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REPORT
issued by an Accredited Testing Laboratory

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SWEDAC ACKREDITERING 1002 ISO/IEC 17025

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Corrosion test
(1 appendix)

Commission

Cyclic corrosion test according to the standard Nordtest Method NT MAT 003 for 12 weeks and determination of the corrosivity class through exposure of reference test panels according to ISO 9226.

Samples

20 fasteners named Nano coating.

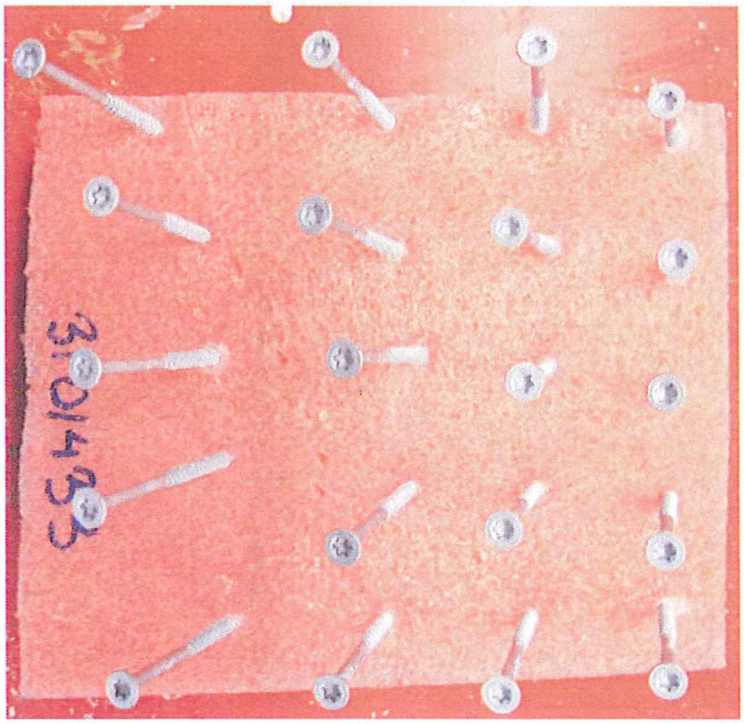

Figure 1 The test objects

Corrosion testing

The 20 fasteners were pressed in polystyrene foam with 15 - 30° angles from the vertical. The test specimens were exposed according to Nordtest Method NT MAT 003 for 12 weeks from March 14 to June 6, 2012. The samples were examined every week with respect to the appearance of base metal corrosion.

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 according to the standard DIN 50017 KFW (8 h at 100 % RH and 40 °C followed by 16 h at 75 % RH and 23 °C)
3. 48 h conditioning at 23 °C and 50 % RH

Conditions of testing, salt spray

High refined vacuum salt (NaCl) with less than 0.001 % copper and nickel was used. It was dissolved in deionised water with conductivity less than 5 µS/cm.

Temperature	35 ± 2°C
Salt rain	1.5-2.0 ml/h and 80 cm^2
pH	6.5-7.2
Salt content	5.0 ± 0.5 % NaCl

Together with the samples are also exposed 10 reference test panels each of carbon steel and zinc. The reference test panels were ground and polished down to 500 grit, 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 procedure described in standard ISO 8407. The reference panels of carbon steel were pickled in a solution of concentrated hydrochloric acid in water (1:1), containing inhibitors. The solution used for the reference panels of zinc was glycine dissolved in deionised water (saturated solution). The panels were then weighed and the metal loss, expressed in micrometres, was calculated as a function of exposure time.

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 Method B and NT MAT 003 was calculated. The results are shown in the tables below.

Table 1. Metal loss of zinc and carbon steel depending on the exposure according to ISO 11997-1 method B as well as requirements for corrosivity class

Testing time (cycles)	Zinc		Steel		Limit for corrosivity class
	Metal loss (µm)	C-class	Metal loss (µm)	C-class	
0	0	-	0	-	-
2	12	2.2	18	1.2	1.7
5	30	3.0	73	2.2	2.6
10	44	3.6	155	3.0	3.3
12	63	4.1	251	3.4	3.8
13	72	4.4	275	3.7	4.0

Table 2. Requirements for different corrosivity classes

Corrosivity class	Testing time according to ISO 11997-1 Method B (tests cycles of one week)
C1	$0 \leq t < 1.1$
C2	$1.1 \leq t < 4.8$
C3	$4.8 \leq t < 12.1$
C4	$t \geq 12.1$

All values in the tables above are mean values of two samples.

Coating thickness measurement

Twenty samples of each kind were controlled according to SS-EN ISO 1463. A piece of the head from each screw was cut out and embedded in thermosetting plastic. After grinding and polishing the test objects, the layers were measured using a microscope and calibrated scale at 625 times magnification.

The results for each sample, presented in Table 1, are arithmetic mean values of measurements at 5 different points.

The measuring accuracy is ± 0,8 µm. The reported uncertainty of measurement is an expanded uncertainty (U), based on a standard uncertainty multiplied by a coverage factor, k=2, which provides a level of confidence of approximately 95 %. The uncertainty of measurement applies for a single measured value. The spread in results due to variations in sample characteristics is not accounted for in the reported uncertainty of measurement.

Table 1. Results coating thickness measurements

Sample	Mean value [µm]		Standard deviation [µm]	
	Base coat	Top coat	Base coat	Top coat
1	10.8	5.4	0.6	1.6
2	10.3	9.9	1.1	4.2
3	9.5	13.0	2.6	4.7
4	9.6	7.6	1.6	4.8
5	10.3	11.9	1.4	6.3
6	23.5	7.7	5.9	1.2
7	12.4	8.3	0.7	2.7
8	17.0	8.1	1.1	2.6
9	11.6	7.5	0.9	3.3
10	9.9	8.7	0.5	2.1
11	13.3	6.1	1.7	2.0
12	11.8	11.4	3.0	2.8
13	18.2	10.3	1.2	3.2
14	9.9	8.6	2.0	2.4
15	11.0	7.5	2.0	2.4
16	14.0	11.8	1.0	4.2
17	9.8	8.7	1.1	3.4
18	10.8	7.9	0.5	1.9
19	14.7	12.4	1.2	4.6
20	15.4	8.4	1.3	2.1

Results

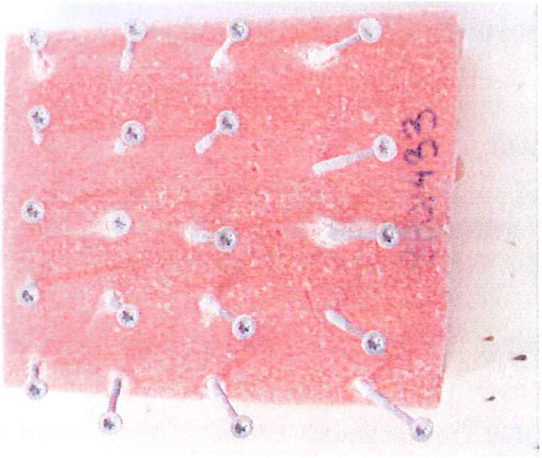

Figure 3 The test specimen 13 weeks into the test

Comments

According to Nordtest Method NT MAT 003, the test object fails if more than 10 % of the specimen show base metal corrosion. The test objects passed the test without any signs of base metal corrosion on any of the 20 objects.

The photos taken during the test are enclosed in the appendix.

Accreditation

SP is an accredited (by SWEDAC) laboratory for cyclic corrosion testing according to ISO 11997-1 Method B as well as for the determination of corrosivity with reference panels according to ISO 9226.

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