



“The tests and activities marked with an ⁽¹⁾ are not covered by ENAC accreditation”

REPORT No.	078978-a
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PURPOSE	Tests according to UNE-EN ISO 12944-6:2018
TESTED MATERIAL	Applied samples Ref. «GALVANOL - Zinker class coating (TU 2312-001-61702992-2009)»
RECEIPT DATE	31.01.2019
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1. TEST SPECIMENS

On 31.01.2019 Foundation Tecnia R&I received from the company “**GALVANOL IBERIA, S.L.**” applied samples referenced as:

- «GALVANOL - Zinker class coating (TU 2312-001-61702992-2009)»

2. TESTS REQUESTED

The tests listed in UNE-EN ISO 12944-6:2018 are requested for a Very High C4 and High C5 corrosion category:

- ◆ Corrosion tests in artificial atmospheres. Salt spray tests, according to UNE-EN ISO 9227:2017
- ◆ Determination of resistance to humidity. Part 1: Continuous condensation, according to UNE-EN ISO 6270-1:2002
- ◆ Assessment of degree of blistering according to UNE-EN ISO 4628-2:2016
- ◆ Assessment of degree of rusting according to UNE-EN ISO 4628-3:2016
- ◆ Assessment of degree of cracking according to UNE-EN ISO 4628-4:2016
- ◆ Assessment of degree of flaking according to UNE-EN ISO 4628-5:2016
- ◆ ⁽¹⁾ Assessment of corrosion along the scribe line according to UNE-EN ISO 12944-6:2018 Annex A
- ◆ Cross-cut test according to UNE-EN ISO 2409:2013 corrected version, February 2014
- ◆ Determination of film thickness according to UNE-EN ISO 2808:2007, method 7C

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3. CARRIED OUT TESTS

◆ **Corrosion tests in artificial atmospheres. Salt spray tests, according to UNE-EN ISO 9227:2017**

The test specimens were tested to determine any variations experienced while neutral saline mist remained and this is carried out in a chamber that has been specially designed for such purpose.

Prior to carrying out the test, we check to ensure the operational stability of the chamber by inserting carbon steel reference test specimens. The loss in mass of the test specimens of reference has been (70 ± 20) g/m².

Test specimens:

- Number of test specimens tested: 4, applied by the client
- Test specimen cleaning process following the test: water
- Angle of tilt of the test specimens in the test chamber: 20°
- The specimens are tested without any cleaning process and the edges are covered.

The conditions and characteristics of the test have been as follows:

- Saline solution: (50 ± 5) g/l of NaCl
 - Water: de-mineralised
 - Salt: for analysis 99.5% purity
- Temperature of the test enclosure: 35°C
- pH of the test solution: 6.8 (measured electrostatically at 25°C)
- pH of the solution collected: 6.8 (measured electrostatically at 25°C)
- Spraying: (1.5 ± 0.5) ml/h

The duration of the test was 1.440 hours for a Very High C4 and High C5 corrosion category, as indicated in the standard UNE-EN ISO 12944-6:2018.

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At the end of the test the following evaluations have been carried out as indicated in the UNE-EN ISO 12944-6:2018:

- Assessment of degree of blistering according to UNE-EN ISO 4628-2:2016
- Assessment of degree of rusting according to UNE-EN ISO 4628-3:2016
- Assessment of degree of cracking according to UNE-EN ISO 4628-4:2016
- Assessment of degree of flaking according to UNE-EN ISO 4628-5:2016
- ⁽¹⁾ Assessment of corrosion along the scribe line according to UNE-EN ISO 12944-6:2018 (Annex A)
- Cross-cut test according to UNE-EN ISO 2409:2013 corrected version, February 2014

The number of defects, consisting of discontinuities or other local imperfections of the coating, scattered over the test area, with greater or lesser intensity, must be designated according to Table I. The degree must be expressed with a whole number, unless otherwise specified contrary:

Table I – Evaluation scheme for the designation of the number of defects

Grade	Number of defects
0	None, that is, no defects are detected
1	Very few, that is, some scarcely significant defects
2	Few, that is, small, but significant, number of defects
3	Moderate number of defects
4	Considerable number of defects
5	Dense concentration of defects

The mean size (order of magnitude) of the defects should be designated, if necessary and significant, in accordance with table II.

Table II – Evaluation scheme for the designation of the number of defects

Grade	Size of defects ^a
0	Not visible at 10x magnification
1	Visible only with magnifications up to x10
2	Incipiently visible with normal corrected vision (up to 0.2 mm) ^b
3	Clearly visible with normal corrected vision (greater than 0.2 mm and up to 0.5 mm)
4	Greater than 0.5 mm up to 5 mm
5	Greater than 5 mm

^a Unless otherwise specified in the later parts of ISO 4628.
^b Typically, defects larger than 0.2 mm are visible with normal corrected vision.

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The type of defect, the quantity present (table I) and its size (table II) must be expressed as indicated in the following example:

- Blistering: degree of blistering, 2 (S2), that is, quantity 2 / size 2

The degree of oxidation (Ri) on a painted surface is evaluated by reference to the photographic patterns shown in Figures 1 to 5. The approximate amounts of oxide (loose oxide plus visible underlying oxide) shown in these patterns are indicated in Table III:

Table III – Scheme of evaluation for the designation of the size of the defects

Degree of rusting	Area rusted %
Ri 0	0
Ri 1	0.05
Ri 2	0.5
Ri 3	1
Ri 4	8
Ri 5	40 a 50

◆ **Determination of resistance to humidity. Part 1: Continuous condensation, according to UNE-EN ISO 6270-1:2002**

The test was carried out according to the standard UNE-EN ISO 6270-1:2002.

The test material has been exposed to continuous condensation.

Test temperature was $(38 \pm 2)^{\circ}\text{C}$.

Three specimens with an inclination of $(15 \pm 5)^{\circ}$ are placed in the chamber. The specimens are inserted without edge protection and reverse.

The thickness of the dry film in microns is determined according to the standard UNE-EN ISO 2808:2007.

The duration of the test was 720 hours for a Very High C4 and High C5 corrosion category, as indicated in the standard UNE-EN ISO 12944-6:2018.

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During the test it has made the following assessments as indicated in the standard UNE-EN ISO 12944-6:2018:

- Assessment of degree of blistering according to UNE-EN ISO 4628-2:2016
- Assessment of degree of rusting according to UNE-EN ISO 4628-3:2016
- Assessment of degree of cracking according to UNE-EN ISO 4628-4:2016
- Assessment of degree of flaking according to UNE-EN ISO 4628-5:2016
- Cross-cut test according to UNE-EN ISO 2409:2013 corrected version, February 2014

These evaluations are described in the previous section.

◆ **Cross-cut test according to UNE-EN ISO 2409:2013 corrected version, February 2014**

The test specimens are conditioned for at least 16 hours at $(23 \pm 2)^{\circ}\text{C}$ and $(50 \pm 5)\%$ Hr. The test is performed under these ambient conditions.

Six incisions should be made in each direction of the square grid. The spacing between incisions has been 3 mm.

The test is performed in three different places of the specimen.

A single-blade cutting tool is used and the procedure has been manual.

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The removal of the detached paint has been done using a tape.

Table IV

Classification	Description
0	The edges of the incisions are perfectly smooth: no square from the cross-cut tester has become detached.
1	Slight detachment of the coating is observed on the edges and/or at the intersections of the incisions. The area affected is not much greater than 5 per 100.
2	Detachment of the coating is observed on the edges and/or at the intersections of the incisions. The area affected is from 5 to 15 per 100 approximately.
3	The coating has become partially or totally detached in large strips all along the edges of the incisions and/or has become totally or partially detached on different parts of the squares. The area affected is from 15 to 35 per 100 approximately.
4	The coating has become detached in large strips all along the edges of the incisions and/or some squares have become partially or totally detached. The area affected is from 35 to 65 per 100 approximately.
5	Any degree of detachment above that of classification 4 is observed.

This test is performed at the beginning and after conditioning the samples for 7 days at a temperature of (23 ± 2) °C and (50 ± 5) h.r. after testing for 1.440 hours of salt fog and 720 hours of the humidity resistance test.

◆ **Determination of film thickness according to UNE-EN ISO 2808:2007, method 7C**

In order to perform the test, a magnetic induction is used due to the ferrous metallic nature of the substrate of the sample. These devices are based on the principle that the high frequency electromagnetic field generated in the instrument probe produces a series of currents induced in a conductor over which the aforementioned probe is placed; furthermore, the amplitude and phase of these currents are a function of the thickness of the non-conductive coating between the conductor and the probe.

The device is placed over the test specimen and ten measurements are taken.

The thickness is displayed in μm , from the arithmetic mean of the readings taken. The thickness is measured on the test specimen as provided by the customer.

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4. RESULTS

“The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%”.

◆ **Corrosion tests in artificial atmospheres. Salt spray tests, according to UNE-EN ISO 9227:2017**

The enclosed table show the results obtained for a Very High C4 and High C5 corrosion category.

Table V

Reference	Test	Standard	Result	Specification according UNE-EN ISO 12944-6:2018	Result
«GALVANOL - Zinker class coating (TU 2312-001-61702992-2009)»	Assessment of degree of blistering	UNE-EN ISO 4628-2:2016	0(S0)	0(S0)	Satisfactory
	Assessment of degree of rusting	UNE-EN ISO 4628-3:2016	Ri0	Ri0	
	Assessment of degree of cracking	UNE-EN ISO 4628-4:2016	0(S0)	0(S0)	
	Assessment of degree of flaking	UNE-EN ISO 4628-5:2016	0(S0)	0(S0)	
	⁽¹⁾ Assessment of corrosion along the scribe line $M = \frac{C - W}{2} \text{ (mm)}$	UNE-EN ISO 12944-6:2018 (Annex A)	0	Max. 1.5 mm	Satisfactory

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◆ **Determination of resistance to humidity. Part 1: Continuous condensation, according to UNE-EN ISO 6270-1:2002**

The enclosed table show the results obtained for a Very High C4 and High C5 corrosion category.

Table VI

Reference	Test	Standard	Result	Specification according UNE-EN ISO 12944-6:2018	Result
«GALVANOL - Zinker class coating (TU 2312-001-61702992-2009)»	Assessment of degree of blistering	UNE-EN ISO 4628-2:2016	0(S0)	0(S0)	Satisfactory
	Assessment of degree of rusting	UNE-EN ISO 4628-3:2016	Ri0	Ri0	
	Assessment of degree of cracking	UNE-EN ISO 4628-4:2016	0(S0)	0(S0)	
	Assessment of degree of flaking	UNE-EN ISO 4628-5:2016	0(S0)	0(S0)	

◆ **Cross-cut test according to UNE-EN ISO 2409:2013 corrected version, February 2014**

The enclosed table show the results obtained:

Table VII

Reference	Test area	Assessment			Specification according UNE-EN ISO 12944-6:2018	Result
		Initial	After 1.440 hours of salt spray	After 720 hours of humidity		
«GALVANOL - Zinker class coating (TU 2312-001-61702992-2009)»	1	0	1	1	0 to 2	Satisfactory
	2	0	2	1		
	3	1	2	1		

Initial test result: ISO 2409: 2013-1C-0

Test result after 1.440 hours of salt spray: ISO 2409: 2013-1C-2

Test result after 720 hours of humidity: ISO 2409: 2013-1C-1

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◆ **Determination of film thickness according to UNE-EN ISO 2808:2007, method 7C**

The results obtained for this test are shown in the attached table:

Table VIII

Reference	Test tube	Thickness (μm)									
		Sample									
		1	2	3	4	5	6	7	8	9	10
«GALVANOL - Zinker class coating (TU 2312-001- 61702992-2009)»	1	148.0	141.0	138.0	142.0	160.0	139.0	156.0	135.0	160.0	128.0
	2	133.0	143.0	139.0	122.0	157.0	143.0	156.0	131.0	169.0	135.0
	3	138.0	147.0	136.0	147.0	168.0	132.0	141.0	138.0	170.0	147.0
	4	138.0	138.0	137.0	130.0	161.0	141.0	141.0	127.0	150.0	144.0
	5	128.0	143.0	133.0	130.0	167.0	144.0	139.0	131.0	165.0	160.0
	6	137.0	132.0	129.0	130.0	156.0	160.0	153.0	130.0	165.0	132.0
	7	141.0	133.0	140.0	151.0	174.0	147.0	144.0	121.0	168.0	137.0
	8	132.0	138.0	138.0	131.0	163.0	152.0	153.0	132.0	148.0	158.0
	9	136.0	130.0	133.0	133.0	176.0	153.0	141.0	128.0	171.0	148.0
	10	121.0	131.0	141.0	138.0	140.0	151.0	135.0	131.0	159.0	148.0
	Average	135	138	136	135	162	146	146	130	163	144
	Uncertainty (K=2)	15	13	9	19	21	17	16	10	17	22



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5. CONCLUSIONS

The applied samples referenced as «GALVANOL - Zinker class coating (TU 2312-001-61702992-2009)» complies with the requirements defined in the UNE-EN ISO 12944-6:2018 standard for a Very High C4 and High C5 corrosion category. The very high durability range corresponds to more than 25 years and the high between 15 and 25 years according to UNE-EN ISO 12944-1:2018.