REPORT

Issued by an Accredited Testing Laboratory

Contact person RISE
Frida Willhammar
Division Materials and Production
+46 10 516 62 59
frida.willhammar@ri.se

Date	Reference	Page
2022-03-22	O100104-177178	1 (5)

PPG Taiwan Industrial Coating
49 Jhongheng Street, Hsiao Kang District
812 Kaohsiung
Taiwan

Evaluation of corrosion resistance

(1 appendix)

Accreditation

RISE is an accredited (by SWEDAC) laboratory for cyclic corrosion testing according to ISO 11997-1:2018 Cycle B, visual examination of base metal corrosion according to SS-EN ISO 10289:200, determination of corrosivity with reference panels according to ISO 9226:2012 and removal of corrosion products from corrosion test specimens according to ISO 8407:2021.

Commission

Cyclic corrosion test according to the standard ISO 11997-1 Cycle B:2018 and determination of corrosivity class through exposure of reference test panels according to ISO 9226:2012. The test is performed according to the NORDTEST-method NT MAT 003 (2002).

Test objects

8 set of coated screws (at minimum 40 pieces of each set) were received at RISE Research Institutes of Sweden on October 19, 2021. The product information provided by the customer can be seen in table 1.

Table 1: Information regarding the products provided by the customer.

Name	Code	Sample ID (by RISE)
Elecropolyseal V - Sandstone ecoat	(CP672)-1500H	PPG1
Elecropolyseal V - Brown ecoat	(CP669) -1500H	PPG2
Elecropolyseal V - Dark green ecoat	(CP593) -1500H	PPG3
Elecropolyseal V - Black ecoat	(CP453A) -1500H	PPG4
Elecropolyseal V - Green ecoat	(CP518A) -1500H	PPG5
Elecropolyseal V - Yellow tint ecoat	(CP529C) -1500H	PPG6
Elecropolyseal V - Redwood ecoat	(CP511A) -1500H	PPG7
Elecropolyseal V - Tan ecoat	(CP516A) -1500H	PPG8

Confidentiality level
C3 - Sensitive

This report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

SWEDAC ACKREDITERING
Accred. No. 1002
Testing
ISO/IEC 17025

Evaluation of corrosion resistance

20 screws of each sample were mounted on a piece of polystyrene foam with a 15 - 30° angle from the vertical plane. The test specimens were exposed according to ISO 11997-1 Cycle B (2018) for 13 weeks from November 19, 2021.

One test cycle corresponds to 7 days and consists of:

1. 24 h salt spray according to the standard ISO 9227 NSS
2. 96 h condensation (Four periods consisting of: 8 h at 100 % RH and 40 ºC followed by 16 h at 50 % RH and 23 ºC)
3. 48 h conditioning at 23 ºC and 50 % RH

8 reference test panels of carbon steel and 8 reference test panels of zinc were exposed together with the samples. The reference test panels were ground and polished with diamond spray down to a grain size of at least 9 μm, cleaned in ethanol and weighed before the test. Prior to exposure, the unpolished face of the reference panels was protected with an adhesive plastic film.

Reference panels were removed regularly from the chamber during the exposure. The adhesive plastic film was removed and the corrosion products were removed by repetitive pickling according to the standard ISO 8407:2021. The reference panels of carbon steel were pickled in a solution of concentrated hydrochloric acid in water (1:1), containing inhibitors. The reference panels of zinc were pickled in a saturated solution of glycine. The panels were then weighed and the metal loss, expressed in micrometres, was calculated as a function of exposure time.

Conditions of testing, salt spray

The salt used for the preparation of salt solution was a vacuum salt containing at least 99,9% sodium chloride from Salinity (art no 2012). The impurities were less than 0.001 % copper, less than 0.001 % nickel, less than 0.001% lead and less than 0.1% sodium iodide. The sodium chloride was dissolved in deionised water with a conductivity lower than 5 μS/cm.

The salt concentration of the collected solution is measured as conductivity instead of direct concentration. A salt concentration of 50 g/l ± 5g/l NaCl results in a conductivity between 70,2-84,0 mS/cm.

Test conditions:

Temperature	35 ± 2°C
pH in collected solution:	6,6 - 6,9
Volume of collected solution:	1,2 – 2,0 ml / 80 cm^2, hour
Conductivity of collected solution:	77 – 82 mS/cm
Test equipment:	Ascott 4, inventory number: 902322
Test engineers:	Frida Willhammar Martina Thomasson Jennifer Jacobsson

**Deviations:*
In week 2 and 9 the rain downfall was not collected and measured the day after the spray.

Relationship between corrosivity class and exposure time

Using the results of the reference panels of zinc and carbon steel, the relationship between corrosivity class and exposure according to ISO 11997-1 Cycle B (2018) was calculated. The results are shown in Table 4 and 5 below.

Table 4: Metal loss of zinc and carbon steel depending on the exposure according to ISO 11997-1 cycle B(2018) and corresponding corrosivity class based on a technical life-time of 15 years.

Testing time (cycles)	Zinc		Steel		Corrosivity class, mean value
	Metal loss (µm)	C-class	Metal loss (µm)	C-class	
0	0	-	0	-	-
2	16,9	2,8	57,2	1,5	2,1
5	42,2	4,1	143,1	2,3	3,2
9	76,0	5,0	257,5	3,3	4,1
12	101,3	5,2	343,4	3,9	4,6

Table 5: Requirements for different corrosivity classes according to ISO 11997-1 Cycle B (2018) based on a technical life-time of 15 years.

Corrosivity class	Testing time according to ISO 11997-1 Cycle B (test cycles of one week)
C1	$0,6 \leq t < 1,7$
C2	$1,7 \leq t < 4,3$
C3	$4,3 \leq t < 8,4$
C4	$t \geq 8,4$

Result, assessment of corrosivity class

During the corrosion test, the test areas of the samples were visually examined every week with respect to base metal corrosion. The degree of base metal corrosion was assessed according to the standard SS-EN ISO 10289:2001 by giving a grade between 0 and 10 to each sample. The testing time when more than 10 % of the samples exhibited base metal corrosion (grade 9, i.e. between 0 and 0.1 % of the surface area was corroded) was assessed by interpolation. The photos from the inspections were sent to the customer (appendix 1). The sample was removed from the chamber after 13 weeks.

Conclusion

The tested samples corrosivity class are summarize in table 6. The corrosivity class is for 15 years technical life-time according to the requirements of the method.

Table 6: Corrosivity class of each sample..

Sample ID	Name	Weeks until >10 % base metal corrosion	Corrosivity class
PPG 1	Elecropolyseal V - Sandstone ecoat	>12	C4
PPG 2	Elecropolyseal V - Brown ecoat	11	C4
PPG 3	Elecropolyseal V - Dark green ecoat	11	C4
PPG 4	Elecropolyseal V - Black ecoat	9	C3
PPG 5	Elecropolyseal V - Green ecoat	>12	C4
PPG 6	Elecropolyseal V - Yellow tint ecoat	>12	C4
PPG 7	Elecropolyseal V - Redwood ecoat	10	C4
PPG 8	Elecropolyseal V - Tan ecoat	12	C4

The tested sample PPG4 is approved for corrosivity class C3 (15 years technical life-time) according to the requirements of the method with reference panels of steel and zinc.

The tested samples PPG1, PPG2, PPG3, PPG5, PPG6, PPG7 and PPG8 are approved for corrosivity class C4 (15 years technical life-time) according to the requirements of the method with reference panels of steel and zinc.

Comments and restrictions

The results in this report concern only the tested products. The test method does not include damage to the products that may arise during installation in the field (in actual use). Accelerated corrosion testing is not an exact model of long-term exposure in the field. However, cyclic corrosion tests (like ISO 11997-1:2018 Cycle B) correlate much better with real exposure than tests with continuous salt spray.

Table A.1 and A.2 in NORDTEST-method NT MAT 003 (2002) are revised according to new values for metal loss in the latest version of ISO 9224:2012.

RISE Research Institutes of Sweden AB
Department Corrosion, RISE AB - Product Durability

Performed by

Signed by: Frida Willhammar
Reason: I am the author of this document
Date & Time: 2022-03-23 09:09:35 +01:00

Frida Willhammar

Examined by

Signed by: Peter Eriksson
Reason: I have reviewed this document
Date & Time: 2022-03-23 09:07:34 +01:00

Peter Eriksson

Appendix

USB flash drive with photos from weekly inspections

Appendix 1

USB flash drive with photos from weekly inspections