (min)							
		0	**5**	**10**	**20**	**30**	**40**	**50**	**60**
3a	8	73.3	84.3	89.9	92.9	93.6	94.0	93.6	94.9
3b	16	51.5	61.0	68.3	76.4	79.0	79.5	79.4	79.6
3c	25	40.0	45.9	51.6	60.5	63.8	66.4	67.9	68.7
		Thermal isolation (% temperature reduction)							
3a	8	57	51	47	44	43	43	43	43
3b	16	70	64	60	55	54	53	54	53
3c	25	77	73	70	67	64	61	60	60

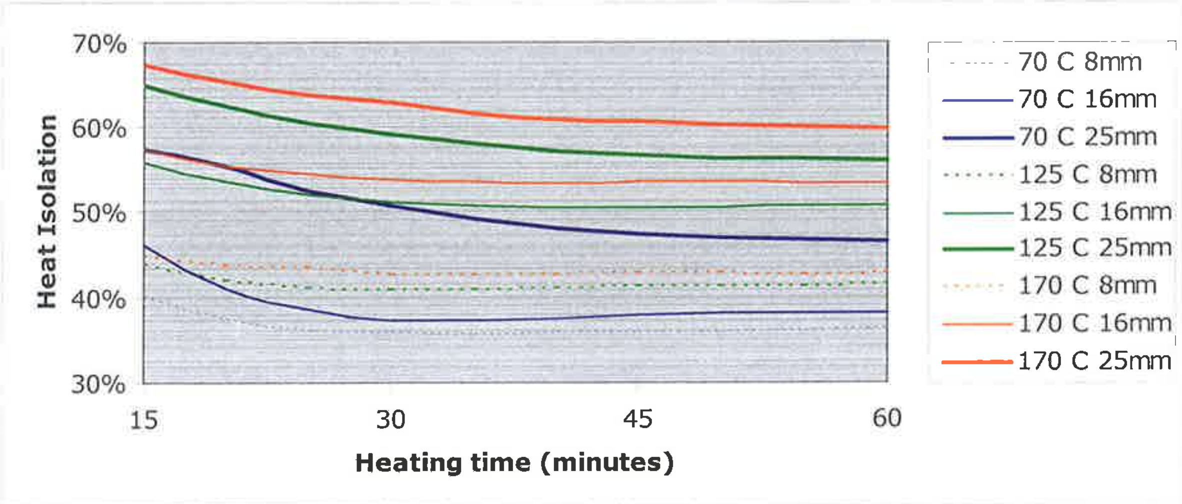


Figure 1: Graphical representation of thermal/heat isolation (% temperature reduction) for the 3 substrate temperatures (70, 125 and 170 °C) and the 3 isolation thicknesses (8, 16 en 25 mm) as a function of time (in minutes); data points in Tables 2-4

3.2 Impact Resistance

The results after impact testing are the same for all samples. There is cracking in the top layer but no defects up to the steel surface. Some photographs are presented in Annex III.

4 DISCUSSION

Table 5 summarizes the data of the insulation tests and interprets it as a relative percentage temperature difference. All systems show about the same behavior: the relative temperature difference between top and bottom of the coating system increases with temperature.
Also the relative temperature difference increases at one temperature with isolation thickness.

Table 5: Substrate temperature (T1) and temperature of the top of the coating system (T2) and the difference (ΔT) for 3 coating systems (COT sample number 12-09-11/0606) measured in the thermal insulation test.

Coating system number	Isolation thickness (mm)	Substrate Temperature T1 (°C)	Top Coat Temperature T2 (°C)	T1 – T2 (°C)	(T1 - T2)* 100% / T1 (%)
3a	8	70	45	25	36
		125	73	52	42
		170	94	76	45
3b	16	70	43	27	38
		125	62	63	50
		170	79	91	54
3c	25	70	37	33	47
		125	54	71	57
		170	68	102	60

All coating systems (COT sample number 12-09-11/0606) show a good impact resistance.

CENTRUM VOOR ONDERZOEK
EN TECHNISCH ADVIES (COT bv)

Ing. 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 170 °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 170 °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, 125 and 170 °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.

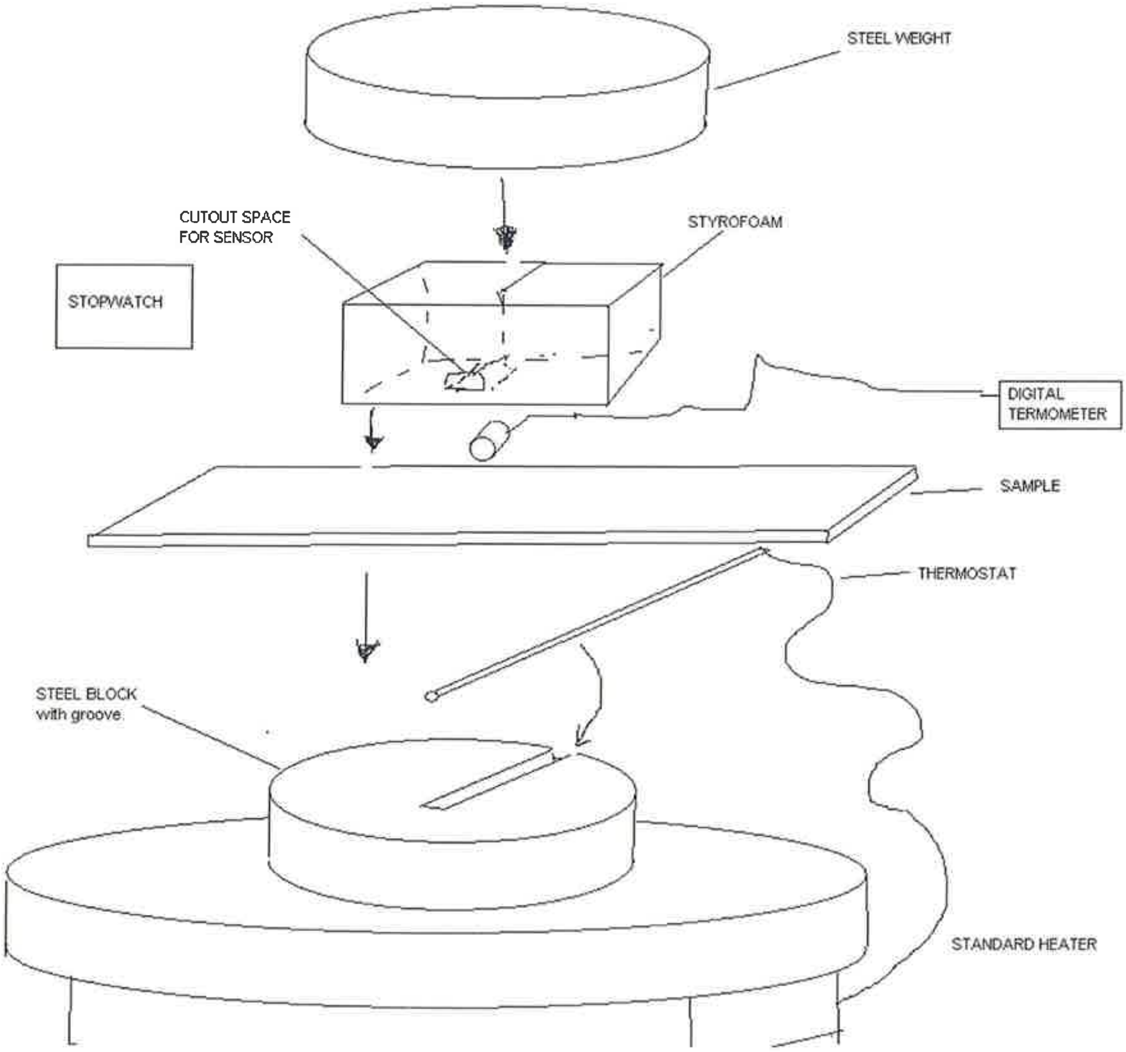


Figure 1: Quick doodle of experimental setup for determining insulation

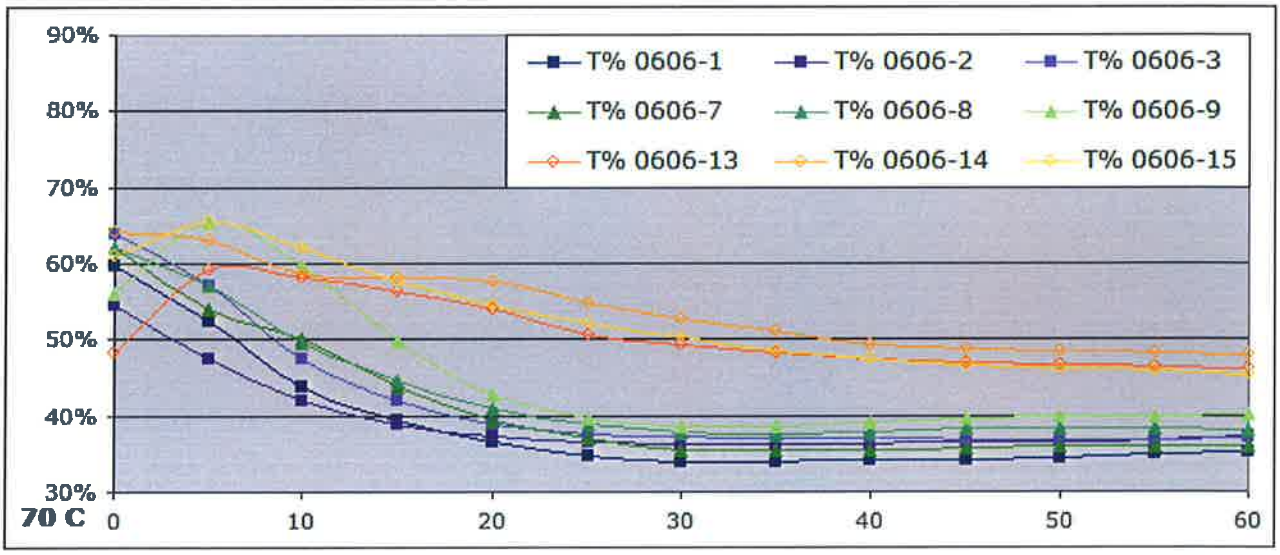
ANNEX II

Insulation test results

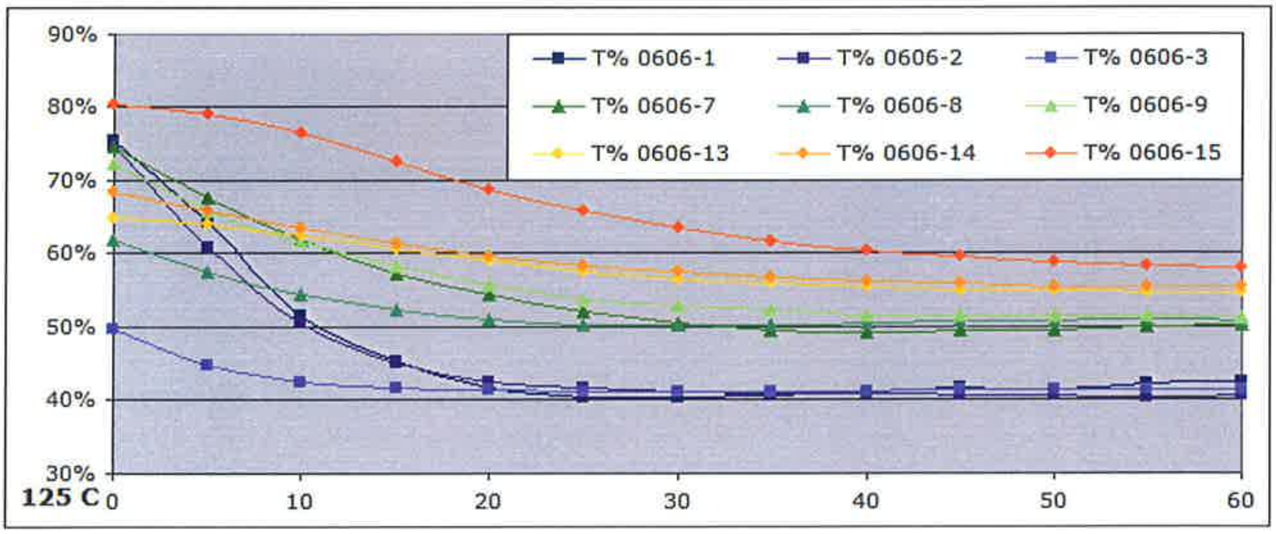
T% = transmitted heat through panel and coating system (in %)
Panel code: 0606-1 to 0606-18:
1-6 system 3a, isolation 8 mm
7-12 system 3b, isolation 16 mm
13-18 system 3c, isolation 25 mm

Percentage of **heat transmitted** through panel + coating at 3 panel temperatures and 3 coating thicknesses

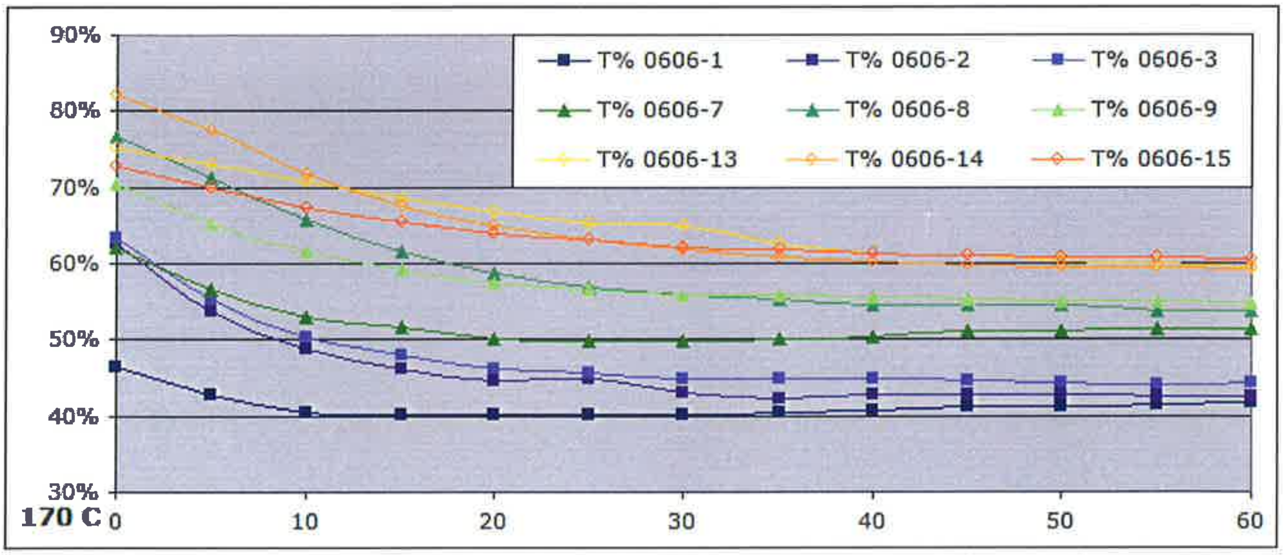
70°C	T%								
Time (min)	0606-1	0606-2	0606-3	0606-7	0606-8	0606-9	0606-13	0606-14	0606-15
0	60%	54%	64%	62%	62%	56%	48%	64%	61%
5	52%	48%	57%	54%	57%	66%	59%	63%	65%
10	44%	42%	47%	50%	49%	60%	58%	59%	62%
15	39%	39%	42%	44%	45%	50%	56%	58%	58%
20	36%	37%	39%	39%	41%	43%	54%	58%	55%
25	35%	37%	37%	37%	39%	40%	51%	55%	52%
30	34%	36%	37%	36%	38%	38%	49%	53%	50%
35	34%	36%	37%	36%	38%	39%	48%	51%	49%
40	34%	36%	37%	35%	38%	39%	47%	49%	47%
45	34%	37%	37%	36%	38%	40%	47%	49%	47%
50	34%	37%	37%	36%	38%	40%	47%	48%	46%
55	35%	37%	37%	36%	38%	40%	46%	48%	46%
60	35%	37%	37%	36%	38%	40%	46%	48%	46%
Avg	36%			38%			49%		



125°C	T%								
Time (min)	0606-1	0606-2	0606-3	0606-7	0606-8	0606-9	0606-13	0606-14	0606-15
0	75%	75%	50%	75%	62%	72%	65%	68%	80%
5	64%	61%	45%	68%	57%	66%	64%	66%	79%
10	52%	51%	42%	62%	54%	62%	63%	63%	76%
15	45%	45%	42%	57%	52%	58%	61%	61%	73%
20	42%	43%	41%	54%	51%	56%	59%	60%	69%
25	40%	42%	41%	52%	50%	54%	57%	58%	66%
30	40%	41%	41%	50%	50%	53%	57%	57%	63%
35	41%	41%	41%	50%	50%	52%	56%	57%	62%
40	41%	41%	41%	49%	50%	52%	55%	56%	60%
45	42%	41%	41%	49%	51%	52%	55%	56%	60%
50	42%	41%	41%	50%	51%	51%	55%	56%	59%
55	42%	40%	41%	50%	51%	51%	55%	55%	58%
60	43%	41%	41%	50%	51%	51%	55%	55%	58%
Avg	41%			51%			57%		



170°C	T%								
time (min)	0606-1	0606-2	0606-3	0606-7	0606-8	0606-9	0606-13	0606-14	0606-15
0	46%	63%	63%	62%	77%	70%	75%	82%	73%
5	43%	54%	55%	57%	71%	65%	73%	77%	70%
10	40%	49%	50%	53%	66%	62%	71%	72%	67%
15	40%	46%	48%	52%	62%	59%	69%	68%	65%
20	40%	45%	46%	50%	59%	57%	67%	65%	64%
25	40%	45%	46%	50%	57%	57%	65%	63%	63%
30	40%	43%	45%	50%	56%	56%	65%	62%	62%
35	41%	42%	45%	50%	55%	56%	63%	61%	62%
40	41%	43%	45%	50%	55%	55%	61%	60%	61%
45	41%	43%	45%	51%	54%	55%	61%	60%	61%
50	41%	43%	44%	51%	54%	55%	60%	60%	61%
55	41%	42%	44%	51%	54%	55%	60%	59%	61%
60	42%	42%	44%	52%	54%	55%	60%	59%	61%
Avg	43%			54%			61%		



ANNEX III

Photos

Photo 1. Panel of coating system 3a (8 mm isolation) after Impact Resistance test.

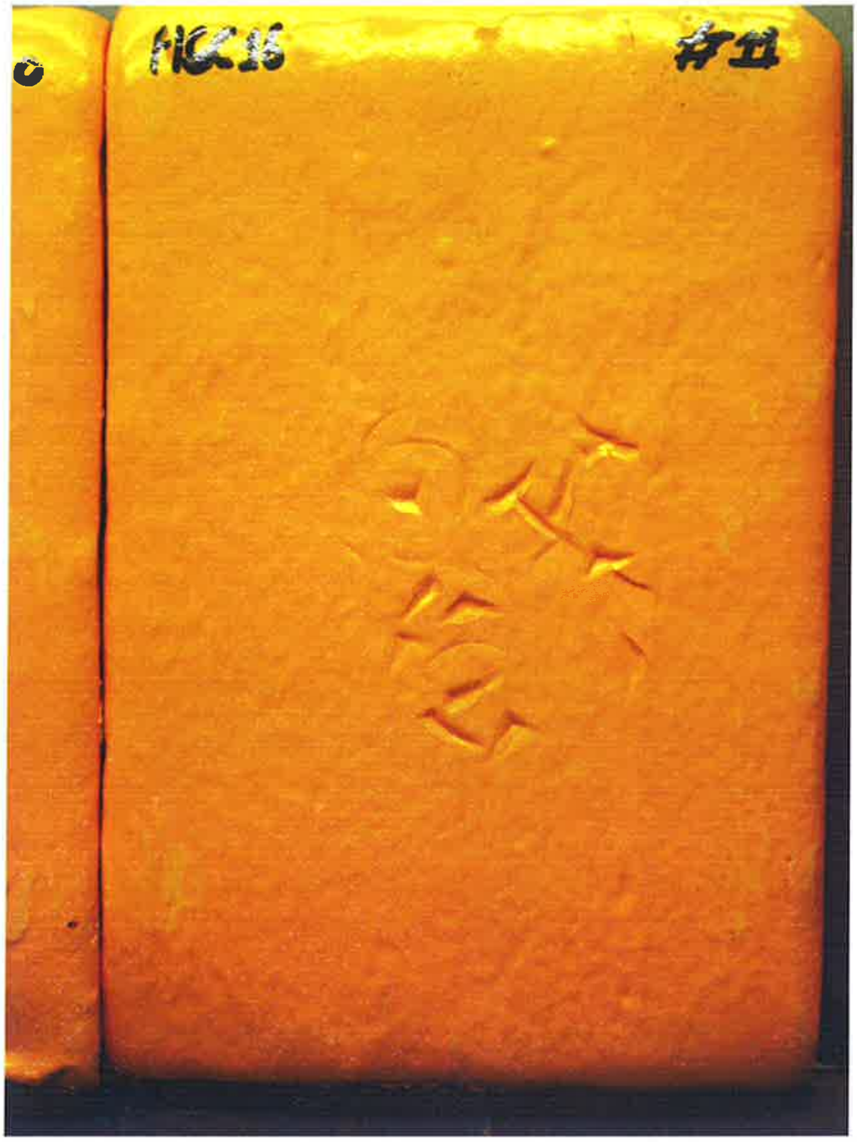


Photo 2. Panel of coating system 3b (16 mm isolation) after Impact Resistance test.

Photo 3. Panel of coating system 3c (25 mm isolation) after Impact Resistance test.