OMECO SRL
Centro Ricerca - Prove Materiali - Tarature
Research Centre - Material Testing - Calibration

Sede Centrale, Amministrativa e Laboratori:
Headquarter and Laboratories:
I-20900 MONZA (MB) - Via Monviso, 56
Tel. 039748983 (r.a.) - Fax 039736433

Sedi distaccate e Laboratori:
Branches:
I-20835 MUGGIÒ (MB)
Via Milano, 4
Tel. 0399418049 - Fax 0399418051

I-24061 ALBANO S. ALESSANDRO (BG)
Via Madonna delle Rose, 56
Tel. 035581016 (r.a.) - Fax 035580153

www.omecosrl.it - E-mail: direzione@omecosrl.it - omeco@pec.omecosrl.eu

TEST REPORT	
Number: SAC/0095/13e date: 18/03/2013	**NANOPROTECH ITALIA S.R.L.**
OMECO Ref.: 2874 Page 1 of 12	CENTRO DIREZIONALE MIRAFIORI STRADA 6 PALAZZO N. 3 20089 ROZZANO MI
CUSTOMER Ref.: ORD.OMECO01 21/11/12	

Sample: N. 2 SPRAY BOTTLES FILLED WITH NANOPARTICLES BASED PROTECTIVE PRODUCTS

Identification: H2OFF Anticorrosion
H2OFF Electric

Date of receipt: 26/11/2012

Test Procedures: UNI EN ISO 9227:2012

Equipments:
Salt spray chamber identified SAC-0012
pH meter identified SAC-0206
Technical balance identified SAC-0112
Thermometer identified SAC-0124

SCOPE OF THE TESTS

Evaluate the protective efficiency in regard to corrosion resistance of the two products denominated H2OFF Anticorrosion and H2OFF Electric.

TEST SPECIMENS

Steel: specimens thickness 1mm declared as steel CR4 (ISO 3574).
Aluminium: specimens thickness 0.4 mm declared as commercial aluminium (> 99 %).
Copper: specimens thickness 0.5 mm declared as copper Cu-ETP

PRODUCT APPLICATION

After the test specimens were degreased with acetone, the products were sprayed evenly on both surfaces.

Treatment	identification n°
H2OFF electric	1
H2OFF Anticorrosion	2
Not protect	3

Before the test, the specimens were maintained for a longer time of 24h at room temperature.

This test report is the complete translation into English of the test report " SAC/0095/13 dated 18/03/2013"

This test report concerns only the sample submitted to the test. If not otherwise indicated, the sampling operation were performed by the Customer.

Date/s of execution: 03÷15/12/2012 e 01÷06/03/2013 **At:** OMECO Lab. - Monza

The samples have to be kept (after the test execution): 20 days (in case of Law 1086 and supervised tests) and 6 months (in case of other tests).

Operator/s		Technical Manager	
R. CARMILLA	A. TREVISSON	ING. M. CASARIL	

SALT SPRAY CORROSION TEST (UNI EN ISO 9927 NSS)

OPERATIVE CONDITION (P.C. 225)

Test solution:	5% weight NaCl RPE in distilled water
Time of exposure:	360 hours
Exposed surface condition :	The sample was placed at 20° to the vertical on an inert support in the test room.

Test time (h)	Temperature (°C)	Solution pH	Pluviometric constant (ml/h)	Density (g/cm^3)
Initial Condition	*35.1*	*6.7*	*1.0*	*1.035*
24 ÷ 360	34.8 ÷ 35.3	6.6	1.0 ÷ 1.3	1.030

Legenda:
a. no significant variations
b. red rust
c. white salification
d. green salification

STEEL			
EXPOSITION HOURS	**OBSERVATIONS**		
	H2OFF electric (Id.1)	H2OFF Anticorrosion (id. 2)	Not protect (Id. 3)
24	**b.** slight appearance of red rust near the edges (< 5%)	**b.** appearance of red rust near the edges (< 5%)	**b.** appearance of red rust on exposed surface (~ 80%)
48÷96	**b.** increase of red rust on the edges and surface (~ 30%)	**b.** slight increase of red rust near the edges (~ 5%)	**b.** increase of red rust on exposed surface(~ 100%)
120 ÷ 168	**b.** increase of red rust on exposed surface (~ 90 %)	**b.** increase of red rust near the edges (~ 20 %)	**b.** increase of red rust on exposed surface(~ 100%)
192	**b.** increase of red rust on exposed surface (~ 100%) **TEST END**	**b.** increase of red rust near the edges (~ 30%)	**b.** increase of red rust on exposed surface(~ 100%) **TEST END**
216÷ 264	-----	**b.** slight increase of red rust near the edges (~ 30%)	----
288 ÷ 360	----	**b.** slight increase of red rust near the edges (~ 50%) TEST END	----

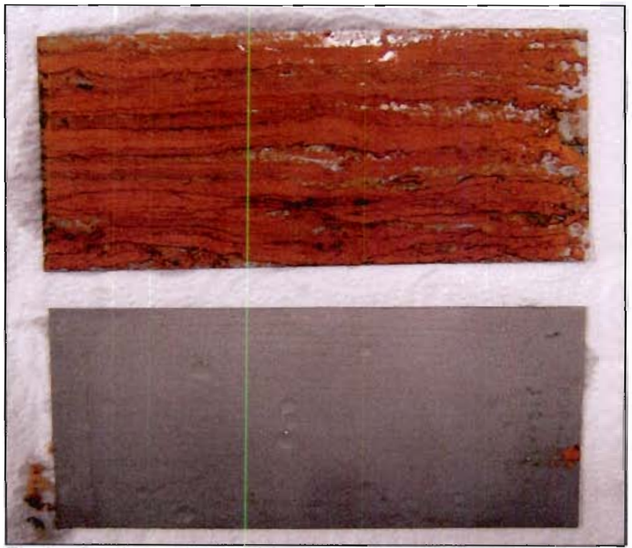

Fig.1 – Steel sample 1 and 3 after 24 h

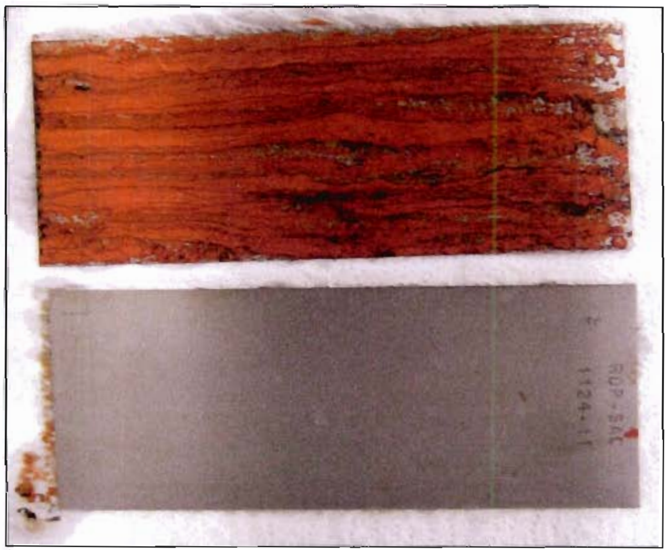

Fig.2 – Steel sample 2 and 3 after 24 h

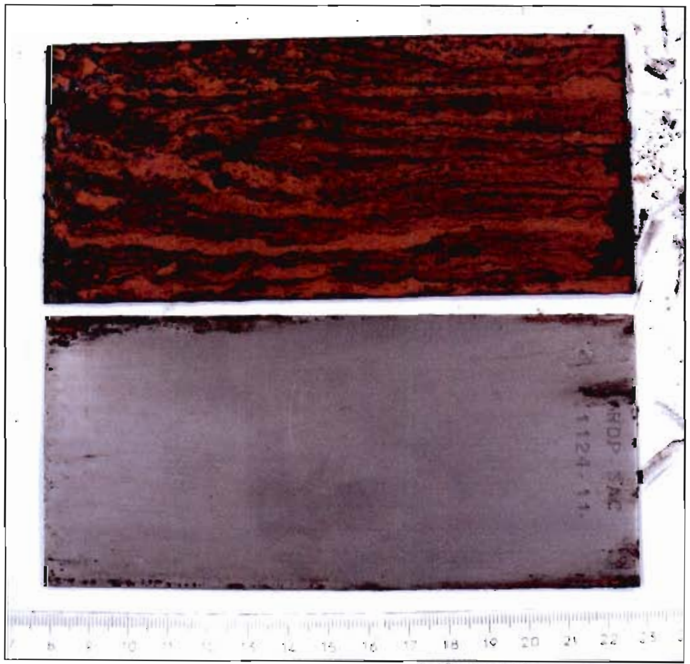

Fig.3– Steel sample 1 and 3 after 144 h

WEIGHT CHANGE AND CORROSION RATE:

Measurement Condition:

The protective products H2OFF were removed at the end of testing by a solvents mixture (n-eptano and acetone)

The corrosion products were removed by using the "Aupperle solution" (ref. UNI EN ISO 1460; HCl 1:1+ 3.5g of Hexamethylenetetramine as corrosion inhibitor)

	STEEL							
	Initial weight (g)	**Final weight (g)**	**ΔP (g)**	**ΔP (%)**	**Surface (mm^2)**	**Corrosion rate (g/m^2)**	**Corrosion rate (g/m^2*h)**	**Exposure time (h)**
H2OFF electric (Id.1)	81,0779	79,7843	1,2936	1,60	10425,32	124,08	0,6463	192
H2OFF Anticorrosion (id. 2)	81,7261	80,7745	0,9516	1,16	10473,49	90,86	0,2524	360
Not protect (Id. 3)	81,8561	79,1517	2,7044	3,30	10519,08	257,09	1,3390	192

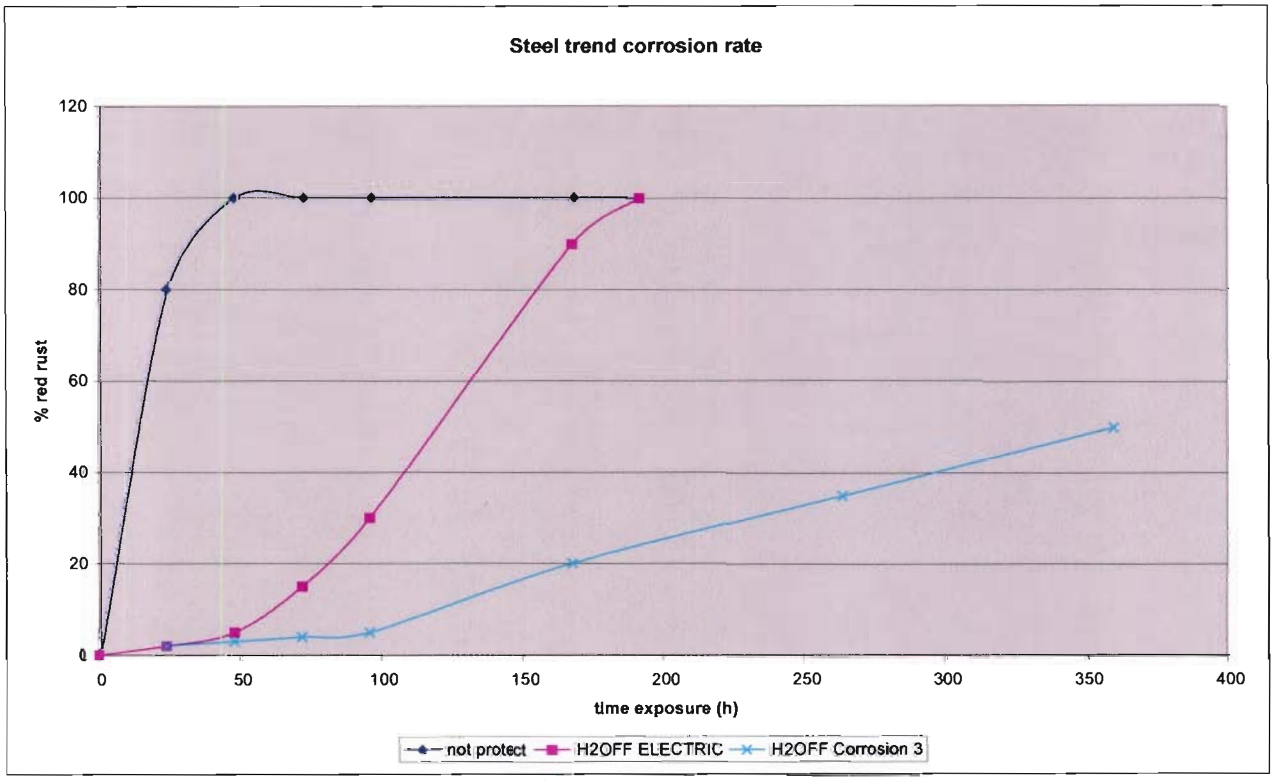

Fig.4 – Trend of corrosion rate on steel samples

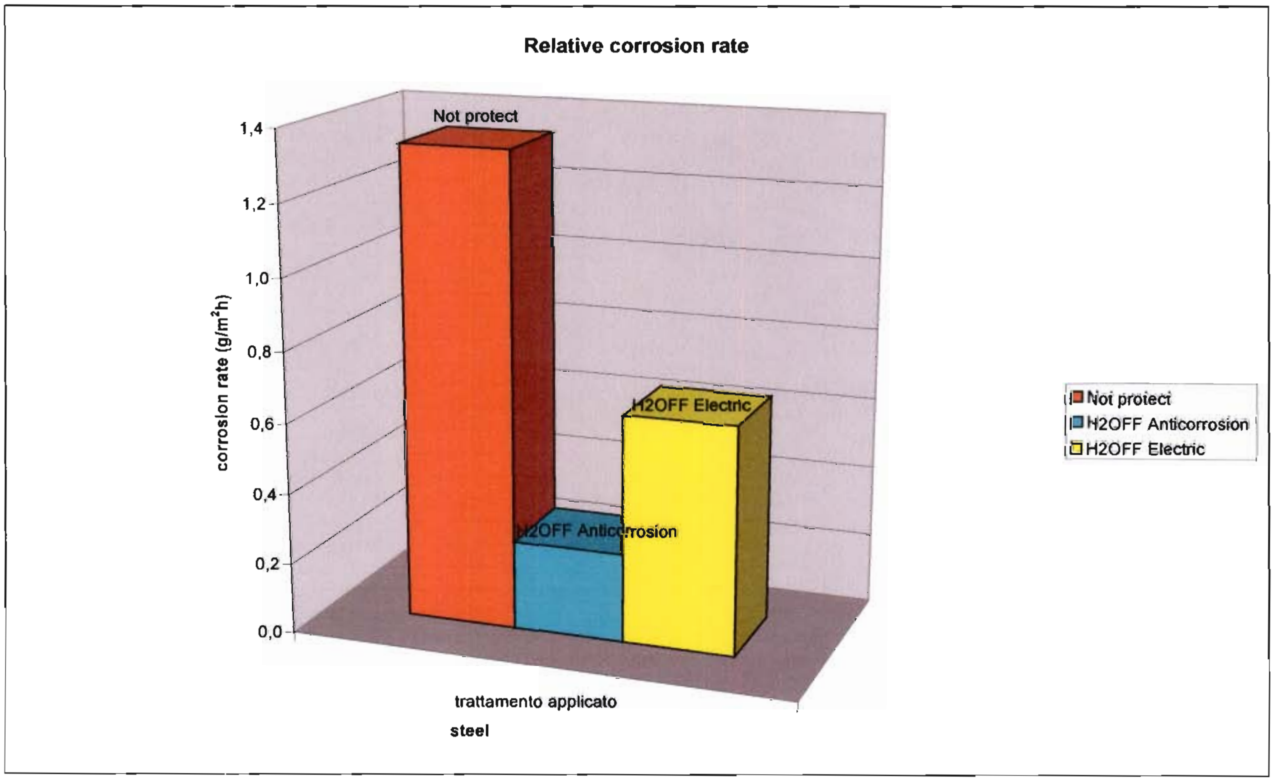

Fig. 5 - Representative graph of the corrosion rate on steel samples with the treatment H2OFF

CONCLUSIONS:

Steel test specimens:

The tests showed a significant reduction both in the corrosion rates and time needed for the appearance and the progressive development of corrosion phenomena (fig. 1).

The reduction of the corrosion rate is equal to 82% for the product H2OFF corrosion and 54% for the product H2OFF electric.

ALLUMINIUM			
EXPOSURE TIME	**OBSERVATIONS**		
	H2OFF electric (Id.1)	H2OFF Anticorrosion (id. 2)	Not protect (Id. 3)
24	**a.** no significant variation	**a.** no significant variation	**c.** appearance of white salification on exposed surface (< 5 %)
48÷96	**a.** no significant variation	**a.** no significant variation	**c.** slight increase of white salification (~ 5 %)
120 ÷ 168	**a.** no significant variation	**a.** no significant variation	**c.** slight increase of white salification (~ 5/10 %)
192 ÷ 264	**a.** no significant variation	**a.** no significant variation	**c.** slight increase of white salification (~ 10/15 %)
288 ÷ 360	**a.** no significant variation	**a.** no significant variation	**c.** slight increase of white salification (~ 20 %)


Fig.6 – samples 1 and 3 Alluminium after 24 hours


Fig.7 – samples 2 and 3 Alluminium after 24 hours

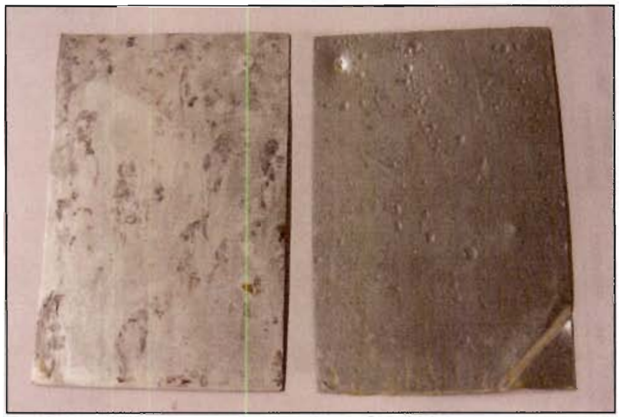
Fig.8 – samples 1 and 3 Alluminium after 192 hours


Fig.9 – samples 2 and 3 Alluminium after 192 hours

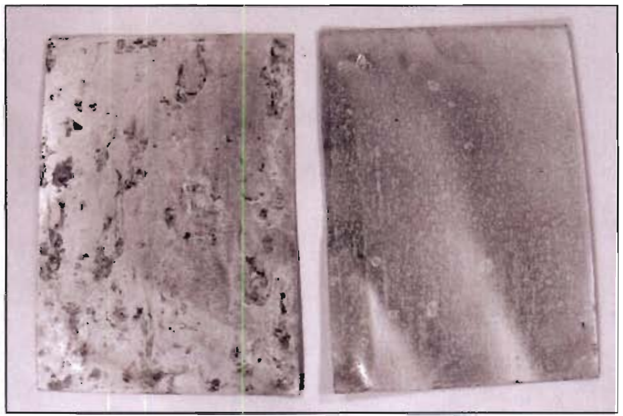
Fig.10 – samples 2 and 3 Alluminium after 360 hours

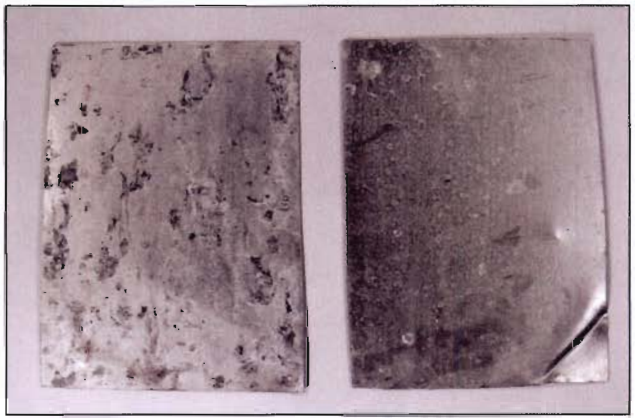
Fig.11 – samples 1 and 3 Alluminium after 360 hours

WEIGHT CHANGE AND CORROSION RATE:

Measurement Condition:

The protective products H2OFF were removed with a mixture of solvents (n-Heptane and acetone) after testing.

The corrosion products were then removed by NaOH solution 10% w/w.

ALUMINIUM								
	Initial weight (g)	**Final weight (g)**	**ΔP (g)**	**ΔP (%)**	**Surface (mm^2)**	**Corrosion rate (g/m^2)**	**Corrosion rate (g/m^2*h)**	**Exposure time (h)**
H2OFF electric (Id.1)	7,3600	7,3454	0,0146	0,2	6985,21	2,09	0,00581	360
H2OFF Anticorrosion (id. 2)	7,5637	7,5395	0,0242	0,3	7157,01	3,38	0,00939	360
No protect (Id. 3)	7,2972	6,1445	1,1527	15,8	6943,12	166,02	0,46117	360

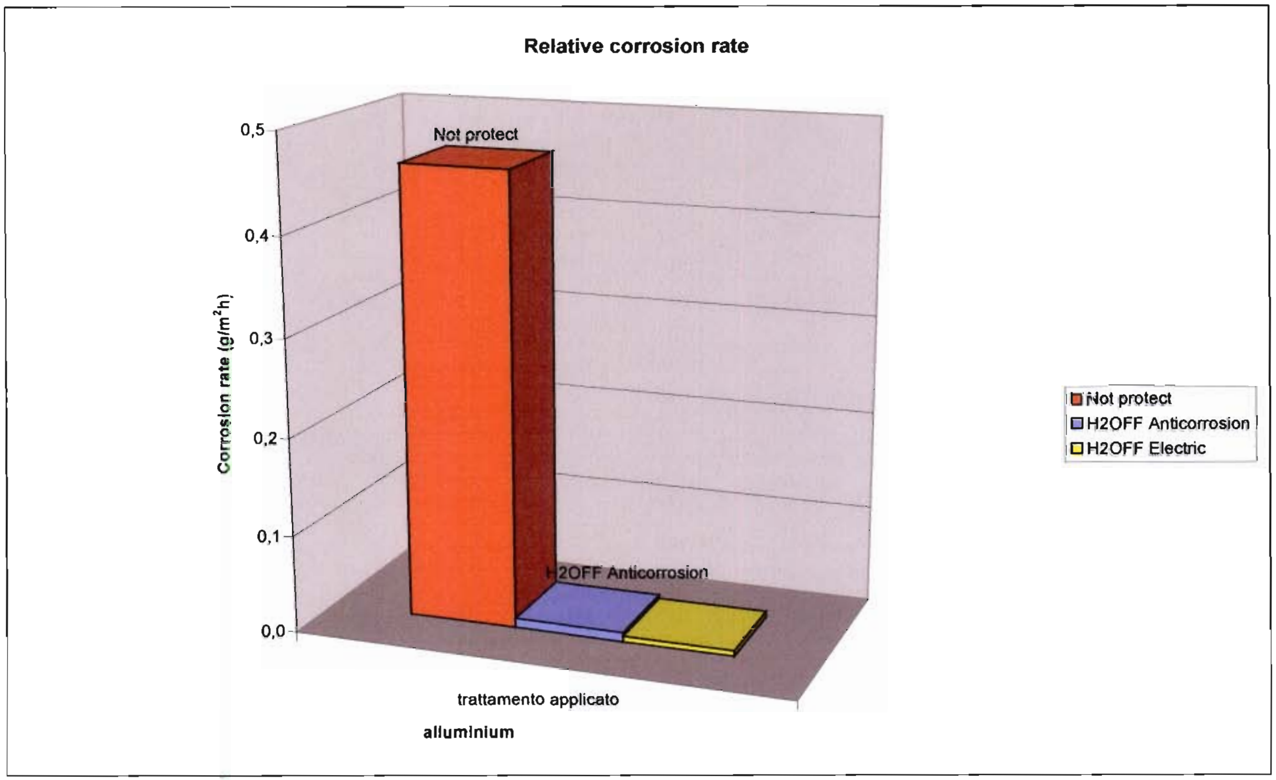

Fig.12 – Representative graph of the corrosion rate on Aluminium samples with the treatment H2OFF

CONCLUSIONS:

Aluminium test specimens:

The samples where the products were applied showed a significant reduction in both the corrosion rate and the time required for the appearance and the progressive development of corrosion damage, that, for the not protect sample, was localized corrosion in the test environment chosen for testing (fig. 10-11).

The reduction of the corrosion rate is equal to 97% for the product H2OFF corrosion and 98% for the product H2OFF electric.

The corrosion protection of aluminium achieved by both the products is almost complete in the environment considered, wherein just localized corrosion was detected. The slight weight loss observed could therefore be associated to the slight dissolution at surfaces due to final pickling in NaOH, that was used to remove the corrosion products.

COPPER			
	OBSERVATIONS		
EXPOSURE TIME	H2OFF electric (Id.1)	H2OFF Anticorrosion (id. 2)	Not protected (Id. 3)
24	**a.** no significant variation	**a.** no significant variation	**a.** no significant variation
48÷96	**d.** appearance of green salification on exposed surface (<5%)	**a.** no significant variation	**a.** no significant variation
120 ÷ 168	**d.** increase of green salification on exposed surface (~ 10/15%)	**d.** appearance of green salification on exposed surface (<5%)	**a.** no significant variation
192 ÷ 264	**d.** slight increase of green salification on exposed surface (~ 20/30%)	**d.** slight increase of green salification on exposed surface (~ 5/10%)	**d.** appearance of green salification on exposed surface (<5%)
288 ÷ 360	**d.** slight increase of green salification on exposed surface (~40/50%)	**d.** slight increase of green salification on exposed surface (~ 15 %)	**d.** slight increase of green salification on exposed surface (~ 10/15%)

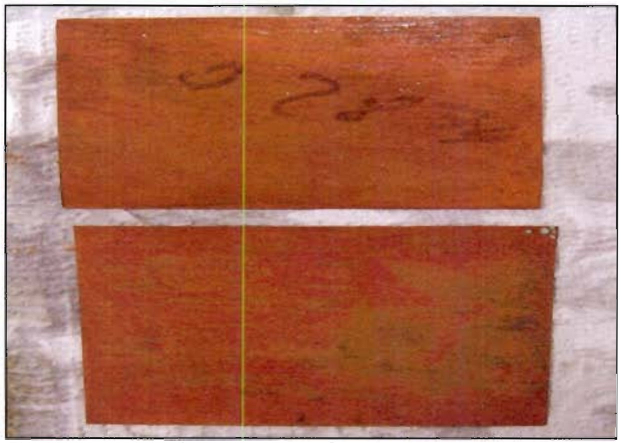
Fig.13 – samples 1 and 3 opper after 24 hours


Fig.14 – samples 2 and 3 Copper after 24 hours

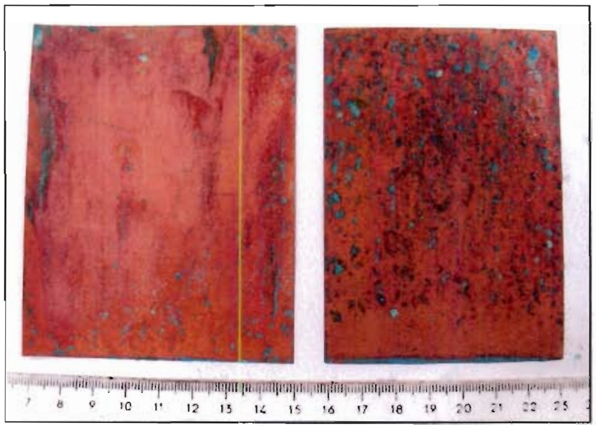
Fig.15 – samples.1 and 3 Copper after 192 hours

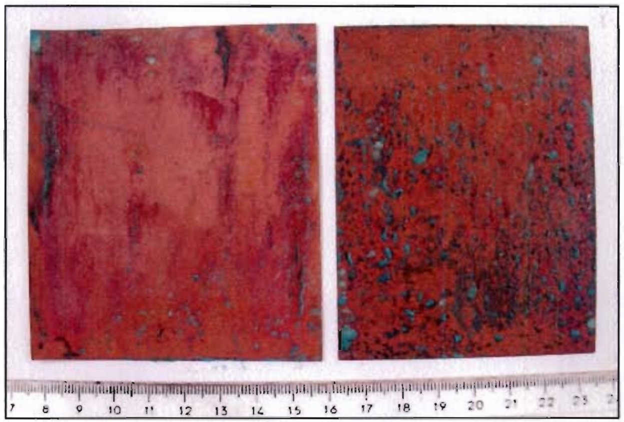
Fig.16 – samples 2 and 3 Copper after 192 hours

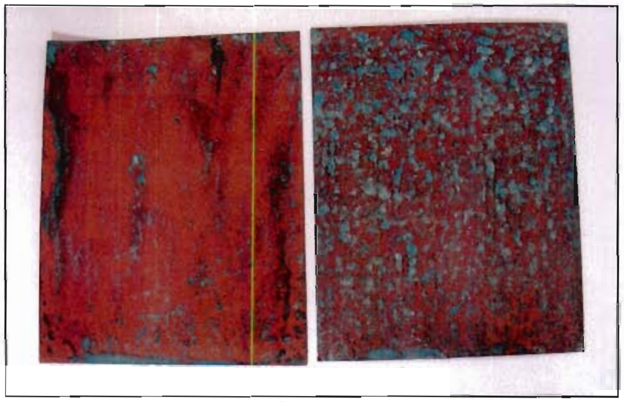

Fig.17 – samples 2 and 3 Copper after 360 hours

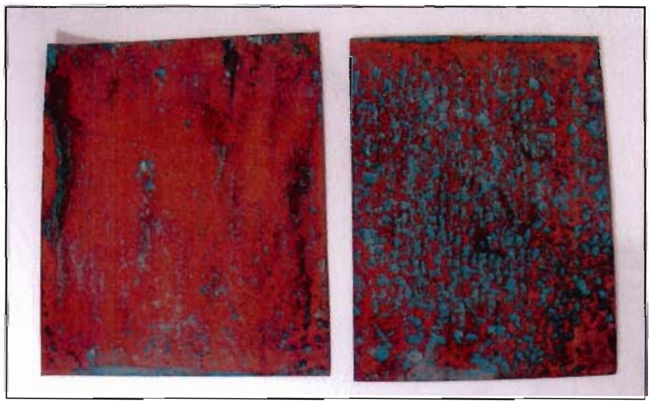

Fig.18 – samples 1 and 3 Copper after 360 hours

Measurement Condition:
At test end the protective products H2OFF were removed with a solvents mixture (n-Heptane and acetone)
The corrosion products were also removed by using HNO_3 solution (10% w/w).

COPPER								
	Initial weight (g)	**Final weight (g)**	**ΔP (g)**	**ΔP (%)**	**Surface (mm^2)**	**Corrosion rate (g/m^2)**	**Corrosion rate ($g/m^{2}*h$)**	**Exposure time (h)**
H2OFF electric (Id.1)	31,5660	31,322	0,2440	0,8	7314,14	33,36	0,09267	360
H2OFF Anticorrosion (id. 2)	31,6622	31,4632	0,1990	0,6	7313,95	27,21	0,07558	360
No protect (Id. 3)	35,3399	34,9882	0,3517	1,0	8153,25	43,14	0,11982	360

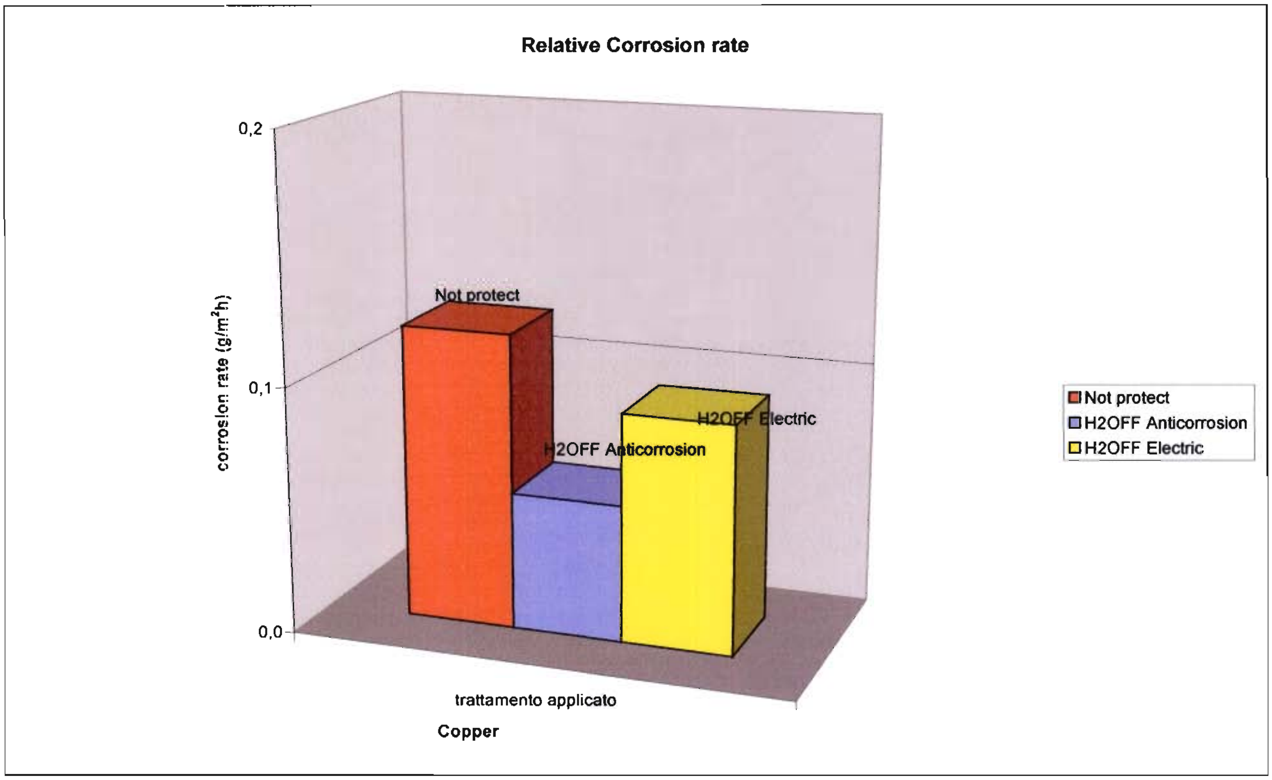

Fig.19 – Representative graph of the corrosion rate on Copper samples with the treatment H2OFF

Ammonia Vapor Exposure Test

OPERATIVE CONDITIONS (P.C. 225bis)

Test solution:	5% weight of ammonia RPE in distilled water
Test temperature:	25°C
Time of exposure:	120 hours
Exposed surface condition :	The sample was suspended at 10cm above test solution level

a. no significative variations

b. blue corrosion products

COPPER			
EXPOSURE TIME	OBSERVATIONS		
	H2OFF electric (Id.5)	H2OFF Anticorrosion (id. 4)	Not protected (Id. 6)
24	**a.** no signficative variatons	**a.** no signficative variatons	**a.** no signficative variatons
48÷72	**a.** no signficative variatons	**a.** no signficative variatons	**b.** appearance of blue corrosion products on exposed surface (~80/ 90%)
96 ÷ 120	**a.** no signficative variatons	**a.** no signficative variatons	**b.** slight increase of blue corrosion products on exposed surface (~90%)

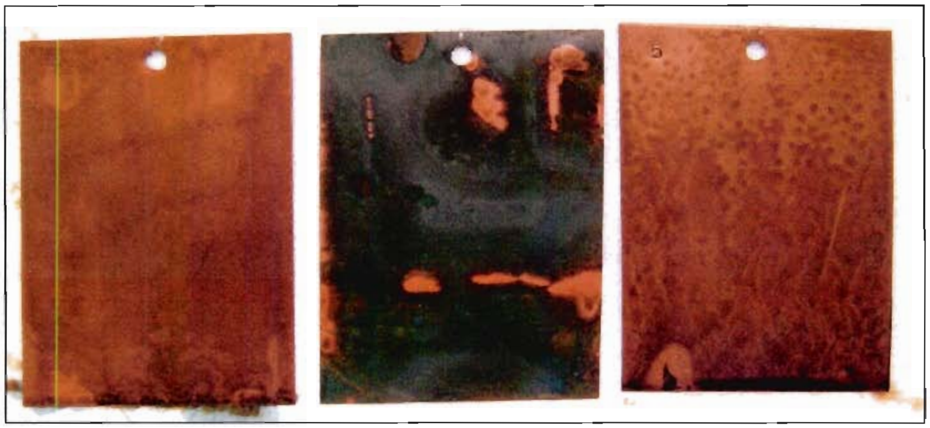

Fig.20 – sample 4 (corrosion at sx) and 5 (electric at dx) in comparison with a reference sample no protected (at center) after 120 hours of exposure to ammonia vapor

Copper test specimens:

The tests showed no significant corrosion for all the laminations in copper, this is due to the good resistance of this material in the environment considered (which exclusively determines the formation of a slight surface chloride based compounds patina that is protective in the later stages). The data reported in the table correspond to negligible corrosion rate resulting from the slight weight loss associated with the slight dissolution consequent to pickling in nitric acid even if the loss of weight of the treated samples is however lower than that detected for the reference non-treated plate. This confirms that the green salification detected on the specimens treated (fig. 15÷18) does not correspond to corrosion phenomena of the protected specimen but, more likely, to the formation of salts of the compounds that make up the product itself (nanoparticles).

For the verification of the protective effect of this material more significant results were obtained from the test for resistance to ammonia fumes (which are detrimental for unprotected copper).

It is noted as both products tested inhibit almost completely the formation of the film of copper complexed by the ammonium ion, present in substantial amounts (as expected) on the reference sample.

Document end