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PERFORMANCE REQUIREMENTS FOR EXTERIOR TOPSIDES COATINGS

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Juan A. MORENO
Vice Admiral, ESP(N)
Director, NATO Standardization Agency

NATION	SPECIFICATION RESERVATIONS

RECORD OF CHANGES

Change Date	Date Entered	Effective Date	By Whom Entered

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FORWARD

Through contacts with various navies it appeared that objectives are shared, in particular:

- increased dry-docking intervals (between 6-10 years),

- reduction of maintenance works including crew labour.

These common objectives should succeed in reaching a high operational availability combined with reduction in running costs.

The choice of the protective paint system has to be considered to fulfill the objectives and to be translated in terms of durability and maintainability. In such a matter, the probable optimum for many locations is to reach a durability superior to 15 years, i.e. corresponding to H category of the standard EN-ISO 12944-1.

The choice of the protective paint system should be based on recognised performance standards to be credible. However these do not exist at an International level in ISO and CEN standardisation or within certification society's rules. However, they often exist for each navy where they were nationally developed.

Regarding the work in progress inside ISO and CEN organisations, it seems very unlikely that the various ship locations will be covered by ISO or CEN performance standards. That is why in such conditions it appears useful to develop APs recognizing naval qualification conditions of protective paint systems for the various ship locations.

These APs will constitute internationally recognised documents and consequently will contribute to promote a world wide market adapted to navies.

The interest of these standards is reinforced by the evolution of products under the pressure of regulations regarding Health/Safety and the Environment (VOC, ,…..).

CHAPTER 1 - INTRODUCTION

The aim of this Allied Publication is to establish the minimum requirements for the corrosion protection of ships exterior topsides. This is a specification for the approval of paint systems and paints which have the following functions :

- corrosion control (≥ 15 years)
- cosmetic (as required)

This document does not establish requirements for emissivity (IR), reflectance, or absorbance of the top coat.

This Allied Publication represents the minimum performance standards acceptable for the coating systems covered by this document.

CHAPTER 2 - SCOPE

This AP deals with the performance requirements for corrosion protection by protective paint systems of ships exterior topsides and related structures exposed to the marine atmosphere. Cosmetic coatings are designed to be repaired and over-coated through system service life

This Standard deals with high durability protective paint systems for ships exterior topsides and related structures. These structures are exposed to the corrosion category C5-M in accordance with ISO 12944-2 with special stresses as given in § 4.3 and annex B of that standard.

This Standard addresses :

- Laboratory performance test methods for assessment of the durability of the protective paint system(s)
- Evaluation criteria for performance testing
- Test methods for the identification of the individual components of the protective paint system
- Acceptance criteria

CHAPTER 3 - NORMATIVE REFERENCES

ISO 1247	Aluminium pigments for paints
ISO 1248	Iron oxide pigments (red oxide) for paints
ISO 1514	Paints and varnishes — Standard panels for testing
ISO 2114	Plastics (polyester resins) and paints and varnishes (binders) — Determination of partial acid value and total acid value
ISO 2409	Paints and varnishes — Cross-cut test
ISO 2808	Paints and varnishes - Determination of film thickness.

ISO 2810 Paints and varnishes - Natural weathering of coatings – exposure and assessment

ISO 2811 (all parts) Paints and varnishes — Determination of density

ISO 3001 Plastics – Epoxy compounds – Determination of epoxy equivalent

ISO 3233 Paints and varnishes — Determination of percentage volume of non-volatile matter by measuring the density of a dried coating

ISO 3251 Paints and varnishes — Determination of non-volatile matter of paints, varnishes and binders for paints and varnishes

ISO 3270 Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing

ISO 3549 Zinc dust pigments for paints — Specifications and test methods

ISO 3678 Paint and varnishes – Paint-free test

ISO 3679 Paints, varnishes, petroleum and related products — Determination of flashpoint — Rapid equilibrium method

ISO 3682 Determination of acid value – Titrometric method 2114

ISO 4618 Paints and varnishes - Terms and definitions

ISO 4624 Paints and varnishes — Pull-off test for adhesion

ISO 4628 Paints and varnishes - Evaluation of degradation of paint coatings - Designation of intensity, quantity and size of common types of defect.

- Part 1: General introduction and designation system
- Part 2: Assessment of degree of blistering
- Part 3: Assessment of degree of rusting
- Part 4: Assessment of degree of cracking
- Part 5: Assessment of degree of flaking
- Part 6: Rating of degree of chalking by tape method
- Part 7: Assessment of degree of chalking by velvet method
- Part 8: Evaluation of corrosion around a scribe (ISO/DIS)
- Part 10: Assessment of degree of filiform corrosion

ISO 4629 Binders for paints and varnishes — Determination of hydroxyl value — Titrimetric method

ISO 6270 Paints and varnishes - Determination of resistance to humidity (continuous condensation)

ISO 6745 Zinc phosphate pigments for paints — Specifications and methods of test

ISO 7253 Paints and varnishes — Determination of resistance to neutral salt spray (fog)

ISO 7724 Paints and varnishes – Colorimetry
- Part 1: Principles
- Part 2: Colour measurement
- Part 3: Calculation of colour differences

ISO 8044 Corrosion of metals and alloys — Basic terms and definitions

ISO 8501-1 Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness
- Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

ISO 8502 Preparation of steel substrates before application of paint and related products – Tests for the assessment of cleanliness
- Part 1: field test for soluble iron corrosion products
- Part 3 : Assessment of dust on steel surfaces prepared for painting
- Part 4 : Probability of condensation prior to paint
- Part 6 : Extraction of soluble contaminant for analysis – Bresle method
- Part 9 : Field method for conductometric determination of water soluble salts

ISO 8503 Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates
- Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces
- Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel — Comparator procedure

ISO 9223 Corrosion of metals and alloys – Corrosivity of atmospheres – Classification

ISO 9514 Paints and varnishes - Determination of the pot-life of liquid systems

ISO 10601 Micaceous iron oxide pigments for paints — Specifications and test methods

ISO 11014-1	Safety data sheet for chemical products Part 1: Content and order of sections
ISO 11507	Paints and varnishes — Exposure of coatings to artificial weathering — Exposure to fluorescent UV and water
ISO 11890-1/-2	Paints and varnishes - Determination of volatile organic compounds
ISO 11908	Binders for paints and varnishes — Amino resins — General methods of test
ISO 11909	Binders for paints and varnishes — Polyisocyanate resins — General methods of test
ISO/CD 11998	Paints and varnishes - Determination of wet scrub resistance and cleanability of coatings
ISO 12944	Paint and varnishes — Corrosion protection of steel structures by protective paint systems Part 1: General introduction Part 2: Classification of environments Part 5: Protective paint systems Part 6: Laboratory performance test methods
ISO 14680	Paints and varnishes — Determination of pigment content — Part 1: Centrifuge method Part 2: Ashing method
ISO 19840	Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the dry film thickness on rough surfaces
EN 971-1	Paints and varnishes — Terms and definitions for coating materials Part 1: General terms
EN 29117	Determination of through-dry state and through-dry time – method of test
ASTM D 2372	Standard Practice for Separation of Vehicle from Solvent-Reducible Paints
ASTM D 2572	Test method for isocyanate groups in urethane materials and prepolymers
ASTM D 2621	Standard Test Method for Infrared Identification of Vehicle Solids from Solvent-Reducible Paints
ASTM D 3960	Standard practice for determining volatile organic compound (VOC)

SSPC SP1 Solvent cleaning

NF T34-554 Système de peinture anti-corrosion. Stabilité dans le temps des caractéristiques colorimétriques d'une peinture de finition pour ouvrage métallique

CHAPTER 4 - DEFINITIONS

For the purposes of this agreement, the following terms and definitions apply.

NOTE : Some of the definitions have been taken from ISO 8044:1999, ISO 12944-1 or EN 971-1:1996 and ISO 4618, as indicated.

4.0 Cleaned surface (Cleanliness)
Surface from which the contaminants have been removed to a specified level

4.1 Coat
A continuous layer of a coating material resulting from a single application [ISO 4618]

4.2 Corrosion
Physico-chemical interaction between a metal and its environment that results in changes in the properties of the metal and that may often lead to impairment of the function of the metal, the environment or the technical system of which these form a part [ISO 8044]

4.3 C5-M
This is the very high marine corrosivity category, defined by standards ISO 12944-2, in terms of the mass or thickness loss of standard specimens made of low-carbon steel and/or zinc, after the first year of exposure. It corresponds to coastal and offshore areas with high salinity.

4.4 Durability
The expected life of a protective paint system to the first major maintenance painting [ISO 12944-1]. Durability in accordance of 12944-1 concerns only the anticorrosive performances of the paint system and not the cosmetic behaviour of topcoat.

4.5 Paint
A pigmented coating material in liquid, in paste or powder form that, when applied to a substrate, forms an opaque film having protective, decorative or specific technical properties [ISO 4618].

4.6 Protective paint system
The sum total of the coats of paints or related products that are to be applied or have been applied to a substrate to provide corrosion protection [ISO 12944-1].

4.7 Substrate
The surface to which the coating material is applied or is to be applied [ISO 4618].

4.8 Nominal dry film thickness (NDFT)
The dry film thickness specified for each coat and the whole paint system to achieve the required durability [ISO 12944-5].

4.9 Dry film thickness (DFT)
The thickness of a coating remaining on the surface when the coating has hardened.

4.10 Product data sheet (PDS)
A document designed to provide information on a specific paint product
NOTE 1: The type of information includes product uses, features, service properties, application properties, application instructions, packaging information, and information on storage and handling.
NOTE 2: See 5.4 for specific required minimum information.

4.11 Material safety data sheet (MSDS)
A document designed to provide information regarding the health and safety aspects of a paint product or thinner
NOTE : The MSDS typically includes information concerning generic material identification, hazardous ingredients, physical data, fire and explosion data, health hazards, reactivity data, spill or leak procedures, special protection requirements and other special precautions.

4.12 Qualification
A process for the evaluation of protective paint systems using test criteria which allow the selection of suitable paint systems for distinct environmental exposure conditions

4.13 Shelf life
The period from the date of manufacture during which the paint can be transported and / or stored in undamaged and unopened packaging without any influence on its application or performance providing the ambient conditions are within the limits recommended by the paint manufacturer, or otherwise agreed.
NOTE 1 : After exceeding this period, the paint is subject to re-inspection.

4.14 Re-coatability
Property of paint dry film (generally top coat) to receive a general coat, without compatibility failure.

4.15 Maintenance aptitude
Aptitude of paint system to be repaired by maintenance paint system, including repair of anticorrosive paint and topcoat.

4.16 VOC (Volatile organic compound)
Fundamentally, any organic liquid and/or solid that evaporates spontaneously at the prevailing temperature and pressure with which it is in contact

4.17 VOC Content (Volatile organic compound content)
The mass of the volatile organic compounds present in a coating material, as determined under specific conditions

Note 1: The properties and the amount of the compounds to be taken into account will depend on the field of application of the coating material. For each field of application, the limiting values and the methods of determination or calculation are stipulated by regulations or agreement.

Note 2: Under certain US governmental legislation, the term VOC is restricted solely to those compounds that are photochemical active in the atmosphere (see ASTM D 3960). Any other compound is then defined as being an exempt compound.

[ISO 11890-1 adapted from ISO 4618-1]

4.18 Toxicological risk

Risks due to paint raw materials (pigments, binders, solvents, thinner…)

4.19 Fire risk

Risk due to flammable raw materials and application modes

CHAPTER 5 - FIELD OF APPLICATION

The field of application for which this AP is developed is characterised by:

- the type of structure,
- the environment
- the durability requirement
- the type of application
- the type of substrate and surface preparation,
- the type of paints

5.1 Type of structures

This AP concerns structures, exterior topsides of ships, made of Carbon Manganese steels, other metallic materials or Glass Reinforced Plastic (resin fibreglass).

Not covered by this agreement are :

- steel cable structures
- functional surfaces like bearings
- rubber components

5.2 Type of environment

This AP deals with the atmospheric corrosivity category C5-M in accordance with ISO 12944-2.

5.3 Type of Durability

The corrosion protection of the paint system is of High Durability and must have a minimum life expectancy of 15 years (ISO 12944-1). During this period, localized repairs and general topcoat applications which are considered necessary for minor maintenance should be undertaken. This work is considered as minor maintenance. During this period, the level of the coating failure before the first major maintenance painting shall not exceed 25 % of each exterior topsides area. The high durability classification does not concern the topcoat and his colorimetric and cosmetic properties.

5.4 Type of paint works

The applications covered by this document are new building application or equivalent (total removal of pre-existing coatings).
The new building paint system must be adapted to maintenance procedures such as localized repairs (due to mechanical damages, weld burn, etc) and general topcoat application.
No mechanical surface preparation shall be required for the general topcoat application.
The maintenance shall be carried out using a standard paint maintenance system.

5.5 Type of substrate and surface preparation

The major substrate of exterior topsides is steel, which may or may not have been protected by shop primer (e.g. zinc rich primer, zinc ethyl silicate) at construction.
If used, shop primers are not considered as the first coat of paint system.

The description of surface preparation covers cleanliness, levels of contamination and roughness .The surface preparations generally used for the different types of substrates are :

Table 1 : Surface preparation

Nature of substrate	Surface preparation	Standardization
Steel	A Sa 2½	ISO 8501-1
Fibre reinforced composites	*Sweep blast to remove gloss*	
Other metallic materials (copper alloys, aluminium alloys, stainless steel,)	*Sweep blast and optional solvent wipe*	

Table 2 : Cleanliness

For all types of substrate, the minimum level of cleanliness (contamination) before paints application must meet the following criteria:

Criteria	Minimum level	Standardization
Dust	Intensity : < 2 (Fig 1 of ISO 8502-3) Size : ≤ 2 (Board 1 of ISO 8502-3)	ISO 8502-3 (*)
Probability of condensation	Relative humidity : ≤ 85 % Substrate temperature ≥ dew point + 3°C Application temperature between + 5°C and +35 °C	ISO 8502-4 (*)
Oils and greases	0	” (*) SSPC SP 1
Soluble salts	≤ 7 µg/cm² (Chloride equivalent)	ISO 8502-6/-9 (*)

(*) These specifications are standardized only for steel surfaces but may be used on other types of substrates commonly encountered in building naval vessels (Steel, GRP, copper and aluminium alloys, etc).

Roughness

The grade used is MG (Medium Grit) of the comparator procedure defined by ISO 8503-2.

5.6 Type of paint product

The generic types of paint widely used in paint systems for the protection of steel structures against corrosion are described but not limited in ISO 12944-5.

Paints may be applied by brush, roller, or spray and dry at ambient temperatures in normal shipyard condition, within the parameters specified for each paint.

CHAPTER 6 - REQUIREMENTS FOR QUALIFICATION

Requirements for paint systems submitted for the qualification approval are described in the following items :

- Document requirements
- Basic requirements
- Qualification tests
- Paint identification

For the proposed paint system, the manufacturer shall prepare and submit documents in accordance with 6.1.

Basic requirements for the paint system submitted for the qualification are listed in 6.2; characteristics of paint system shall be in accordance with them.

The protective paint systems shall be performance tested in accordance with paragraph 7 and the individual paints comprising the system shall be identified in accordance with paragraph 8.

The chemical composition of the paints in the protective paint system shall be controlled during and after the qualification process. Any change shall be noted and justified by the manufacturer proving that such changes do not negatively affect the long-term properties of the material (see appendix A 1.6). A product data sheet and material safety data sheet shall be submitted for each modified paint.

6.1 Document requirements

At the time of qualification submission the paint system shall be identified by unique nomenclature (system name, alpha/numeric identification) and also each individual product constituting the system shall be identified by unique nomenclature (product name, alpha/numeric identification, index of product formulation, chemical nature, colour, nominal drying film thickness for each coat in µm).

The Manufacturer shall submit a technical file containing all of the following information and documents:

- Technical data sheet of paint system including (see appendix A1.1)
- Fingerprint for each paint component of the paint system (see A.1.2)
- Technical data sheet for each paint component of the paint system (see A.1.3)
- Safety data sheet and labelling requirements for each paint; including VME, TLV or MAC for each paint constituting the paint system (see A.1.4)
- Use references (see A.1.5)

6.2 Basic requirements

6.2.1 General objectives

Paint systems submitted for qualification shall have :

- Good anticorrosive performance in service life in very high marine corrosivity category (C5--M) for minimum 15 years, without total removal (see 5.3). During this period of time it is supposed that the topcoat will be re-applied regularly (1 coat every 2-5 years)
- Good corrosion resistance on specific areas (edges, welds, anchor pattern, …)
- The primer of the paint system submitted shall be similar or compatible with the anticorrosive paint system of the hull (joining between exterior top side and hull areas paint system)
- Compatibility with standard maintenance paint system indicated by each nation
- Suitability for localized repair and general topcoat application
- Colour and gloss level of the topcoat shall be stable and resistant to soiling. The minimum period of performance shall be 3 years.

6.2.2 Requirements

Paint systems submitted for qualification shall have :

- Paint system architecture

Table 3

Metallic substrate		
Nature of Primer	Zinc rich	Other
Number of coats (Primer)	1	≥ 1
NDFT (µm) (Primer)	≥ 40	≥ 60
Total Number of coats	≥ 3	≥ 3
NDFT (µm) (1)	≥ 200 (2)	≥ 240 (2)

(1) Nominal Dry Film Thickness
(2) different from ISO 12944-5 which indicates 300and 350 µm

Table 4

Non Metallic substrate	
Nature of Primer	Other
Number of coats (Primer)	1
NDFT (µm) (Primer)	≥ 40
Total Number of coats	≥ 2
NDFT (µm) (1)	≥ 100

(1) Nominal Dry Film Thickness

- Paints constituting paint systems shall be applicable and shall dry in normal atmospheric conditions :
  - Relative Humidity : ≤ 85 %,
  - Substrate temperature : ≥ T dew point + 3°C,
  - Environmental temperature for application : + 5°C → +35 °C.

- Each paint shall be applied with brush, roller, or spray, with a mean dry thickness of at least 1,5 times the specified NDFT (nominal dry film thickness) without defects.

- Dry hard time is maximum 16 hours (ISO 3678)

- Pot life : > 2 hours at 20°C (ISO 9514)

- Paints comprising the paint system submitted shall be in accordance with the national regulations, minimum requirements for toxicological risk, fire risk, safety and health, environment impact are given in the following table :

Table 5

Criteria	Primer and intermediate coat (1)	Topcoat (1)
Toxicological risk (max.)	Xi	-
Fire risk (max.)	Flammable	-
VME, TLV, MAC (2)	≥ 50 ppm	≥ 100 ppm
VOC (target)	250 g/l (3)	250 g/l (3)

(1) For two component products, values are for the mixed and ready to use product
(2) VME : Minimum Value of exposition, TLV : Threshold Limit Value, MAC : Maximum Allowable Concentration (in parts per million [ppm] or milligrams per cubic meter [mg/m³])
(3) Target in accordance with national regulation

Adhesion of paint system is a minimum of 4 MPa and 3 MPa with zinc rich primer (Pull off test ISO 4624)

- Shelf life of each paint is at least 18 months (on delivery)

- Paints shall not exhibit on delivery or during shelf life: hard settling, skinning, phase separation, corrosion of container, persistent foam after mix or other properties indicating unfitness for use.

- Colour and gloss of different topcoats limited to grey colour, are given in the following table

Table 6

Reference						
Colour	Colour chips reference	Nation	ΔE *	ΔL *	Specular gloss %0 (60 °)	Standard
Grey/blue middle	AFNOR A625	F	≤ 1	± 0,7	> 60	ISO 7724 / -1 /–2 /-3
Dark grey/blue	AFNOR A605	F	≤ 1,5	± 0,7	> 60	
Haze grey	FED STD 26270	USA	≤ 1		35 – 60	
Light weatherwork grey	BS 381C:676	UK	≤ 1,5		> 60 gloss units	
Grey	KN 01020	NE	-	-	-	
Dark grey	FED STD 595 xxxxxx	IT			60 – 70	
Middle grey	FED STD 595 26373	IT			60 - 70	
Grey	FED STD 595B, 16480 being changed to 26480	CA			45 – 60	
Storm grey	AS 2700 N42	AUS			12 - 18	

Grey	RAL 7000	GE	≤ 1,5			
Grey	RAL 7012	GE	≤ 1,5			
Grey	FSD 7416	SE	≤ 1,5	± 0,3	≤ 1	

NB: The colour stability must be in accordance with the criteria given in this table, on delivery and during shelf life

CHAPTER 7 – REFERENCE AREAS

7.1 Preparation and conditioning of test panels

Test panels: Type, size, number, preparation and conditioning of test panels are in accordance with the ISO 12994-6 and the instructions of manufacturer of coating material. If not otherwise agreed, the thickness of panels is 5 mm. These panels shall be in steel complying with ISO 1514.

Surface preparation: The test panels shall be grit blasted to Sa 2½ (ISO 8501-1) and using a non-metallic abrasive (inert slag). The surface profile of the test side of each panel shall correspond to MG class (Medium grit) as defined in ISO 8503-1 and checked with comparator as ISO 8503-2. Surface contaminant levels are : dust : ≤ 2 (ISO 8502-3), oils and greases free (SSPC SP1), soluble salts ≤ 3µg/cm² (ISO 8502-6/-9).

Other surface preparation may be used to represent actual field conditions such as hydrojetting, in accordance with the manufacturer's instructions and agreed by parties.

Application and curing: The panels shall be coated by spraying and strictly in accordance with the latest manufacturer's written instruction.
Backside and edges of test panels shall be protected with an appropriate protection agreed by parties.

Dry film thickness (DFT): For each layer, prior to overcoating, the DFT on test face panels shall be measured at minimum 5 positions (centre and corners, 15 to 20 mm from edges). Values of thickness (ISO 19840) shall be recorded as minimum, maximum and average.
The thickness of each layer shall be
- From NDFT to 1,5 NDFT if NDFT ≤ 60 µm
- From NDFT to 1,25 NDFT if NDFT > 60 µm

Overcoating time: Overcoating time for each layer shall be conducted in accordance with the paint manufacturer's instructions. Deviated overcoating time shall be agreed between parties involved and recorded in the test report.

Conditioning: The panels shall be conditioned under controlled temperature and humidity as ISO 3270.

Scratch line: Scratch lines, when specified (see following table), shall cut through the protective paint system down into the substrate. In accordance with ISO 12944-6 annex A, these scratch lines shall be at least 50 mm long and 20 mm from any edges.

Two types of scratch line are made on test panel.

Scribing machine (fig 1 Annex 2, Appendix 1) such as drill press with cobalt slot drills. In such a case, a 2 mm width is recommended for the drill and shall be used for calculation of undercutting with the formula given in annex A of ISO 12944-6 (use W = 2 mm).

This type of scratch line is made horizontally on one face of test panel, at the bottom (see Annex 2, Appendix 1)

Manual scribing (fig 2 of Annex 2, Appendix 1) with a single blade cutting tool as described in ISO 2409 subclass 4.1.1 In such a case, a 0.05 mm width shall be used for calculation of the undercutting with formula given in annex A of ISO 12944-6 (use W= 0.05 mm)

This type of scratch line is made vertically on one face of test panel, on left side (fig 3)
The minimum distance between the 2 scratch lines is 10 mm (fig 3 of annex 2, Appendix 1)

7.2 Performance test

Before paint application on panels for performance tests, the applicability and storage stability of paints are checked :

- Applicability : Each paint shall be applied by brush, roller, or spray, without runs and sags to a vertical and smooth sheet metal with minimum area of 1 m², with a mean dry thickness of at least 1,5 time the specified NDFT (nominal dry film thickness) See Annex 2, Appendix 3.

- Storage stability: Paints shall not exhibit on delivery or during shelf life: hard settling, skinning, , phase separation, corrosion of container, persistent foam after mix or other properties indicating unfitness for use (see Annex 2, Appendix 4).

Table 7

PERFORMANCE TEST ON PAINT SYSTEM			
N°	NATURE	DURATION	STANDARD
1	Salt spray (1)	1440 h (ISO 12944-6)	ISO 7253
2	Condensation	720 h (ISO 12944-6)	ISO 6270
3	UV resistance	600 h (QUV)	ISO –11507
4	Natural weathering for colour and gloss stability (see Appendix A3 - Table1for suggested sites)	12 months	ISO 2810
5	Natural ageing in C5-M environment (see Appendix A3 - Table2 for suggested sites) (1)	At least 2 years	ISO 12944-2, ISO 9223, ISO 2810

6	Recoatability aptitude	Annex 2, Appendix 2	
7	Maintenance aptitude	Annex 2, Appendix 2	
8	Cleanability (2)	15 cycles	ISO/CD 11998

Minimum 2 panels per test

(1) Scratch line, in accordance with Annex 2, Appendix 1. For test N° 1 and 5 scratch line is made on a minimum of one panel

(2) Test 8 is optional

7.3 Acceptance criteria

Table 8

ACCEPTANCE CRITERIA					
N°	NATURE OF TEST	Tests before and after qualification tests N°	Level before qualification tests	Level after qualification tests	STANDARD
1	Pull off test	1, 2, 5, 8	No adhesive failure ≥ 4 MPa or ≥ 3 MPa for paint system with ZRP	≥ 50 % of original value (only cohesive failure)	ISO 4624
2	Cross cut test (1)	1, 2, 5, 8	0	≤ 1	ISO 2409
3	Rusting from scratch line (ISO 12944-6 annex A)	After qualification test N° 1, 5	-	M < 1 mm (manual scribe with 0.05 mm width) M < 3 mm (scribing machine with 2 mm width)	ISO 12944-6
4	Degradations Blistering Rusting Cracking, Flaking Chalking	1, 2, 3, 4, 5, 8	No paint application and drying defects	No failure 0 (S0) 0 (Ri0) 0 (S0) ≤ 1	ISO 4628
5	Colour and gloss stability Total colour difference ΔE * Specular gloss (60 °)	1, 2, 3, 4, 5, 8	See acceptance criteria in § 6.2.2	See table 9	ISO 7724-1/-2 /-3

ZRP : Zinc Rich Primer

(1) Not to be used when NDFT is over 250 µm

TABLE 9 – COLOUR AND GLOSS ACCEPTANCE AFTER QUALIFICATION TESTS

Reference		Acceptance criteria				
Colour	Nation	ΔE *	ΔL *	Δ C	Specular gloss % (60 °)	Standard
Storm grey	AUS					APAS 0501
Grey/blue middle	F	≤ 7,0			≥ 50 % of original value	NF T 34-554
Dark grey/blue	F	≤ 5,0			≥ 50 % of original value	NF T 34-554
Haze grey	USA					
Extra dark sea grey	USA					
Grey RAL 7000 and RAL 7012	GE	< 2,5				12 months (Wilhelmshaven exposure)
Light weatherwork grey	UK	≤ 2,0			≥ 70 % of original value	ISO 7724 Parts 1, 2, 3 ISO 2813

CHAPTER 8 - PAINT IDENTIFICATION

Each paint constituting paint system submitted to the qualification process should be checked according to the following tests (the different values are given by the paint manufacturer) and reported in the form given by Annex 1, Appendix 2 :

Table 10

Tests	Method reference	" x value "
Density	ISO 2811	x ± 0.05 g/cm^3 (1)
Solids content (% by weight)	ISO 3251	x ± 2.0 %
Ash content (% by weight)	ISO 14680-2 (900 ± 20 °C)	x ± 3.0 %
Pigment (including extender) and binder (% by weight)	ISO 14680-1 ISO 3251	x ± 2.0 %
Infrared spectra of binder	ASTM D 2372 ASTM D 2621	Identical than reference spectra
Pigments contents (% by weight) Aluminium Iron oxide (red oxide)	 ISO 1247 ISO 1248	x ± 1.0 %

Micaceous iron oxide Zinc dust Zinc phosphate	ISO 10601 ISO 3549 ISO 6745	
Characteristic index Epoxy OH Acidic Amine Isocyanate	 ISO 3001 ISO 4629 ISO3682 or ISO 2114 ISO 11908 ISO 11909, ASTM D 2572	 x % x % x % x % x %
Drying time Dry to touch Hard time	EN 29117	 ≤ x h ≤ x h
Flash point	ISO 3679	≥ x °C
Pot life	EN ISO 9514	≥ x h
VOC Anticorrosive paint Topcoat	EN ISO11890-1/-2	 ≤ x g/l ≤ x g/l

NB : For multi component products, tests are done on each component, where applicable.
(1) – For density greater than 2,0 g/ cm^3 the relevant tolerance is ± 0,1 g/cm^3 and lower than 1,0 g/cm^3 relevant tolerance is ± 0,03 g/cm^3
x - Value given by paint manufacturer

CHAPTER 9 - TEST REPORT

The test report shall contain at least the following information:

a) test laboratory (name and address)
b) date of tests
c) description of the protective paint system (see § 6.1)
d) environment where the protective paint system is applicable, and qualification tests carried out
e) description of the preparation and conditioning of the test panels (see § 7.1)
f) assessment of the test panels before ageing
g) assessment of the test panels after ageing for each qualification test
h) any deviation from the test methods specified

ANNEX 1
TECHNICAL DATA SHEET

APPENDIX 1 - PAINT SYSTEM

	Name of paint system : (1)	N° : (2)
	DESCRIPTION (3) : Paint system for the protection of ships exterior topsides	EDITION : (4)
	SURFACE PREPARATION : (6) Steel plating (ISO 8501-3), Cleanliness (ISO 8501-1), Level of pollution [dust, humidity , oil, grease, soluble salts](ISO 8502), Roughness (ISO 8503) Paint must be applied in all cases to clean dry surface, free from contamination within the meaning of the standard ISO 8502	

Paint system		Colour	Number of coats	Dry thickness : per coat (µm)			Weigh of dry film ($g/m^2/c$) ①	Application Density ($g/m^2/c$)	Solid content by volume (%)	Spreading rate (m^2/l)	Provisioning prediction ($l/m^2/c$) ②	Application modes ③ (19)					
Paint reference	Data sheet reference			Nom.	Min	max						B	R	P	T	E	
(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)						

Paint characteristics	Contractual Dry thickness (µm) (20)	Total weigh of dry paint system (g/m^2) (21)	Duration before service life : (22)

Paint Reference	Name of products	Drying time (dry to touch) 20 °C	Overcoating time at 20 °C		Pt life④	minimum application temperature	Flash Point (°C)	Thinner
			Minimum	Maximum				
(7)	(23)	(24)	(25)	(25)	(26)	(27)	(28)	(29)

REMARKS

① - For nominal Thickness, ② - Average loss: ≈ 30 % (indicative value), ③- B : Brush, R: Roller, P: Gun, T: Trual, E: Electrostatic gun, ④ - Using time after mixing

FICHE TECHNIQUE D'APPLICATION DE GAMME

APPENDIX 2 - PAINT FINGERPRINT (constituting paint system)

Date of issue		**Base material**	**Curing agent**
Name of paint			
Name of manufacturer			
Batch number			
Production date			
Main parameters			
	Test method	**Test result**	**Test result**
Binder content (% by mass)	ISO 3251	± 2.0 %	± 2.0 %
Pigment content (% by mass)	ISO 3251 and ISO 14680	± 2.0 %	± 2.0 %
Infrared spectra	ASTM D 2372 and D 2621	Identical to reference spectra	Identical to reference spectra
Non-volatile matter (% by mass)	ISO 3251	± 2.0 %	± 2.0 %
Density	ISO 2811	± 0.05 g/cm^3	± 0.05 g/cm^3
Ash	ISO 14680-2	± 3.0 %	± 3.0 %
Optional parameters			
Pigment content (% by mass) Aluminium Iron oxide Micaceous iron oxide Zinc dust Zinc phosphate	 ISO 1247 ISO 1248 ISO 10601 ISO 3549 ISO 6745	± 1.0 %	± 1.0 %
Content of functional groups Epoxy OH Acidic Amine Isocyanate	 ISO 3001 ISO 4629 ISO 3682 or ISO 2114 ISO 11908 ISO 11909		

The binder properties (infrared spectra and content of functional groups) are determined after separation of the resin from the pigment and solvent. Many other additional tests could be useful in characterizing more precisely the components of paint

APPENDIX 3 - PAINT TECHNICAL DATA SHEET

At least the following information, in addition to the material Safety data sheet, shall be provided with each product submitted to qualification procedure

Date of issue	
Name of the product	
Name of manufacturer	
Generic name for the paint	
Generic name for curing agent	
Generic name for each additional component	
Colour of coating material	
Mixing ratio	
Mixing instructions (including the induction time)	
Shelf life under the recommended storage conditions	
Non-volatile matter by volume of mixed product (ISO 3233)	
Density of mixed product (ISO 2811)	
Pot life	
Flash point of each separate component	
Drying time	
Time to full curing	
Recommended thinner	
Flash point of the recommended thinner	
Maximum quantity of thinner allowed for application	
Surface preparation (ISO 8501-1) and profile (ISO 8503)	
Recommended application mode	
Mini and maxi over-coating time	
Recommended mini and maxi drying time in accordance with environmental temperature	
Solvent for cleaning	
Application conditions (temperature, RH)	
VOC	
Reference to the material safety data sheet	
Theoretical spreading rate	

APPENDIX 4 - MATERIAL SAFETY DATA SHEET

Safety data sheet format is in accordance with the regulation of the nation (16 items in EU regulation) or ISO 11014-1. Manufacturer is responsible for the information on their data sheet. The user of a paint product must verify the validity of the safety data sheet.

APPENDIX 5 - USE REFERENCES

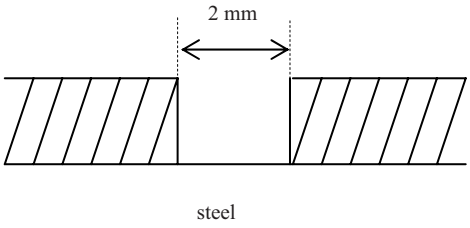
Date of issue	
Name of manufacturer	
Name of paint system	
Description of paint system (name and number of coat, thickness)	
Name of the structure where the paint system is applied	
Date of paint system application	
Environmental conditions of the structure	
Paints and coat thickness on structure	
Locations	
General behaviour of paint system (date)	
Failures (rusting, blistering, cracking, chalking, …..)	
Adhesive properties of paint system on structure	
Others tests or checking done on the structure coated by paint system)	
Works of maintenance (nature, paint quantity, area, date, ..)	

APPENDIX 6 - SYSTEM MODIFICATIONS

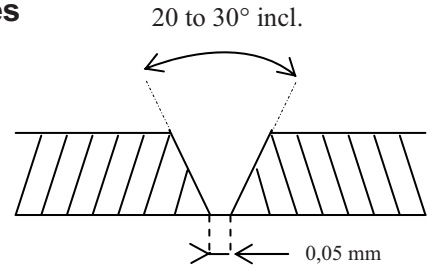
Designation	(1)		Edition (3)
Manufacturer	(2)		
Formula index	(4)	Date of formulation	(5)
New index of formulation	(6)	New Date of formulation	(7)
Nature of the deviation	(8)		
Reasons	(9)		
Analysis of consequences	(10)		
Qualification tests done	(11)		
Use References for the new product	(12)		
Conclusions	(13)		

ANNEX 2 - SPECIFIC TEST METHODS

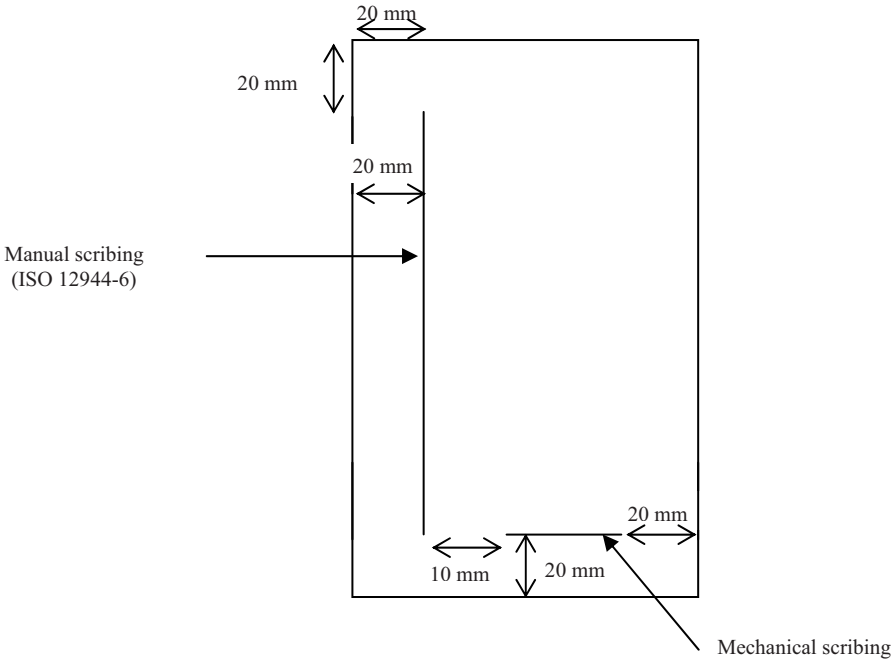
Appendix 1 Scratch-lines



Scribing machine
Figure 1



Manual scribing
(ISO 12944 - annexe A)
Figure 2



Test panel with two scratch-lines -
figure 3

APPENDIX 2 - METHOD OF VALUATION FOR RE-COATABILITY AND MAINTENANCE APTITUDE

1- SCOPE

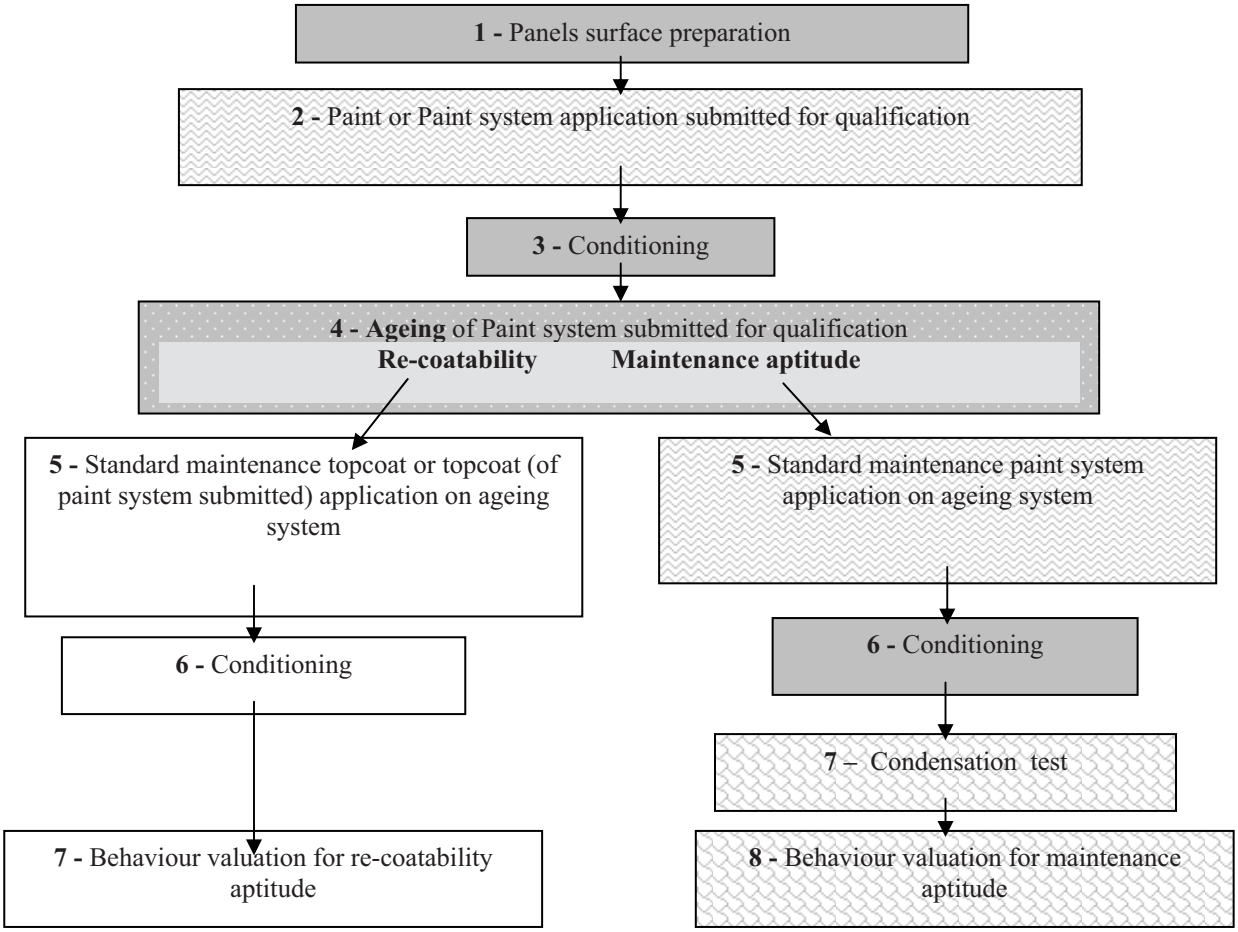
The aim of this method is to describe the different tests to value the re-coatability aptitude for topcoat and the maintenance aptitude of paint system (submitted for qualification process) by re-coating with a standard maintenance paint system.

2 – FIELD OF APPLICATION

This method cover all types of paint systems

3 - TEST PROCEDURE

Flow Diagram of test steps



Operating details of each step are given in the following paragraphs of this method.

3.1 - PANELS AND SURFACE PREPARATION

Theses panels must be steel E 24 quality and sized in accordance with a good realization and a good reproducibility of the tests (e.g. : 250 x 150 x 4 mm)

The surface preparation of panels is in accordance with the technical data sheet of the paint system submitted for qualification. If levels of surface preparation are not specified the following levels are used :

- Visual cleanliness : A Sa 2½ (ISO 8501-1),
- Roughness : MG (ISO 8503),
- Surface pollution (ISO 8502) :
  - Chlorides < 3 µg/cm2,
  - Dust < 2,
  - Oil, grease 0.

3.2 – PAINT APPLICATION

Paint or paint systems, submitted for qualification, are applied in accordance with the technical data sheet requirements of the paint manufacturer. Schemes of application are shown on page 2.7 for re-coatability aptitude and page 2.8 for maintenance aptitude. Nominal dry film thickness (NDFT), and application conditions are those given in the paint manufacturer's data sheet.

3.3 – PANELS CONDITIONING BEFORE AGEING

After paint application or paint system application, panels are conditioned during 21 days under monitored conditions : temperature 23 °C ± 2 °C and relative humidity 50 ± 5 %.

3.4 – PAINT SYSTEM AGEING

Panels coated with a paint system submitted for the qualification process are aged by natural and / or artificial exposure to obtain an "old paint system".

After ageing period panels are cleaned with distilled water, dried and conditioned for 48 hours under the following conditions: temperature 23 °C ± 2°C and relative humidity 50 ± 5 %.

3.4.1 – Ageing for re-coatability aptitude

Panels coated with a paint system submitted for the qualification process are aged by artificial curing for 1 month under the following conditions: temperature 50 °C ± 2 °C and relative humidity 50 ± 5 %.

3.4.2 – Ageing for maintenance aptitude : 2 options

NATURAL AGEING :

Panels coated with a paint system submitted for the qualification process are aged for 1 year in a C 5M marine environment

ARTIFICIAL CURING :

Panels coated with a paint system submitted for the qualification process are cured for 1 month (50 °C, 50 % RH)

3.5 – MAINTENANCE TOPCOAT OR MAINTENANCE PAINT SYSTEM APPLICATION

On aged primer, and aged paint system panels, the maintenance paint system is applied in accordance with the manufacturer's technical data sheet. The standard topcoat or standard maintenance paint system is described by each nation.

At this step, all problems during application and drying are noted (softening, lifting, raising, peeling, swelling, discolouring, bleeding…).

3.6 – PANEL CONDITIONING BEFORE TEST

After application of topcoat or paint system on aged primer or aged paint system, panels are conditioned for 21 days under following conditions: temperature 23 °C ± 2 °C and relative humidity 50 ± 5 %.

3.7 – CONDENSATION TEST FOR VALUATION TO MAINTENANCE APTITUDE

The test used for valuation to maintenance aptitude is ISO 6270 – Water condensation (240h)

3.8 – BEHAVIOUR VALUATION AND ACCEPTANCE CRITERIA

3.8.1 – Visual examination

Failures observed by visual examination are noted during and after tests, in accordance with ISO 4628.

3.8.2 – Pull off test (EN ISO 24624)

Pull off test is carried out on 3 areas of panels and compared to reference panel.

3.8.3 – Cross cut test (EN ISO 2409)

Cross cut test is carried out on one area of panel in accordance with ISO 2409 and thickness of paint system

3.8.4 – Acceptance criteria

ACCEPTANCE CRITERIA		
	RE-COATABILITY APTITUDE	**MAINTENANCE APTITUDE**
Visual examination (1)	No failure Blistering, bleeding, blushing, peeling, or other defects	No failure Blistering, bleeding, blushing, peeling, or other defects

Pull Off Test	No adhesive failure between old system and new coat ➢ > 3 Mpa ➢ > 0,7 reference value	No adhesive failure between old system and new coat ➢ > 3 Mpa ➢ > 0,7 reference value
Cross Cut Test	≤ 1 (between old system and new coat)	≤ 1 (between old system and new coat)

(1) – During and after application, drying, conditioning phases

4 – TEST REPORT

Test report includes reference to this AP and the following indications:

- Identification of paint products and paint systems
- Substrate characteristics
- Conditions of application, drying, de conditioning
- Coats and paint system Thickness and measurement method
- Test conditions and all differences with this document
- Type and reference apparatus
- Results in accordance with the different standards
- Operating details not written in this document.

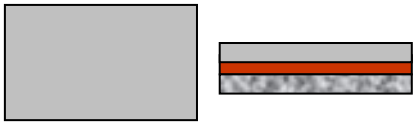
A – Test procedure for re-coatability aptitude

1 - Surface preparation (§ 3.1)

2 - Application of paint system submitted to qualification (§ 3.2)

Primer

Topcoat



3 - Conditioning (§ 3.3)

21 days, 23°C, RH 50 %

4 - Ageing (§ 3.4.1)
Artificial curing 1 month, 50°C, 50 % RH

1 month, 50°C, RH 50 %

5 – Application of maintenance paint (§ 3.5)

Same topcoat

Standard topcoat

(See paragraph 3 of the general document)

6 - Conditioning (§ 3.6)

21 days, 23 °C, RH 50 %

7 – Behaviour valuation (§ 3.8)

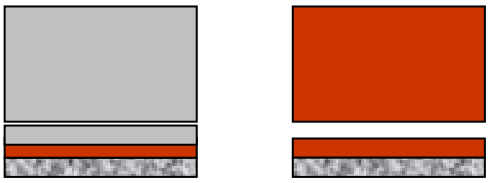
Note failures occurred during phase application or drying.
Pull off test is made on panels obtained at the end of step 3 (as reference) and at the end of step 6 for same topcoat and standard topcoat

B – TEST PROCEDURE FOR MAINTENANCE APTITUDE

1 - Surface preparation (§ 3.1)

2 - Application of paint system submitted to qualification (§ 3.2)

Primer
Topcoat



3 - Conditioning (§ 3.3)

21 days , 23°C, RH 50 %

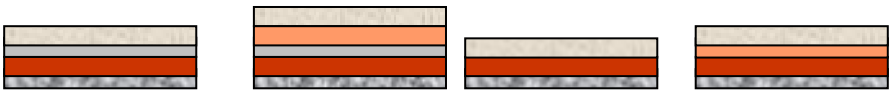
4 – Ageing (§ 3.4.2)
Natural ageing: 1 year in C5M marine environment
Artificial curing: 1 month 50°C , 50% RH

N.A. : 1 Year
A.A. : 1 month

5 – Application of Maintenance standard paint system (§ 3.5)

Primer
Topcoat

(See appendix 3
of the general document)



6 – Conditioning (§ 3.6)

21 days, 23°C, RH 50 %

7 – Condensation test (§ 3.7)

240 h ISO 6270

8 – Behaviour valuation (§ 3.8)

Note failures occurred during phase application or drying.
No rusting, blistering, cracking,or other defects after cycle test (step 7)
Pull off test is made on panels obtained at the end of
step 3 (as reference) and at the end of step 7

APPENDIX 3 - APPLICABILITY TEST

Each coat of the paint system submitted for qualification shall be applied by brush, roller, or spray, without runs and sags to vertical and smooth sheet metal with minimum area of 1 m², with a mean dry thickness of at least 1,5 time the specified NDFT (nominal dry film thickness) ; test temperature is 20°C. Paints are applied in accordance with technical data sheet conditions of paint manufacturer.

APPENDIX 4 - Storage stability

Paints shall not exhibit on delivery or during shelf life: hard settling, skinning, phase separation, corrosion of container, persistent foam after mix or other properties indicating unfitness for use.

- [This is evaluated by the accelerated storage stability method :
  A previously unopened original container of paint, after exposure to a temperature of 60°C for 30 days) shall readily mix with a mechanical mixer within 5 minutes to a smooth uniform condition.
  Paint shall be free of grit, seed, tough or gummy sediment, skin, hard pigment settling and persistent foam.

Paint aged by this method shall not vary from the required applicability characteristics (application condition, NDFT, drying time, colour, gloss…)

ANNEX 3 - NATURAL SITES OF EXPOSURE

Table 1 – Colour and gloss stability

Nation	Location of the exposure site (colour stability)	Exposure Duration	Contact (Organization, address, phone e-mail)
USA	NRL Key-West	12 months	Naval Research Laboratory, 4555 Overlook Ave S.W. Washington DC 20375
CAN	Victoria BC	12 months	1-250-363-2849
ITA	La Spezia – Mar Ligure	12 months	MARIPERMAN I.C.A. Viale S. Bartolomeo 19100 LA SPEZIA + 39.0187.787203
SWE	Bohus-Malmön (west coast)	12 months for alkyde 24 months for urethane	FMW : KESkyddS, Bane'rg.62, 115 88 Stockholm Sweden + 46 8 7826156,
FRA	Florida	12 months	Sub Tropical Testing Service Fax 00.1.305.233.53.42
DEU	Bavarian Alps, Reiteralpe, 1640 m above sea level	12 months	Wehrtechnische Dienststelle für Sprengmittel und Sondertechnik, Oberjettenberg, D-83458 Schneizlreuth, c/o tel. 0049/8651/79/1220, fax 0049/8651/1600

Table 2 - Natural site for ageing

Nation	**Location of the site (Natural ageing in C5-M corrosivity of environment class ISO 9223 and ISO 12944-2)**	**Exposure Duration**	**contact (Organization, address, phone e-mail)**
USA	NASA Kennedy Space Center	2 years	Naval Research Laboratory, 4555 Overlook Ave S.W. Washington DC 20375.
CAN	Victoria BC	2 years	1-250-363-2849
SWE	Bohus-Malmön (west coast)	1 year for alkyd 5 years for urethane	FMW : KESkydd, Bane'rg.62, 115 88 Stockholm Sweden + 46 8 7826156,
FRA	Pippady - Toulon	2 years (min)	ISITV – La Valette 83 phone 33.1.94.14.25.68
FRA	Brest	2 years (min)	Institut de la Corrosion Technopôle de Brest Iroise 220, rue Pierre Rivoalon 29200 Brest (France) T: +33. 2. 98 .05. 15. 52 F: +33 .2 .98. 05 .08 .94
DEU	Wilhelmshaven, north sea, sea dike area	2 years	Wehrwissenschaftliches Institut für Werk-, Explosiv- und Betriebsstoffe, Marinearsenal Wilhelmshaven, D-26379 Wilhelshaven, c/o tel. 0049/4421/49/3450, fax…/3456 or tel. 0049/8122/9590-3620, fax…/3602