

TEST REPORT	
Number: SAC/0594/11-1 date: 30/07/2012 OMECO Ref.: 1408 Page 1 of 15 CUSTOMER Ref.: ACC.PREV.370/4+899	AIR TORQUE S.P.A. VIA AI LIVELLI DI SOPRA, 11 24060 COSTA DI MEZZATE BG

Samples: AT201U D Protection Level "A" / AIR TORQUE PNEUMATIC ACTUATOR

Identification: N° A1 (A2 = Reference)

Date of receipt: 20/05/2011

Test standards: ISO 7724-2/3 – 1984; ASTM D4541-02; ASTM D3359-08 Method B; UNI EN ISO 9227:06 - NSS; ASTM B117-08; ASTM D610-08; ASTM D714-02 (2009); ASTM D 1654-08; ASTM B 537-70 (2007); ASTM E380-08

Support procedure: OMECO SAC-034e Rev. 0

Equipment: Cutter identified SAC-0175
Salt spray chamber identified SAC-0191
pH meter identified SAC-0206
Technical balance identified SAC-0112
Analytical balance identified SAC-0208
Thermometer identified SAC-0124
Cielab Colorimeter
Universal machine identified SPT-0064

NEUTRAL SALT SPRAY CORROSION TEST
(UNI EN ISO 9227:06; ASTM B 117-08)

OPERATIVE CONDITION (P.C. 122)

Surface treatment: as received
Nebulization solution: 5% weight NaCl RPE in distilled water
Time of exposure: 1000 hours
Exposed surface conditions : the surface was exposed at 20° from the vertical (side 2), on inert support in regard to the test room.

Test time (h)	Temperature (°C)	Solution pH	Pluviometric constant (ml/h)	Density (g/cm ³)
Initial Condition	35.2	6.6	1.7	1.030
24 ÷ 1000	34.6 ÷ 35.4	6.5 ÷ 6.6	1.3 ÷ 1.9	1.030 ÷ 1.031

"This test report cancels and substitutes the test report N. SAC/0594/11 dated 30/07/2011"

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

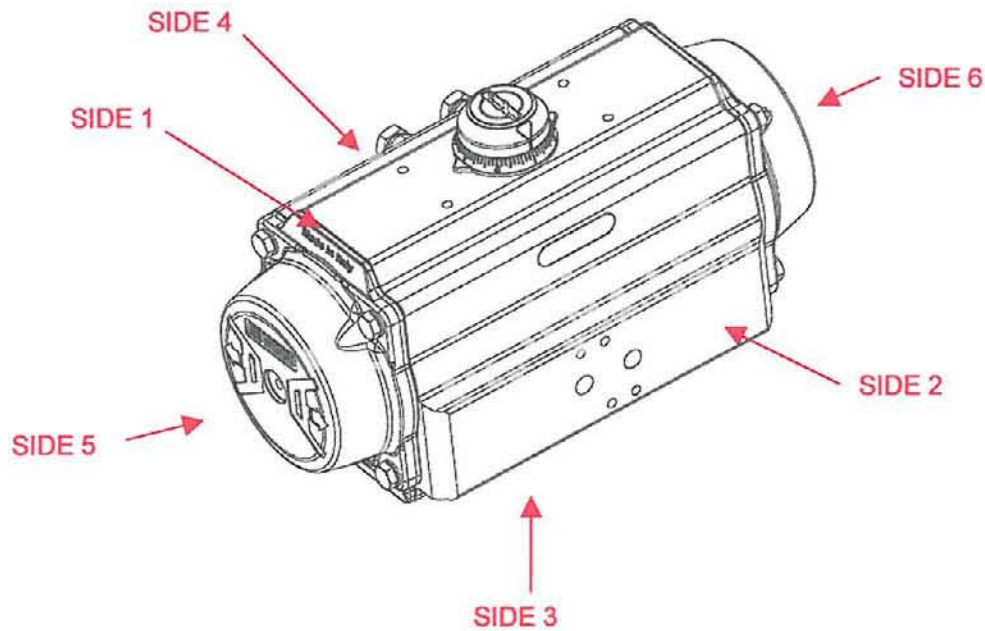
Dates of execution: 31/05÷28/07/2011

At: OMECO Lab. – Monza and External Lab. Test Report 13/07/2011

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
F. LOCATELLI	ING. M. CASARIL

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TEST RESULT

Legend

- a no appreciable changes
- b white salification (ASTM B 537-70 re-approved 2007: refer to ASTM spec. or paragraph 3.0.1 in OMEKO procedure SAC-024e Rev. 0 for details)
- c red rust (ASTM D 610-08: refer to ASTM spec. or paragraph 3.0.2 in OMEKO procedure SAC-024e Rev. 0 for details, paragraph 3.0.3 herein included also furnish a cross comparison with the corresponding classification according to UNI EN ISO 4628-3)
- d blistering/coating damage (ASTM D 714-02: refer to ASTM spec. or paragraph 3.0.4 in OMEKO procedure SAC-024e Rev. 0 for details, paragraph 3.0.5 in the same procedure also gives a correlation with the classification of blistering quantity and size according to UNI EN ISO 4628-2)
- e cracking (UNI EN ISO 4628-4: refer to ISO spec. or paragraph 3.0.6 in OMEKO procedure SAC-024e Rev. 0 for details)

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CYCLE	SIDE	OBSERVATION AND EVALUATION
		IN ACCORDING TO ASTM B 537-70 (2007), D610-08, ASTM D714-02 (2009)
Initial condition	sides1 ,2,3 4,5,6	(Fig. 1a,1b,1c,1d,1e,1f)
1 (24 hours) (1 days)	side 1	c appearance of red rust on the top drive shaft ~0.3% corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 7-S) This area is interested by constant condensation of salt solution. b appearance of white salification on the top drive shaft (protection rating 7)
	sides2 ,3 4,5,6	a no appreciable changes (no white salification – rating 10; no red rust-rust grade 10; no blistering - grade 10; no detectable cracks-rating 0)
2 + 3 (48÷72 hours) (2 + 3 days)	side 1	c slight increase of red rust on the top drive shaft ~ 0.5%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 6-S) This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 6)
	side 3	b appearance of slight white salification on the bottom drive shaft (protection rating 9) (no red rust-rust grade 10)
	sides2 ,4	a no appreciable changes (no white salification – rating 10; no red rust-rust grade 10)
	sides 5,6	b appearance of white salification below the cap screws washers (protection rating 9) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0)
4 + 6 (96÷144hours) (4 + 6 days)	side 1	c slight increase of red rust on the top drive shaft ~ 0.8%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 6-S) .This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 5)
	side 3	b situation as after cycle 2 + 3 (protection rating 9) (no red rust-rust grade 10)
	sides2 ,4	b appearance of slight white salification on the whole surface (protection rating 9) (no red rust-rust grade 10)
	sides 5,6	b slight increase of white salification below the cap screws washers (protection rating 8) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0)
7 (168 hours) (7 days)	side 1	c slight increase of red rust on the top drive shaft ~ 2%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 5-S). This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 4) Fig. 2a
	side 3	b situation as after cycle 4 + 6 (protection rating 9) (no red rust-rust grade 10) Fig. 2c
	sides2 ,4	b increase of white salification on the whole surface (protection rating 7) (no red rust-rust grade 10) Fig. 2b,2d
	sides 5,6	b slight increase of white salification below the cap screws washers (protection rating 8) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) Fig. 2e,2f

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CYCLE	SIDE	OBSERVATION AND EVALUATION
		IN ACCORDING TO ASTM B 537-70 (2007), D610-08, ASTM D714-02 (2009)
8 ÷ 13 (192+312 hours) (8 ÷ 13 days)	side 1	c slight increase of red rust on the top drive shaft ~ 3%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 5-S). This area is interested by constant condensation of salt solution. b situation as after cycle 7 (protection rating 4) Fig. 3a
	side 3	b situation as after cycle 7 (protection rating 9) (no red rust-rust grade 10) Fig. 3c
	sides2 ,4	b increase of white salification on the whole surface (protection rating 6) (no red rust-rust grade 10) Fig.3b,3d
	sides 5,6	b slight increase of white salification below the cap screws washer (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) Fig. 3e,3f
14 ÷ 19 (336+ 456 hours) (14 ÷ 19 days)	side 1	c slight increase of red rust on the top drive shaft ~ 3%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 4-S). This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 3)
	side 3	b situation as after cycle 8 ÷ 13 (protection rating 9) (no red rust-rust grade 10)
	sides2 ,4	b increase of white salification on the whole surface (protection rating 5) (no red rust-rust grade 10)
	sides 5,6	b situation as after cycle 8 ÷ 13 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; not detectable cracks – rating 0)
20 (480 hours) (20 days)	side 1	C slight increase of red rust on the top drive shaft ~ 5%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 4-S). This area is interested by constant condensation of salt solution. B increase of white salification on the top drive shaft (protection rating 3/2) Fig. 4a
	side 3	b situation as after cycle 14 ÷ 19 (protection rating 9) (no red rust-rust grade 10) Fig. 4c
	sides2 ,4	b increase of white salification on the whole surface (protection rating 5) (no red rust-rust grade 10) Fig.4b,4d
	side 5	b situation as after cycle 14 ÷ 19 (protection rating 7) (no red rust-rust grade 10;no blistering – grade 10;no detectable cracks-rating 0) b appearance of white salification on the whole surface (protection rating 8) Fig. 4e
	side 6	b situation as after cycle 14 ÷ 19 (protection rating 7) (no red rust-rust grade 10;no blistering – grade 10;no detectable cracks-rating 0) b appearance of white salification on the whole surface (protection rating 9) Fig. 4f

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CYCLE	SIDE	OBSERVATION AND EVALUATION
		IN ACCORDING TO ASTM B 537-70 (2007), D610-08, ASTM D714-02 (2009)
21 ÷ 26 504 ÷ 624 hours (21 ÷ 26 days)	side 1	c slight increase of red rust on the top drive shaft ~ 6%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 4-S). This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 2)
	side 3	b situation as after cycle 20 (protection rating 9) (no red rust-rust grade 10)
	sides2 ,4	b situation as after cycle 20 (protection rating 5) (no red rust-rust grade 10)
	side 5	b situation as after cycle 20 (protection rating 7) (no red rust-rust grade 10;no blistering – grade 10;no detectable cracks-rating 0) b situation as after cycle 20 (protection rating 8)
	side 6	b situation as after cycle 20 (protection rating 7) (no red rust-rust grade 10;no blistering – grade 10;no detectable cracks-rating 0) b situation as after cycle 20 (protection rating 9)
27 (648 hours) (27 days)	side 1	c slight increase of red rust on the top drive shaft ~ 10%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 4-S). This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 2) Fig. 5a
	side 3	b situation as after cycle 21 ÷ 26 (protection rating 9) (no red rust-rust grade 10) Fig. 5c
	sides2 ,4	b situation as after cycle 21 ÷ 26 (protection rating 5) (no red rust-rust grade 10) Fig.5b,5d
	side 5	b situation as after cycle 21 ÷ 26 (protection rating 7) (no red rust-rust grade 10; no blistering –grade 10; not detectable cracks –rating 0) b increase of white salification on the whole surface (protection rating 7) Fig. 5e
	side 6	b situation as after cycle 21 ÷ 26 (protection rating 7) (no red rust-rust grade 10; no blistering – grade 10; no detectable cracks – rating 0) b situation as after cycle 21 ÷ 26 (protection rating 9) Fig. 5f
28 ÷ 33 (672÷ 792 hours) (28 ÷ 33 days)	side 1	c situation as after cycle 27 (spot rusting – rust grade 4-S). This area is interested by constant condensation of salt solution. b situation as after cycle 27 (protection rating 2)
	side 3	b situation as after cycle 27 (protection rating 9) (no red rust-rust grade 10)
	sides2 ,4	b situation as after cycle 27 (protection rating 5) (no red rust-rust grade 10)
	side 5	b situation as after cycle 27 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b situation as after cycle 27 (protection rating 7)
	side 6	b situation as after cycle 27 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b situation as after cycle 27 (protection rating 9)

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CYCLE	SIDE	OBSERVATION AND EVALUATION
		IN ACCORDING TO ASTM B 537-70 (2007), D610-08, ASTM D714-02 (2009)
34 (816 hours) (34 days)	side 1	c situation as after cycle 28 ÷ 33 (spot rusting – rust grade 4-S) This area is interested by constant condensation of salt solution. b situation as after cycle 28 ÷ 33 (protection rating 2) Fig. 6a
	side 3	b situation as after cycle 28 ÷ 33 (protection rating 9) (no red rust-rust grade 10) Fig. 6c
	sides2 ,4	b situation as after cycle 28 ÷ 33 (protection rating 5) (no red rust-rust grade 10) Fig.6b,6d
	side 5	b situation as after cycle 28 ÷ 33 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b increase of white salification on the whole surface (protection rating 7/6) Fig. 6e
	side 6	b situation as after cycle 28 ÷ 33 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b increase of white salification on the whole surface (protection rating 9/8) Fig. 6f
35 ÷ 41 (840÷ 984 hours) (35 ÷ 41 days)	side 1	c slight increase of red rust on the top drive shaft ~10%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 3-S). This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 1)
	side 3	b situation as after cycle 34 (protection rating 9) (no red rust-rust grade 10)
	sides2 ,4	b increase of white salification on the whole surface (protection rating 4) (no red rust-rust grade 10)
	side 5	b situation as after cycle 34 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b increase of white salification on the whole surface (protection rating 7/6)
	side 6	b situation as after cycle 34 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b increase of white salification on the whole surface (protection rating 9/8)

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CYCLE	SIDE	OBSERVATION AND EVALUATION
		IN ACCORDING TO ASTM B 537-70 (2007), D610-08, ASTM D714-02 (2009)
42 (1008 hours) (42 days)	side 1	c slight increase of red rust on the top drive shaft ~12%, corrosion results to be almost completely localised in the area close to threaded hole of the hexagonal socket screw (spot rusting – rust grade 3-S). This area is interested by constant condensation of salt solution. b increase of white salification on the top drive shaft (protection rating 1) Fig. 7a - Test end
	side 3	b situation as after cycle 35 ÷ 41 (protection rating 9) (no red rust-rust grade 10) Fig. 7c Test end
	sides 2, 4	b situation as after cycle 35 ÷ 41 (protection rating 4) (no red rust-rust grade 10) Fig. 7b, 7d Test end
	side 5	b situation as after cycle 35 ÷ 41 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b increase of white salification on the whole surface (protection rating 6) Fig. 7e Test end
	side 6	b situation as after cycle 35 ÷ 41 (protection rating 7) (no red rust-rust grade 10; no blistering - grade 10; no detectable cracks – rating 0) b increase of white salification on the whole surface (protection rating 8) Fig. 7f
Test End		

Note:

Side 4 was not exposed at the proper exposure angle. Side 3 was also not directly exposed to salt spray (only bottom solution condensation could have occurred).

In the observation table, all the actuator parts not mentioned do not present corrosion phenomena.



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sample A1- Fig. 1a: side 1 as received



sample A1 - Fig. 1b: side 2 as received



sample A1- Fig. 1c: side 3 as received



sample A1- Fig. 1d: side 4 as received



sample A1- Fig. 1e: side 5 as received



sample A1- Fig. 1f: side 6 as received

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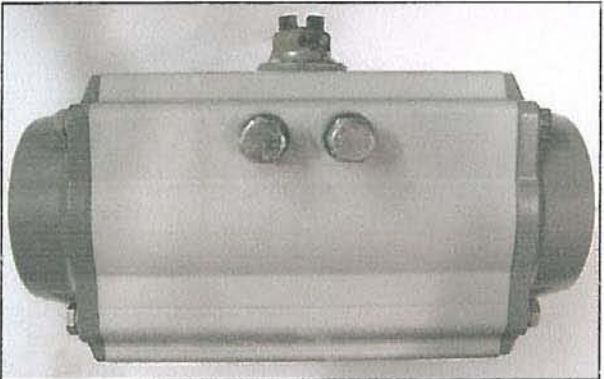
sample A1 - Fig. 2a: side 1 after 168 hours of exposition



sample A1 - Fig. 2b: side 2 after 168 hours of exposition



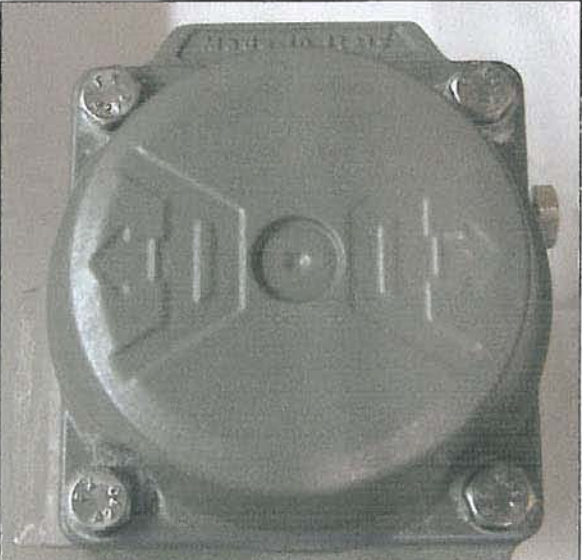
sample A1 - Fig. 2c: side 3 after 168 hours of exposition



sample A1 - Fig. 2d: side 4 after 168 hours of exposition



sample A1 - Fig. 2e: side 5 after 168 hours of exposition



sample A1 - Fig. 2f: side 6 after 168 hours of exposition



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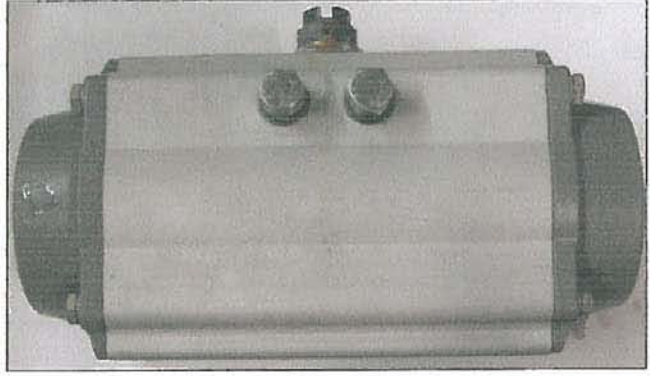
sample A1 - Fig. 3a: side 1 after 312 hours of exposition



sample A1 - Fig. 3b: - side 2 after 312 hours of exposition



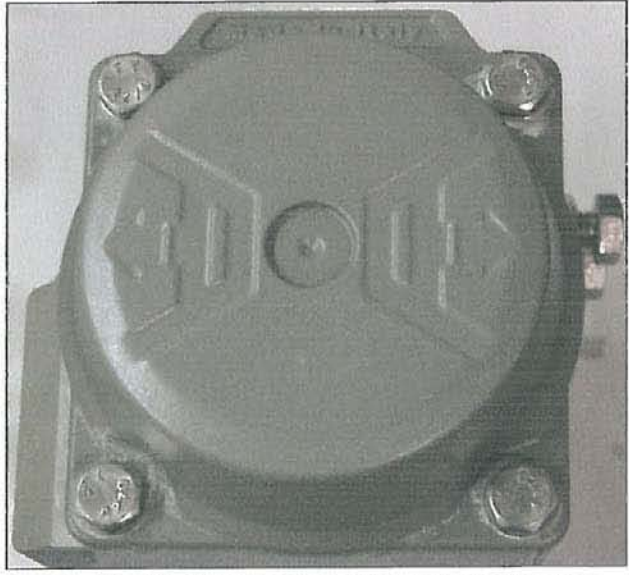
sample A1 - Fig. 3c: side 3 after 312 hours of exposition



sample A1 - Fig. 3d: side 4 after 312 hours of exposition

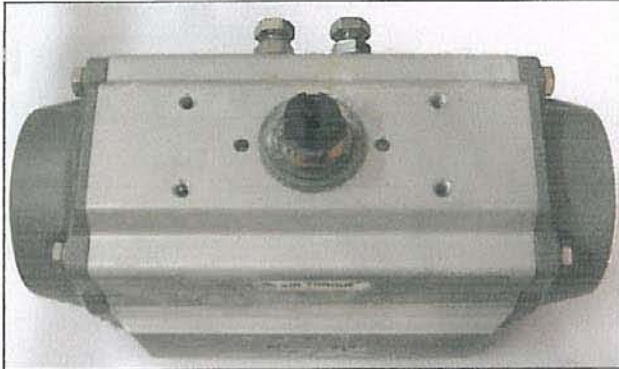


sample A1 - Fig. 3e: side 5 after 312 hours of exposition



sample A1 - Fig. 3f: side 6 after 312 hours of exposition

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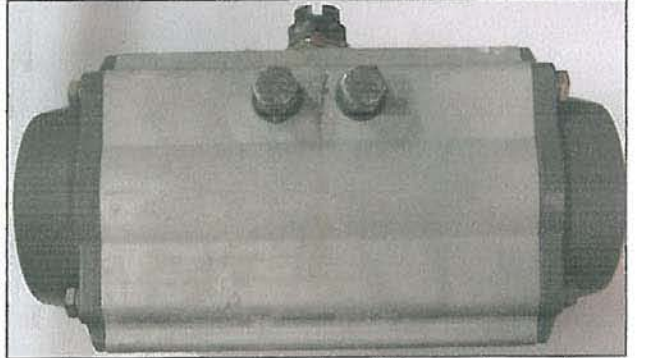
sample A1 - Fig. 4a: side 1 after 480 hours of exposition



sample A1 - Fig. 4b: side 2 after 480 hours of exposition



sample A1 - Fig. 4c: side 3 after 480 hours of exposition



sample A1 - Fig. 4d: side 4 after 480 hours of exposition

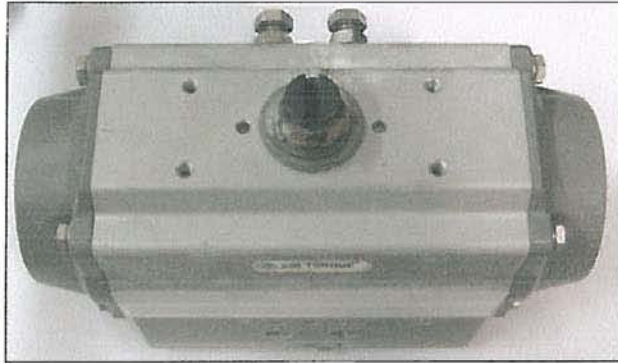


sample A1 - Fig. 4e: side 5 after 480 hours of exposition



sample A1 - Fig. 4f: side 6 after 480 hours of exposition

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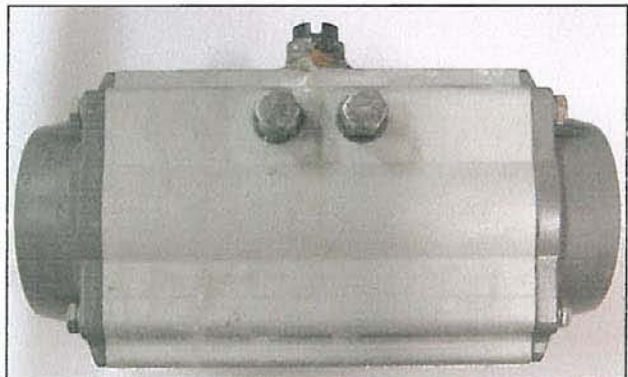
sample A1 - Fig. 5a: side 1 after 648 hours of exposition



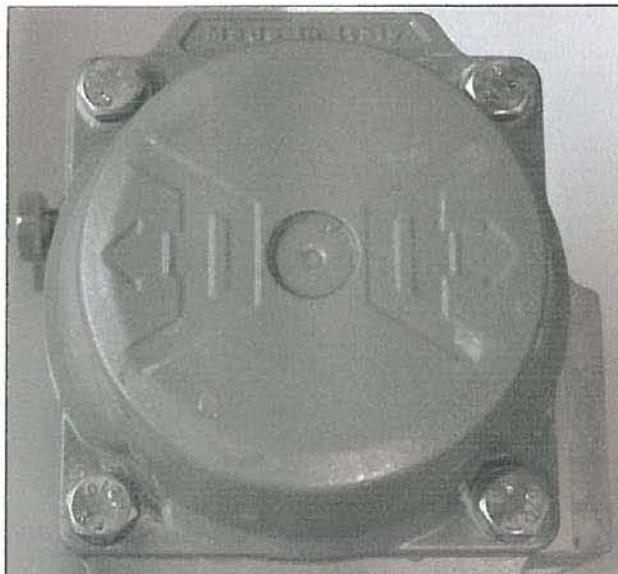
sample A1 - Fig. 5b: side 2 after 648 hours of exposition



sample A1 - Fig. 5c: side 3 after 648 hours of exposition



sample A1 - Fig. 5d: side 4 after 648 hours of exposition



sample A1 - Fig. 5e: side 5 after 648 hours of exposition



sample A1 - Fig. 5f: side 6 after 648 hours of exposition

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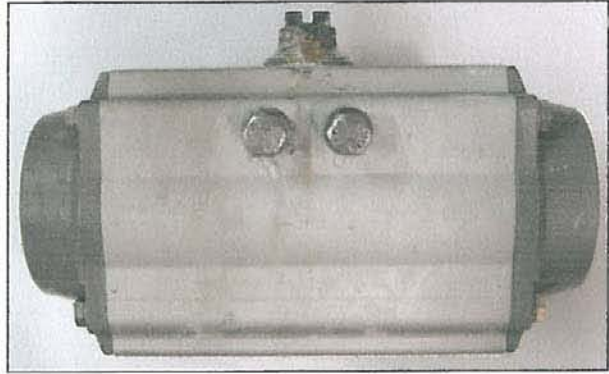
sample A1 - Fig. 6a: side 1 after 816 hours of exposition



sample A1 - Fig. 6b: side 2 after 816 hours of exposition



sample A1 - Fig. 6c: side 3 after 816 hours of exposition



sample A1 - Fig. 6d: side 4 after 816 hours of exposition



sample A1 - Fig. 6e: side 5 after 816 hours of exposition



sample A1 - Fig. 6f: side 6 after 816 hours of exposition

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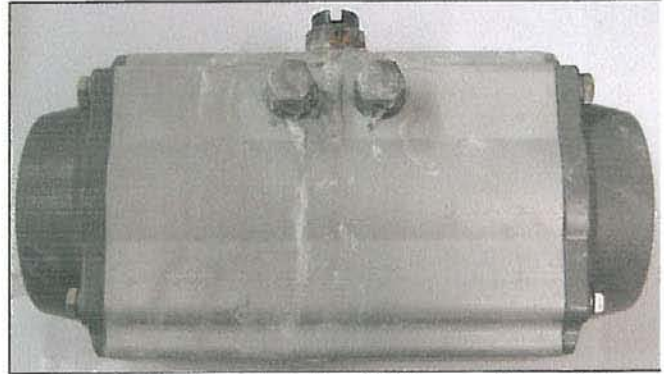
sample A1 - Fig. 7a: side 1 after 1008 hours of exposition



sample A1 - Fig. 7b: side 2 after 1008 hours of exposition



sample A1 - Fig. 7c: side 3 after 1008 hours of exposition



sample A1 - Fig. 7d: side 4 after 1008 hours of exposition



sample A1 - Fig. 7e: side 5 after 1008 hours of exposition



sample A1 - Fig. 7f: side 6 after 1008 hours of exposition

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PULL-OFF STRENGTH TEST (ASTM D4541-02)

Legend

Failure mode

B = coating failure

B/Y = Interface coating-adhesive failure

Adhesive used : HBM - X60

END CAP – SIDES 5-6 (SAMPLE A2)								
Sample condition	Specimen dims. (mm)	Cross Sect. (mm ²)	Relative Humidity %	Temp. (°C)	Tensile strength (N)	Tensile strength		Tearing appearance
						(N/mm ²)	psi	
Reference	Ø 20	314.2	50	+20	2600	8,3	1200	100% B
Reference	Ø 20	314.2	50	+20	2250	7,1	1039	100% B
Average :						7,7	1119	
END CAP – SIDES 5-6 (SAMPLE A1)								
After exposure	Ø 20	314.2	50	+20	1160	3.7	535	80% B/Y - 20% B
After exposure	Ø 20	314.2	50	+20	1009	3.2	466	100% B/Y
Average :						3.5	500	

ADHESION TEST (ASTM D3359-08)

Test condition

Temperature: 23 ± 2°C RH: 50 ± 5%

Test Results

BEFORE EXPOSURE	
IDENTIFICATION	RATING
Sample A2 (Actuator End Cap)	Classification 5B: the edges of the cuts are completely smooth; none of squares of the lattice is detached.
AFTER EXPOSURE	
IDENTIFICATION	RATING
Sample A1 (Actuator End Cap)	Classification 5B: the edges of the cuts are completely smooth; none of squares of the lattice is detached.

To work out the above reported classification refer to ASTM D3359-08 spec. or OMEKO SAC-024e paragraph 3.0.7

**COLOUR MEASUREMENT AND CALCULATION OF COLOUR DIFFERENCES OF PAINTS
(ISO 7724-2/3 and ASTM E308)**

Sample	Position	Colour measurement			Colour difference			
		L*	a*	b*	ΔL*	Δa*	Δb*	ΔE*
A2 (Reference)	End Cap	46.29	0.07	4.38	---	---	---	---
A1 (After exposure)	End Cap	48.50	-0.09	3.51	2.21	-0.16	-0.87	0.29

CIELAB coordinate unit scheme is depicted on the next page (ΔE* < 0.5/1.0 are considered to be below the possibility of being visually appreciate).

An help in handling and interpreting CIELAB coordinate values and variations is provided in OMEKO SAC-024e paragraph 3.0.8 that also includes a visual example of colour variation. Further detailed information are available in ASTM E308 specification.