No. 101 (June 2008) IACS Model Report for IMO Resolution MSC.215(82) Annex 1 “Test Procedures for Coating Qualification”

EXAMPLE COATING PRODUCER

BALLAST TANK COATING TEST OF 2 * 160 µM EXAMPLE EPOXY PAINT ON EXAMPLE SHOP PRIMER

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1 SUMMARY

The coating system, 2 * 160 µm Example Epoxy Paint from Example Coating Producer, applied to Example zinc silicate shop primed panels has been tested in accordance with the IMO Performance Standard for protective Coatings /1/. The coating was applied after 2 months weathering of the shop primer.
The results from the testing show that the Example Epoxy Paint from Example Coating Producer has passed all the requirements given in the Performance Standard for Protective Coatings /1/.

2 SCOPE OF WORK

The following work and tests have been performed:

- Identification of the coating system
- Film thickness measurements and pin hole detection on panels before testing
- 180 days testing in condensation chamber
- 180 days testing in wave tank
- 180 days testing in heating cabinet
- Evaluation of results after testing, including blister detection, undercutting from scribe, adhesion and coating flexibility
- Evaluation of cathodic protection during testing (wave tank)

3 WORK CARRIED OUT PRIOR TO EXPOSURE

3.1 Identification

The coating system was identified by infrared scanning (by means of a ….(name and model of the instrument)) and by determination of specific gravity (according to ISO 2811 -1) by means of an Pyknometer (name and model of the instrument) .

3.2 Surface preparation

Surface preparation was carried out according to the data given in Table B-1 Appendix B.

3.3 Application

3.3.1 Application procedure

Example zinc silicate shop primer was applied to the blast cleaned panels according to the data given in Table 2. The shop primed panels were then exposed out-door for 2 months. The environmental data for the exposure period is given in Appendix A.

Two coats (specified dry film thickness 160 µm per coat) of Example Epoxy Paint were applied to the weathered and cleaned zinc silicate shop primed panels. The application data are given in Table B-2 Appendix B.

3.3.2 Coding

The panels were coded as shown in Figure B-1 in Appendix B.

3.4 Dry film thickness

The dry film thickness measurements were carried out by means of a (name and model of the instrument) dry film thickness unit before testing. Templates, as given in Figure B-2 in Appendix B, were used for the measurements. The results from the measurements are given in Table B-3 in Appendix B.

3.5 Pin hole detection

Pin hole detection was performed on the coated test panels before testing. The detection was carried out by means of a (name and model of the instrument) Pinhole detector at 90 volts.

4 EXPOSURE

The testing was carried out according to the IMO Performance Standard for Protective Coatings /1/. The exposure was started 02.11.07 and terminated 14.06.08.

5 TESTS CARRIED OUT AFTER EXPOSURE

Evaluation of blisters and rust, adhesion, undercutting from scribe and flexibility was carried out according to specifications and standards referred to in the IMO Performance Standard /1/.

6 TEST RESULTS

The results of the product identification are given in Table 1.

The results of the examination of the coated test panels are schematically given in Table 2 and more detailed in Appendix B. Pictures of the panels after exposure are enclosed as Appendix C.

Table 1 Results of analyses (Product identification)

Product	Batch no.	IR identification (main components)	Specific gravity (g/cm^3)
Example, part A	123	Ethyl silicate	0.93
Example, part B	234	NA*	2.21
Example Epoxy Paint Grey, base	345	Epoxy	1.48
Example Epoxy Paint hardener	456	Amide	0.96
Example Epoxy Paint Buff, base	567	Epoxy	1.47

* Identified and spectres stored. No generic correlation to the spectres in the data base found.

Table 2 Results of examination of the coated test samples

Test parameter	**Acceptance criteria**	**Test results**	**Passed / failed**
Pin holes (no)	No pinholes	0	Passed
Blisters and rust (all panels) [1)]	No blisters or rust	0	Passed
Adhesion values (MPa) – wave tank panels [2)]	>3.5 adhesive failure >3.0 cohesive failure	Average: 5.4 Maximum: 7.4 Minimum: 4.2 70 – 80 % cohesive failure 20 – 30 % adhesive failure	Passed
Adhesion values (MPa) – condensation chamber panels [3)]	>3.5 adhesive failure >3.0 cohesive failure	Average: 5.6 Maximum: 6.9 Minimum: 4.1 70 – 80 % cohesive failure 20 – 30 % adhesive failure	Passed
Undercutting from scribe (mm) - average maximum values wave tank panels [4)]	< 8	3.5	Passed
Cathodic disbondment (mm) – Wave tank bottom panel [5)]	< 8	7.2	Passed
Current demand (mA/m^2) – bottom panel [5)]	< 5	3.3	Passed
U-beam [1)]	No degradation (defects, cracking or detachment at the angle or weld)	No degradation	Passed

[1)] Details of blister and rust and u-beam in Table B-4 Appendix B.
[2)] Details of Pull-off adhesion test, wave tank and heat exposed panels in Table B-5 Appendix B.
[3)] Details of Pull-off adhesion test, condensation chamber in Table B-6 Appendix B.
[4)] Details of physical testing in Table B-7 Appendix B.
[5)] Details of Cathodic Protection in Table B-8 Appendix B.

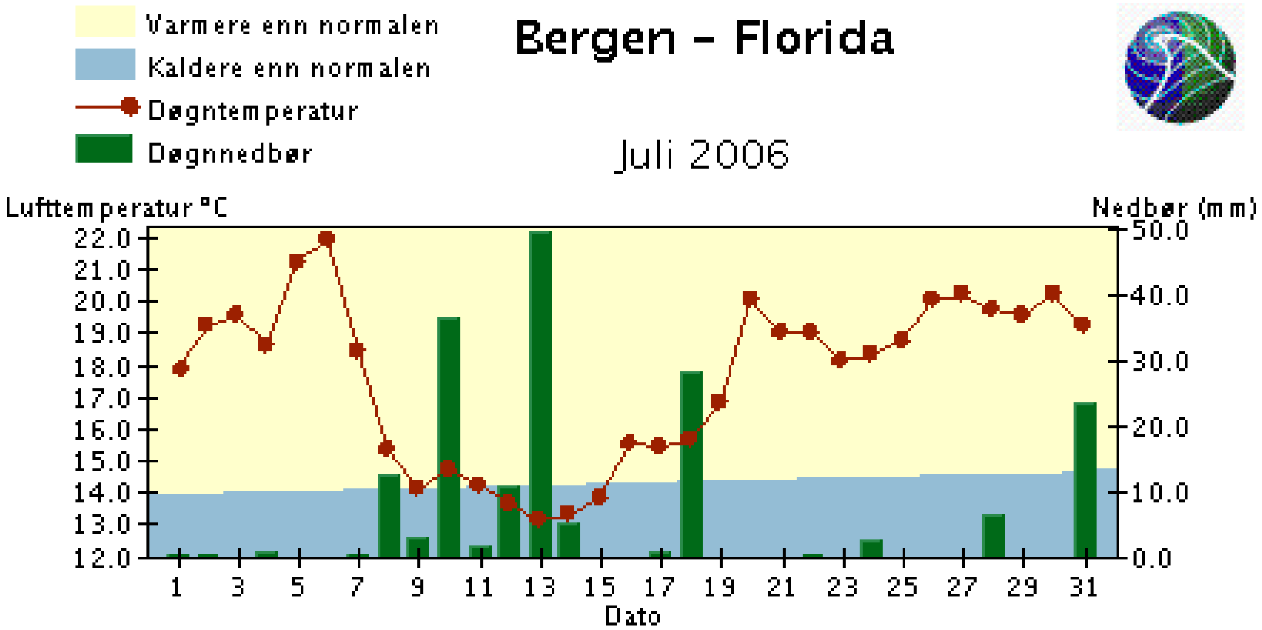
7 CONCLUSION

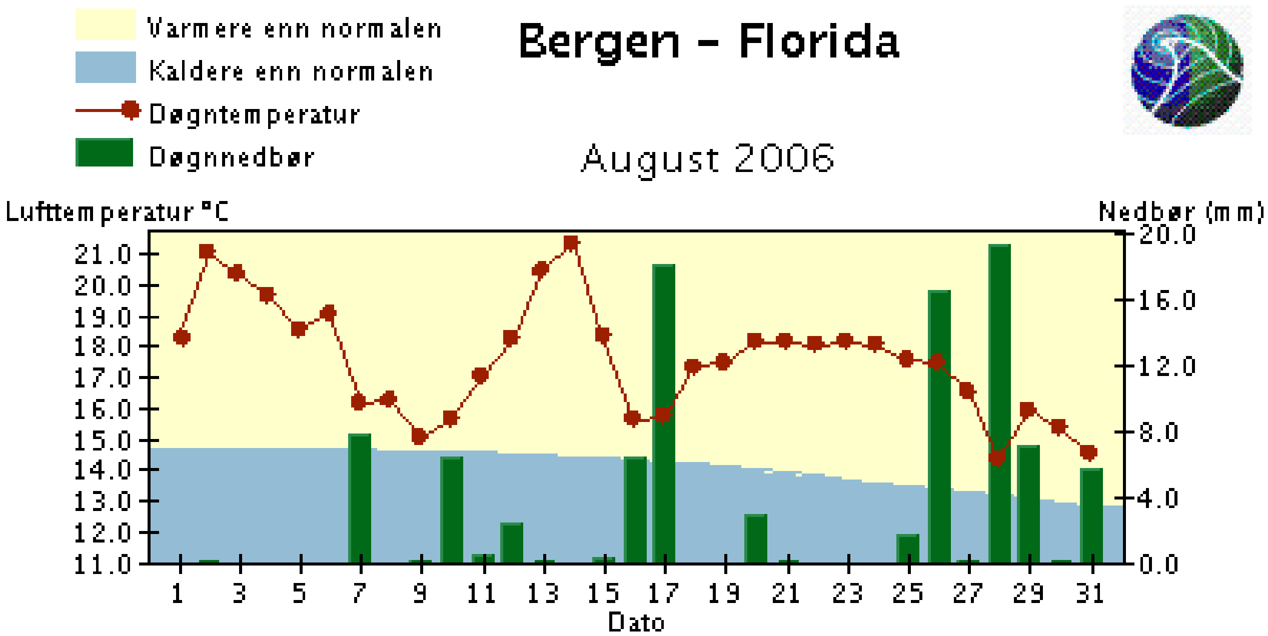
The results from the testing show that Example Epoxy Paint from Example Coating Producer has passed all the requirements given in the Performance Standard for Protective Coatings /1/.

8 REFERENCES

/1/ MSC 215 (82) :2006 Performance Standard for Protective Coatings for dedicated sea water ballast tanks in all types of ships and double-side skin spaces of bulk carriers

9 APPENDIX A - ENVIRONMENTAL DATA - WEATHERING OF SHOP PRIMED PANELS





10 APPENDIX B - DETAILS OF SURFACE PREPARATION, APPLICATION AND TEST RESULTS

Table B-1 Surface preparation data.

Surface preparation date	November 2007 The prepared panels were stored at ambient in- door conditions until use
Surface preparation method	Blast cleaning
Blasting standard	Sa 2 ½
Abrasive used	AlSil A3+ steel shot
Roughness (µm)	R_{max} 50 -75
Water soluble salts	32, 38 and 40 mg / m^2 Spot check performed on 3 out of 30 panels produced at the same time
Dust and abrasive inclusions	No dust or abrasive inclusions observed by visual examination.
Treatment of shopprimer after weathering	Low pressure washing
Water soluble salts after treatment of shopprimer	Spot check 28, 41 and 38 mg / m^2

Table B-2 Application data.

Coating data:	Shop primer	1st coat	2nd coat
Paint system:	Example red	Example Epoxy Paint Al Grey	Example Epoxy Paint Buff
Manufacturer:	Example Coating Producer		
Date	20.11.07	22.01.08	23.01.08
Time	10:00	10:00	10:00
Batch No. curing agent			
Batch No. base			
Thinner name (if used)			
Batch No. thinner(if used)			
Equipment used	Graco King 68:1	Graco King 68:1	Graco King 68:1
Air pressure (bar)	100	170	170
Size nozzle (inches)	0.021	0.021	0.021
Fan width (º)	60	60	60
Mix. ratio (volume)	A: B = 3:1	3:1	3:1
Volume solid (volume)	30 ± 2	80	80
Wet film thickness (μ)	55-70	275	275
Dry film thickness (μ)	15-25	See Table 3	See Table 4
Thinner (%)	0	0	0
Air temperature (ºC)	25	25	25
Humidity (% RH)	78	80	82
Steel temp. (ºC)	25	25	25
Dew point (ºC)	20	20	20
Present at application of shop primer: nn – MM Group (painter) and mm – laboratory. Present at application of test coating: kk - Example Coating Producer, nn – MM Group, and mm – laboratory. **Comments:**			

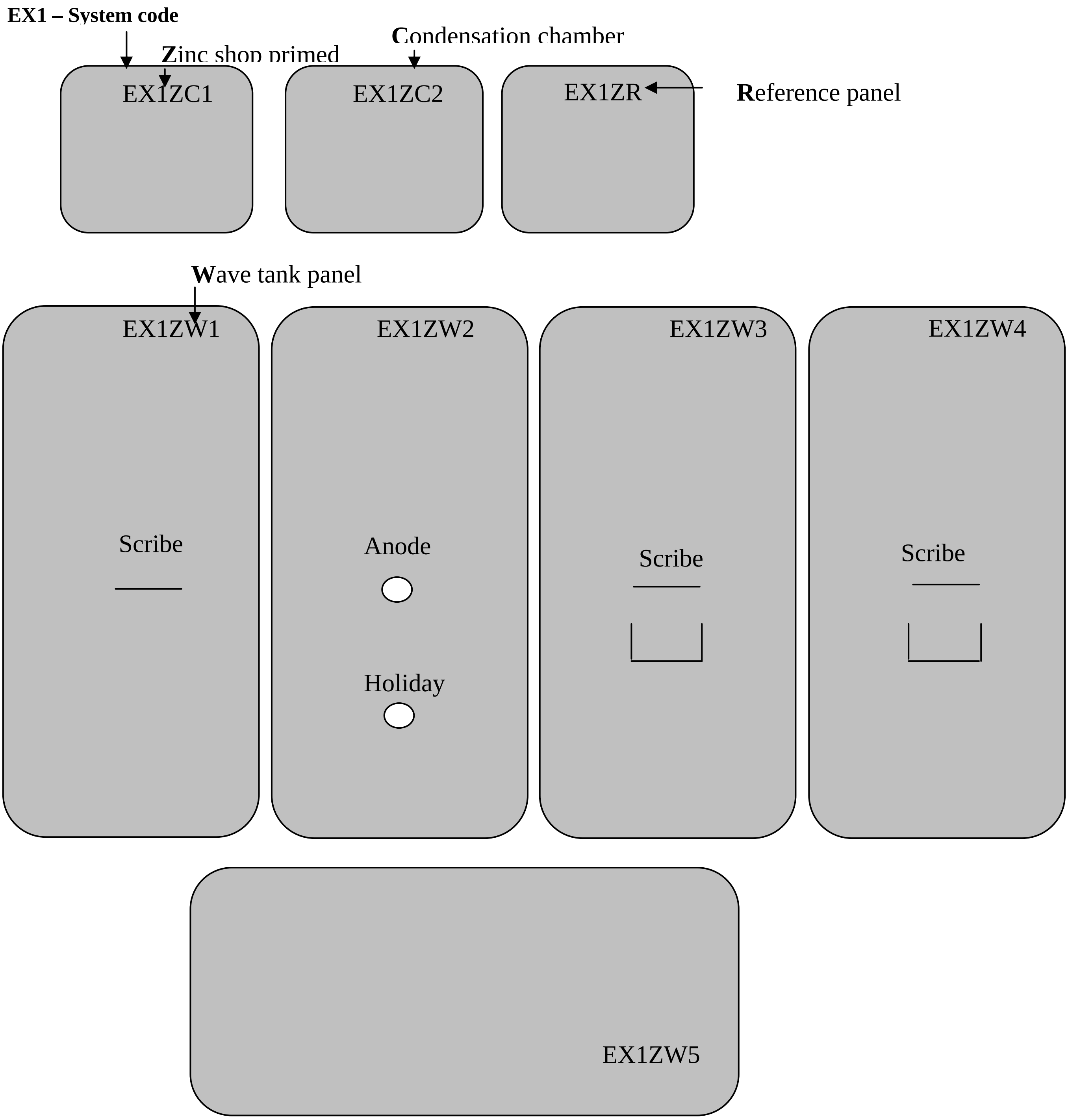


Figure B-1 Coding.

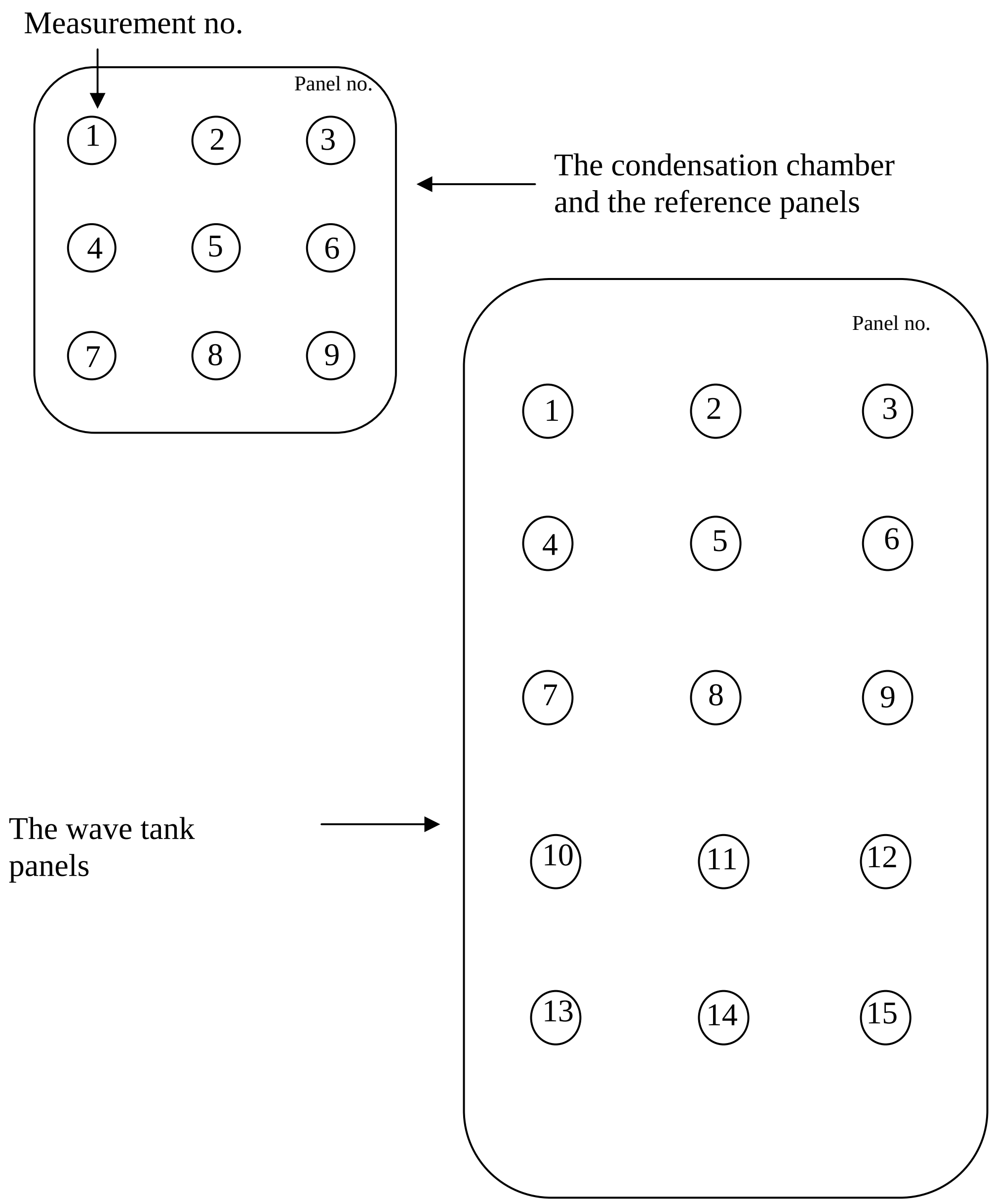


Figure B-2 Thickness measurement locations.

Table B-3 Total Dry Film Thickness – Example Epoxy Paint (20 µm subtracted for shop primed substrate).

Measurement	Panel no EX1-								
	ZW1	ZW2	ZW3	ZW4	ZW5	ZC1	ZC2	ZR	Total
1	332	330	338	322	324	325	320	354	
2	324	356	362	360	388	360	322	320	
3	320	320	328	326	336	342	334	322	
4	320	344	368	320	320	330	340	364	
5	352	356	412	350	326	346	358	336	
6	340	320	340	320	320	362	342	342	
7	320	326	366	356	320	340	330	320	
8	380	348	428	398	348	358	320	346	
9	338	320	380	364	330	338	322	320	
10	320	319	356	338	316				
11	342	360	408	456	340				
12	316	320	326	324	324				
13	320	344	356	332	320				
14	366	424	410	380	366				
15	342	348	330	350	346				
Max	380	424	428	456	388	362	358	364	456
Min	316	319	326	320	316	325	320	320	316
Average	**335**	**342**	**367**	**353**	**335**	**345**	**332**	**336**	**344**
StDev	19	27	34	37	20	13	13	17	27

Table B-4 Development of blisters and rust after exposure.

Code	Description	Blister size	Blister density	Rust	Other defects
EX1ZW1	Top wave tank panel with scribe	0	0	0	0
EX1ZW2	Bottom wave tank panel with anode	0	0	0	0
EX1ZW3	Side wave tank panel with scribe and U-beam Cooling	0	0	0	0
EX1ZW4	Side wave tank panel with scribe and U-beam No cooling	0	0	0	0
EX1ZW5	Panel exposed to 70 ºC air (heating chamber)	0	0	0	0
EX1ZC1	Condensation chamber	0	0	0	0
EX1ZC2	Condensation chamber	0	0	0	0

Table B-5 Results of the Pull-off adhesion test, wave tank and heat exposed panels.

Panel no.	Adhesion strength (MPa)	Fracture
Top wave tank panel with scribe W1	4.5	30 % B, 20 % C, 30 % C/D, 20 % D
	5.2	20 % B, 30 % C, 30 % C/D, 20 % D
	4.8	30 % B, 20 % C, 20 % C/D, 30 % D
Bottom wave tank panel with anode W2	5.3	30 % B, 20 % C, 20 % C/D, 30 % D
	4.2	30 % B, 20 % C, 30 % C/D, 20 % D
	6.1	20 % B, 30 % C, 30 % C/D, 20 % D
Side wave tank panel with scribe and U-beam Cooling W3	7.0	20 % B, 30 % C, 30 % C/D, 20 % D
	4.6	30 % B, 20 % C, 20 % C/D, 30 % D
	5.3	30 % B, 20 % C, 30 % C/D, 20 % D
Side wave tank panel with scribe and U-beam No cooling W4	5.3	30 % B, 20 % C, 30 % C/D, 20 % D
	7.4	20 % B, 30 % C, 30 % C/D, 20 % D
	5.1	30 % B, 20 % C, 20 % C/D, 30 % D
Panel exposed to 70 ºC air (heating chamber) W5	4.6	30 % B, 20 % C, 20 % C/D, 30 % D
	6.6	30 % B, 20 % C, 30 % C/D, 20 % D
	5.3	20 % B, 30 % C, 30 % C/D, 20 % D
Average	5.4	70 – 80 % Cohesive failure, 20 – 30 % Adhesive
Max	7.4	
Min	4.2	

A/B	Fracture between the steel surface and 1st coat (shop primer).
B	Fracture in the 1st coat.
B/C	Fracture between the 1st and 2nd coat.
C	Fracture in the 2nd coat.
C/D	Fracture between the 2nd and 3rd coat.
D	Fracture in the 3rd coat
-/Y	Fracture between the outer coat and the glue.

Table B-6 Results of the Pull-off adhesion test, condensation chamber and reference panels.

Condensation chamber panel C1	6.1	20 % B, 30 % C, 30 % C/D, 20 % D
	4.1	30 % B, 20 % C, 20 % C/D, 30 % D
	6.9	30 % B, 20 % C, 30 % C/D, 20 % D
Condensation chamber panel C2	4.6	30 % B, 20 % C, 30 % C/D, 20 % D
	5.2	20 % B, 30 % C, 30 % C/D, 20 % D
	6.4	30 % B, 20 % C, 20 % C/D, 30 % D
Average	5.6	70 – 80 % Cohesive failure, 20 – 30 % Adhesive
Max	6.9	
Min	4.1	
Reference panel (not exposed) R	4.1	30 % B, 20 % C, 20 % C/D, 30 % D
	4.5	30 % B, 20 % C, 30 % C/D, 20 % D
	5.0	20 % B, 30 % C, 30 % C/D, 20 % D

A/B Fracture between the steel surface and 1st coat (shop primer).
B Fracture in the 1st coat.
B/C Fracture between the 1st and 2nd coat.
C Fracture in the 2nd coat.
C/D Fracture between the 2nd and 3rd coat.
D Fracture in the 3rd coat
-/Y Fracture between the outer coat and the glue.

Table B-7 Results of physical testing.

Panel	Undercutting from scribe (mm)*	Flexibility**	Comment
Top wave tank panel EX1ZW1	5.7	150 mm	≤ 2 % elongation
Cooled side wave tank panel EX1ZW3	2.2	NA	
Not cooled side wave tank panel EX1ZW4	2.6	NA	
Average	3.5		
Reference panel (not exposed) EX1ZR	Not applicable	75 mm	≤ 4 % elongation

* *Evaluated by scraping with knife.*

** *Flexibility[1)] modified according to panel thickness (3 mm steel, 300 μm coating, 150 mm cylindrical mandrel gives 2% elongation) for information only;1) Reference standards: ASTM D4145:1983. Standard Test Method for Coating Flexibility of Prepainted Sheet.*

Undercutting from scribe:

"Rinse the test panel with fresh tap water immediately after exposure, blowing off residues of water from the surface using compressed air if necessary, and inspect for visible changes. Carefully remove any loose coating using a knife blade held at an angle, positioning the blade at the coating/substrate interface and lifting the coating away from the substrate." (From ISO 4628-8:2005, section 5.3.1.)

"Calculate the degree of delamination d, in millimetre using the equation d=(d1-w)/2 where d1 is the mean overall width of the zone of delamination, in millimetres; w is the width of the original scribe, in millimetres." (From ISO 4628-8:2005, section 6.1.)

"Calculate the degree of corrosion c, in millimetre using the equation c=(wc-w)/2 where wc is the mean overall width of the zone of corrosion, in millimetres; w is the width of the original scribe, in millimetres." (From ISO 4628-8:2005, section 6.2.)

Additionally IACS interpretation of IMO PSPC: Undercutting from scribe can be either corrosion of the steel substrate or delamination between the shop primer and the epoxy coating (compability test). For PSPC maximum width is used (MSC.215(82), Appendix 1, section 2.2.6 and not mean overall width as in the ISO standard. The average of the three maximum records (three panels with scribe) is used for acceptance and shall be less than 8 mm for epoxy based systems to be acceptable. Cohesive adhesion failure in the shop primer is not to be included as part of the delamination.

Table B-8 Results of Cathodic Protection (CP).

Panel	Cathodic disbondment (mm)	Blisters / rust	Zinc anode weight loss (g)	Current demand (mA/m^2)
EX1ZW2	7.2	0	1.2345	3.32

Exposure time: *120 days (Total time 180 days. Each cycle consists of 2 weeks seawater immersion and 1 week exposure in air)*

Utilisation factor: *0.8*

Consumption rate for Zn-anodes: 11.3 kg/A year

Cathodic protection; disbonding from artificial holiday:

"On completion of the test, thoroughly rinse the panel with tap water, taking care not to damage the coating." (From ISO 15711:2003)

"Assess loss of adhesion at the artificial holiday by using a sharp knife to make two cuts through the coating to the substrates, intersection at the holiday. With the point of the knife, attempt to lift and peel back the coating from around the holiday. Record whether the adhesion of the coating to the substrate has been reduced and the approximate distance, in millimetres, that the coating can be peeled." (From ISO 15711:2003)

Additionally IACS interpretation of IMO PSPC: Repeat the cutting and lifting all around the artificial holiday to find the maximum loss of adhesion. Disbonding from artificial holiday can be either loss of adhesion to the steel substrate or between the shop primer and the epoxy coating and shall be less than 8 mm for epoxy based systems to be acceptable (compability test). Cohesive adhesion failure in the shop primer is not to be included as part of the loss of adhesion.

11 APPENDIX C – PHOTO DOCUMENTATION

(It should be overview pictures of the panels and close up pictures of the undercutting from scribe and the disbonding from artificial holiday)

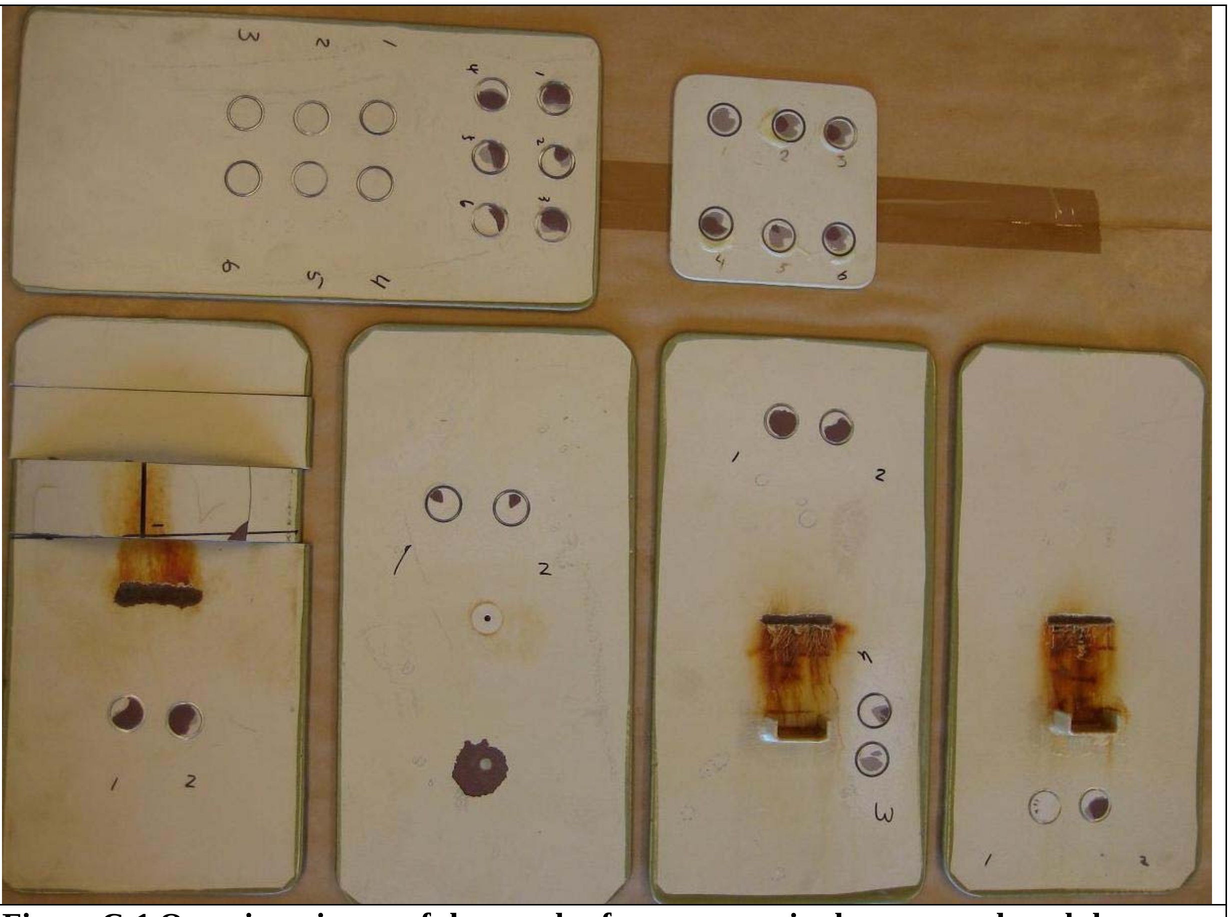


Figure C-1 Overview picture of the panels after exposure in the wave tank and the heating chamber. Reference panel not exposed on the top right. Picture taken after examination (example picture not connected to example results in this model report).

Picture missing

Figure C-2 Overview picture of the panels exposed in condensation chamber (example picture not connected to example results in this model report).

Figure C-3 Scribe area of top wave tank panel before removing of loose coating (example picture not connected to example results in this model report).

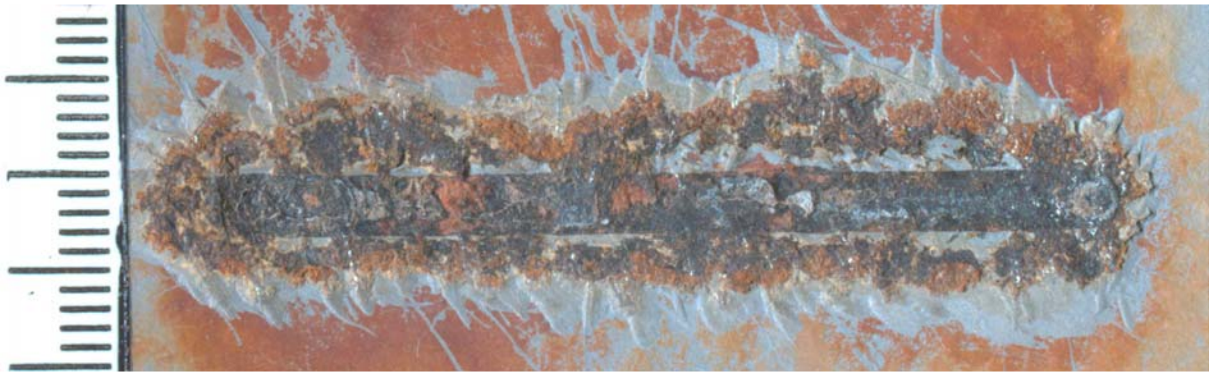


Figure C-4 Undercutting from scribe, top wave tank panel (example picture not connected to example results in this model report).

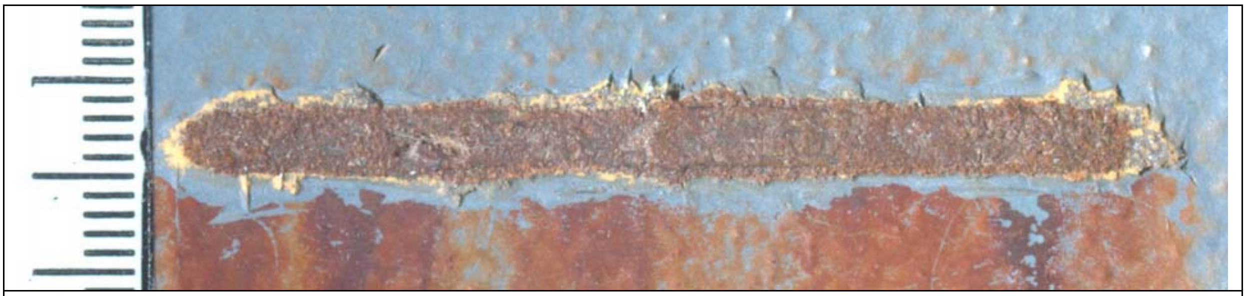


Figure C-5 Undercutting from scribe, side wave tank panel without cooling (example picture not connected to example results in this model report).

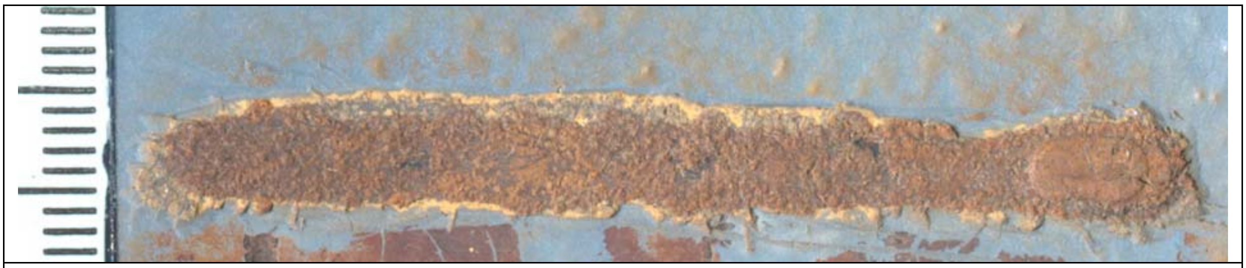


Figure C-6 Undercutting from scribe, side wave tank panel with cooling (example picture not connected to example results in this model report).

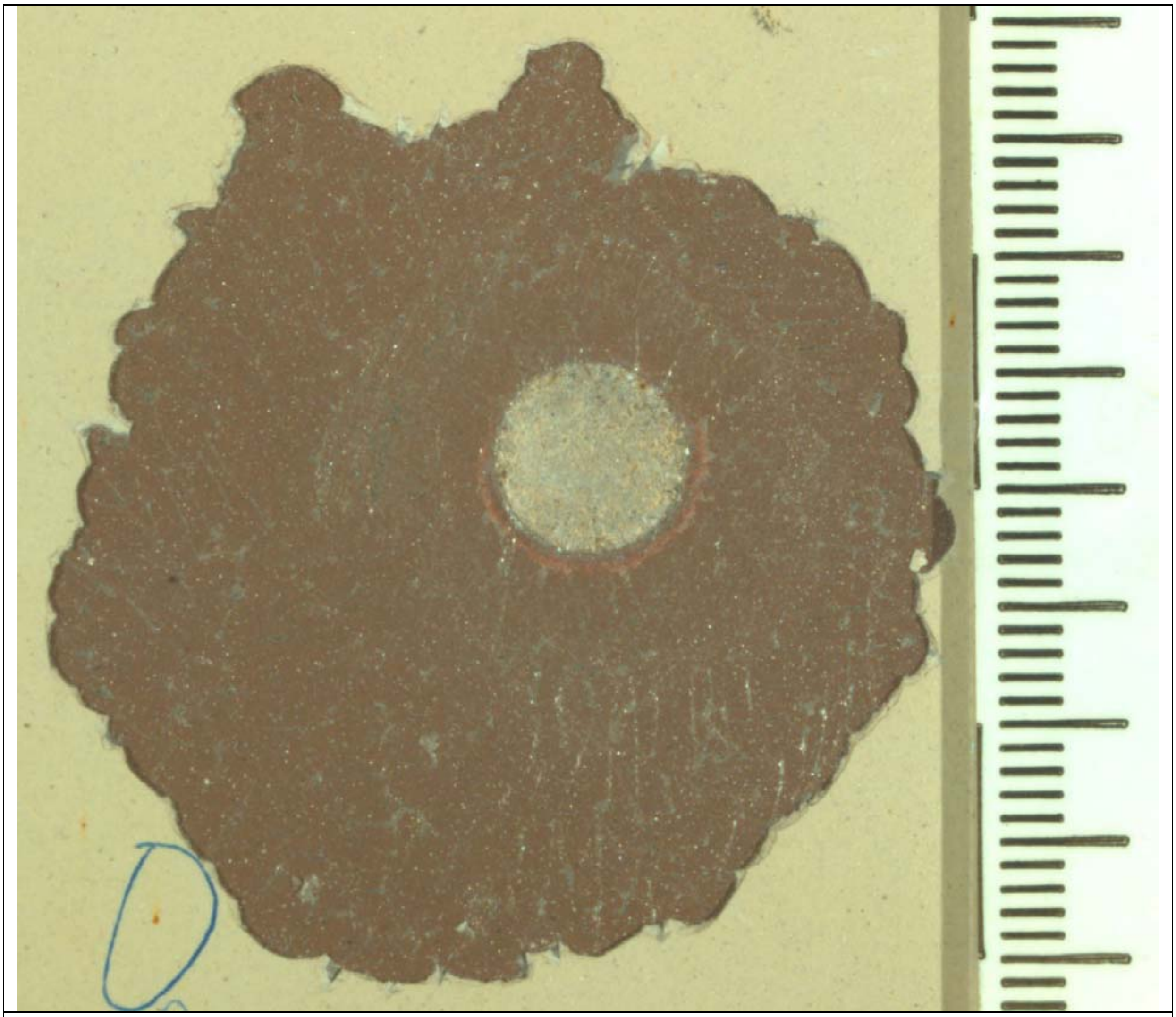


Figure C-7 Disbonding from artificial holiday, bottom wave tank panel (example picture not connected to example results in this model report).

12 APPENDIX D - INFRARED SCANNING CHARTS

Figure D-1

Figure D-2

Figure D-3

Figure D-4

Figure D-5

Figure D-6

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