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## 1 OBJECTIVE

- 1.1 This specification establishes the minimum requirements to pre-qualify paint systems.
- 1.2 **VENDOR** shall prepare a complete and detailed Painting System Specification. The Painting Procedure shall include details of equipment, materials, surface preparation, painting scheme, application process, application control, repairs and testing.

## 2 STANDARDS

The following codes and standards include provisions that, through reference in this text, constitute provisions of this specification. The latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used, provided it can be shown that they meet or exceed the requirements of the standards referenced below.

- ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus
- ASTM D1141 Standard Practice for the Preparation of Substitute Ocean Water.
- ASTM D1308 Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes
- ASTM D2485- Standard Test Methods for Evaluating Coatings for High Temperature Service;
- ASTM D2247 Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
- ASTM D 2794 Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
- ASTM D4060 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
- ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
- ASTM D523 Standard Test Method for Specular Gloss
- ASTM D610 Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
- ASTM D870 Standard Practice for Testing Water Resistance of Coatings Using Water Immersion
- ASTM G 8 Standard Test Methods for Cathodic Disbonding of Pipeline Coatings
- ASTM G154 Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
- ISO 2812-1- Paints and Varnishes - Determination of Resistance to Liquids - Part 1: Immersion in Liquids other Than Water
- ISO 2812-2 - Paint and Varnishes - Determination of resistance to liquids – Part 2: Water immersion method.
- ISO 12944-2 - Paints and Varnishes - Part 2 :Corrosion protection of steel structures by protective paint systems.

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- ISO 12944-9 Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures
- ISO 15711 - Determination of resistance to cathodic disbonding of coatings exposed to sea water.
- ISO 17025 - General requirements for the competence of testing and calibration laboratories.
- ISO 12944-9 - Paints and varnishes -- Corrosion protection of steel structures by protective paint systems -- Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures
- NACE TM 0104 - Offshore Platform Ballast Water Tank Coating System Evaluation.
- NACE TM 0404 - Offshore Platform Atmospheric and Splash Zone New Construction Coating System Evaluation.
- NORSOK M-501 – Surface preparation and protective coating
- RESOLUTION MSC.215(82) Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in All Types Of Ships and Double-Side Skin Spaces of Bulk Carriers

### 3 CLASSIFICATION OF ENVIRONMENTS

3.1 For offshore units the environment classification is according to ISO 12944 - Part 2.

3.2 Three regions are considered in offshore units:

- a) Atmospheric zone: For offshore units, it means those structures situated above the water line;
- b) Splash zone: For offshore units, it means the structures that are alternately above and below the water line. For fixed offshore units this means the region alternatively wet and dry due to tide and waves. For mobile offshore units this means the boot top region;
- c) Immersed zone: For offshore units, this means the regions that are underwater and not subjected to wet and dry alternation.

### 4 DEFINITIONS

“PAINT SYSTEM” is the total sum of the coats of metallic materials and/or paints or related products that are to be applied or which have been applied to a substrate to provide corrosion protection.


“VENDOR” is the party that performs paint removal, surface preparation and coatings application on offshore structures, equipment, components and instruments, and to whom the coating project has been contracted.

“PAINT MANUFACTURER” is the party producing and supplying the coating materials, and providing an advisory role in all processes associated with the coating project.

“NACE” - The National Association of Corrosion Engineers.

“ABRACO” - The Brazilian Association of Corrosion.

“FROSIO” - The Norwegian Professional Council for Education and Certification of Inspectors for Surface Treatment.

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## 5 GENERAL CONDITIONS

- 5.1 The Painting System Specification, including quality control plan, shall be submitted by PETROBRAS for previous approval. This procedure shall be based in recognized international standards and contain as a minimum the requirements stated in NORSOK M-501.
- 5.2 The minimum performance requirements shall be in accordance with chapter 6 for each specific application.
- 5.3 The qualification procedures for coatings are based on:
- The environmental classification;
  - Equipment function (tank, vessel, pump, and others).
  - Substrate temperature.
- 5.4 Additional requirements for qualification of paint systems may be presented at the equipment/ package technical specification.
- 5.5 VENDOR shall provide at the procedure information about the painting system regarding:
- Material Safety Data Sheet;
  - Information data required by item 6.4 of ISO 12944-9 Paints and varnishes - Performance requirements for protective paint systems for offshore and related structures;
  - Qualification tests reports.
- 5.6 The Quality Control Plan shall be issued for PETROBRAS approval and contain at least:
- List of applied codes, standards, technical specifications and procedures in item (b);
  - "Painting Inspection and Quality Standard" detailing all activities and acceptance criteria for painting;
  - Periodic reports about Coat inspection (only for package units);
  - The organization chart of Manufacturer of equipment' quality control team, clearly defining the responsibilities and authorities.
- 5.7 The painting procedure shall be executed and approved by a painting inspector qualified, at least, by NACE International Coating Inspector Training and Certificate Program, level 3 or equivalent qualification by ABRACO or by FROSIO.
- 5.8 Each coating material forming a paint system must be produced by the same PAINT MANUFACTURER.
- 5.8.1 In case the paint system is applied on a shop-primer or any other existing coating system of a different PAINT MANUFACTURER, the PAINT MANUFACTURER of the paint system shall confirm its compatibility and its durability.
- 5.9 The paint systems shall be pre-qualified in accordance with established performance criteria by test laboratories certified in accordance with ISO/IEC 17025. Laboratories shall be accredited under the IAF or INMETRO.

5.10 The test reports shall show at minimum:

- a) Identification of the entity responsible for conducting tests;
- b) Responsible for conducting the tests;
- c) Paint system information regarding surface preparation, application and cure according ISO 12944;
- d) Test results after testing for the selected paint systems according to TABLES 2 and 3;
- e) Conclusion;
- f) Standards used during tests.

## 6 PAINT SYSTEM PRE-QUALIFICATION

### 6.1 REQUIREMENTS FOR QUALIFICATION OF HIGH PERFORMANCE COATINGS

6.1.1 The coating system shall meet the requirements of ISO 12944-9 for conditions CX and Im4 and meet the additional tests described in TABLE 1.

6.1.2 This coating system is applicable to carbon steel with maximum operating temperature < 120 °C. Examples are: structural steel, exteriors of equipment, vessels, piping and valves (not insulated).

6.1.3 If this coating system is subjected to UV, an additional coat is required. The additional coat shall meet the test requirements described in TABLE 3.

6.1.4. This coating system may be applied in other substrates provided there is a previous PETROBRAS approval.

TABLE 1 - HIGH PERFORMANCE COATINGS - DRY FILM CHARACTERISTICS

Tests	Requirements		Standards to be used
	Min.	Max.	
Abrasion Resistance, mg/1,000 cycles	-	70,0	ASTM D4060 (See Note 1)
Edge retention	50%		NACE TM 0404
Flexibility	1,5%		NACE TM 0404
Impact Resistance, J	1,5	-	ASTM D2794
Adhesion (Pull-Off Test), MPa	15	-	ASTM D4541 (See Note 2)
Adhesion (Pull-Off Test) after the tests of ISO 12944-9, MPa	8	-	ASTM D4541 (See Note 2)

NOTE 1 The abrasion resistance test shall be carried out using a CS-17 abrasive wheel with a load of 1 kg.

NOTE 2 The pull-off test shall be performed in accordance with ASTM D4541 or ISO 4624 using Pneumatic Equipment Type IV (Test Method D) or Automatic Hydraulic Equipment Type V (Test Method E). Values and types of acceptable failures in the pull-off test:

- a)  $15.0 < \text{Failures } -/Y, Y \text{ or } Y/Z < 18.0 \text{ MPa}$ ;
- b)  $> 18 \text{ MPa}$  - for any type of failure.

NOTE 3 When not specified in the referenced test standard, specimens shall be made of AISI-1020 carbon steel plate in dimensions of 150 mm x 100 mm x 4 mm. The surface preparation shall be done by abrasive blasting, according to grade Sa 2 ½ of ISO 8501-1 (very thorough blast cleaning). The roughness profile shall be 50 µm to 70 µm, of the angular type.

TABLE 2 – REQUIREMENTS OF TESTS PER ENVIRONMENT.

Tests	CX	Im4	
	Atmospheric	Splash zone	Submersed
Edge retention	X	X	X
Abrasion Resistance, mg/1,000 cycles	X <sup>1</sup>		
Adhesion	X	X	X
Flexibility	X	X	X
Impact Resistance	X	X	

Note: (1) Deck Area, escape route area of offloading Helideck; RISER I - Inner tube painting. Inner painting of Caissons

TABLE 3 - POLYURETHANE, POLYSILOXANE OR FLUOROPOLYMER FINISH PAINT DRY FILM CHARACTERISTICS

Tests	Dry film thickness (µm)	Requirements (Min.)	Standards to be used
Adhesion (Pull-Off Test) (MPa) (See Note 1)	60 to 70	10	ASTM <a href="#">D4541</a>
Gloss at 60°	120 to 140	85	ASTM <a href="#">D523</a>
UV-A Radiation and Condensation of Humidity Resistance, h	120 to 140	960	ASTM <a href="#">G154</a> (See Note 2)

NOTE 1 The pull-off test shall be performed in accordance with ASTM [D4541](#) or ISO [4624](#) using Pneumatic Equipment Type IV (Test Method D) or Automatic Hydraulic Equipment Type V (Test Method E). The types of acceptable failures in the pull-off test are:  
 a) ≤ 18 MPa - without failure A/B;  
 b) Failures -/Y, Y or Y/Z > 12 MPa;  
 c) > 12 MPa - for any type of failure, except A/B.

NOTE 2 In this test, the cycle to be used is 8 h under UV-A radiation and 4 h under moisture condensation. After exposure time, the film shall not exhibit chalking. The gloss reduction shall not exceed 10% of the initial value.

NOTE 3 When not specified in the referenced test standard, specimens shall be made of AISI-1020 carbon steel plate in dimensions of 150 mm x 100 mm x 4 mm. The surface preparation shall be done by abrasive blasting, according to grade Sa 2½ of ISO [8501-1](#) (very thorough blast cleaning). The roughness profile shall be 50 µm to 70 µm, of the angular type.

## 6.2 CORROSION UNDER INSULATION (CUI) COATINGS

6.2.1 The paint shall meet the test requirements described in TABLE 4.

6.2.2 This coating system shall be used for carbon steel and stainless steel surfaces exposed to operating temperature > 200 °C. Carbon steel and stainless steel objects: All insulated surfaces of tanks, vessels, piping.

**TABLE 4 - CUI COATINGS - DRY FILM CHARACTERISTICS**

Properties/Tests	Dry film thickness (Min.) (µm)	Requirements	Standards to be used
Application on Hot Surfaces (°C)	300 (2 x 150)	150°C (min.)	
Salt Spray Resistance (2,000 h) Specimens cured for 3 days @ 25°C.	300 (2 x 150)	Corrosion from the incision = 2.0 mm (max.) Degree of rusting = 10/9 No blistering, cracking or peeling.	ASTM B117 ASTM D610 (See Note 1)
Salt Spray Resistance (2,000 h) Specimens exposed @ 205°C for 96 h before testing	300 (2 x 150)	Corrosion from the incision = 2.0 mm (max.) Degree of rusting = 10/9 No blistering, cracking or peeling.	ASTM B117 ASTM D610 (See Note 1)
Cycle of Corrosion Under Insulation (16 cycles) 5 days alternating 8 hours of immersion in distilled water @ 95°C and 16 hours @ 205°C, followed by 2 days @ 205°C	300 (2 x 150)	No blistering, cracking or peeling.	
Cyclic Heating 205°C - 8 h 260°C - 16 h 315°C - 8 h 370°C - 16 h 425°C - 8 h 24 hours exposure to salt spray (ASTM B117)	300 (2 x 150)	No corrosive attack, blistering, cracking or peeling.	ASTM D2485 (See Note 2)
Adhesion (Pull-Off Test) (MPa) (See Note 3)	300	2 MPa	ASTM D4541


NOTE 1 For salt spray resistance tests, on the specimens coated with the test product, the incision shall be vertical and parallel to its largest dimension.

NOTE 2 In the Cyclic Heating test, the specimens shall be inspected visually after each temperature level for evaluation of any evidence of failure. For this evaluation, the test samples shall be removed from the furnace/muffle and immediately cooled in cold water at 10.0±2.0°C. After the last temperature level, the specimens shall be exposed in a salt spray chamber (ASTM B117) for 24 hours, after which they are inspected again for final evaluation.

NOTE 3 The pull-off test shall be performed in accordance with ASTM D4541 or ISO 4624 using Pneumatic Equipment Type IV (Test Method D) or Automatic Hydraulic Equipment Type V (Test Method E). The types of acceptable failures are:

- a) ≤ 10 MPa - without failure A/B;
- b) Failures -Y, Y or Y/Z > 10 MPa;
- c) > 12 MPa - for any type of failure.

NOTE 4 When not specified in the referenced test standard, specimens shall be made of AISI-1020 carbon steel plate in dimensions of 150 mm x 100 mm x 4 mm. The surface preparation shall be done by abrasive blasting, according to grade Sa 2 ½ of ISO 8501-1 (very thorough blast cleaning). The roughness profile shall be 50 µm to 70 µm, of the angular type.

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### 6.3 REQUIREMENTS FOR QUALIFICATION OF COATINGS FOR SURFACES PRESENTING PERMANENT CONDENSATION

6.3.1 The paint shall meet the test requirements described in TABLE 5.

6.3.2 Preparation of specimens

6.3.2.1 The specimens shall be made of AISI-1020 carbon steel plate in dimensions of 150 mm x 100 mm x 4 mm. The surface preparation shall be done by abrasive blasting, according to grade Sa 2 ½ of ISO 8501-1 (very thorough blast cleaning). The roughness profile shall be 50 µm to 70 µm, of the angular type.

6.3.2.2 The application of the coating shall be done in the laboratory at 25±2°C and relative humidity of 70±10%. It shall be ensured that during application and full curing of the coating (14 days), the specimens are kept at 10±3°C, with permanent condensation of the surface. This condition may be achieved by laying them on a coil within which refrigerated liquid is circulated.

TABLE 5 - COATINGS FOR SURFACES PRESENTING PERMANENT CONDENSATION - DRY FILM CHARACTERISTICS

Tests	Dry film thickness (µm)	Requirements		Standards to be used
		Min.	Max.	
Cyclic Corrosion Test	300	-	-	ISO 12944-9 (Notes 1 and 2)
Cathodic Disbonding (30 days), mm	300	-	10	ASTM G8
Initial Adhesion (Pull-Off Test), MPa (See Note 3)	300	12	-	ABNT NBR 15877 or ASTM D4541 (Notes 1 and 2)
Distilled Water Immersion Resistance @ 40°C, h	300	2,000	-	ISO 2812-1
Substitute Ocean Water Immersion Resistance @ 40°C, h	300	2,000	-	ASTM D1141
NOTE 1 The adhesion test according to ASTM D4541 shall be performed using Pneumatic Equipment Type IV (Test Method D) or Automatic Hydraulic Equipment Type V (Test Method E). NOTE 2 The adhesion test according to ABNT NBR 15877 shall be performed using Pneumatic Equipment (Figure A.2 of ABNT NBR 15877) or Automatic Hydraulic Equipment (Figure A.3 of ABNT NBR 15877). NOTE 3 Type A/B failures are only accepted with Pull-off values above 15 MPa. Failures of the -/Y, Y or Y/Z types are acceptable for values between 10.0 MPa and 15.0 MPa. The final adhesion after the tests shall be measured according to the above standard and exhibit a result of 7.0 MPa or greater, regardless of the type of failure.				

### 6.4 REQUIREMENTS FOR QUALIFICATION OF COATINGS FOR BALLAST AND POTABLE TANKS

6.4.1 For ballast tanks, test requirements are given in TABLE 6.



TABLE 6 -BALLAST TANK TEST PROTOCOL

Test	Standard	Acceptance criteria
Cathodic disbonding (ISO 15711)	ISO 12944-9	According to ISO 12944-9 for Im4 environment
Sea water immersion (ISO 2812)	ISO 12944-9	According to ISO 12944-9 for Im4 environment (note 1)
Edge retention	NACE 0104	A minimum of 50% edge retention for the entire coating system in any specimen.
Hot/wet cycling test	NACE 0104	< 3.5mm No pinholes or blistering
Flexibility	NACE 0404	≥ 1.5 %
Test on simulated ballast tank conditions	IMO RESOLUTION MSC.215(82) <small>(note 2)</small>	According to Appendix 1 of IMO RESOLUTION MSC.215(82)
Condensation chamber test	IMO RESOLUTION MSC.215(82) <small>(note 2)</small>	According to Appendix 2 of IMO RESOLUTION MSC.215(82)
Note (1): The test panel shall have only the 2.0 mm scribe line. The test plate dimensions may be reduced to 75mm x 150 mm x 5 mm.		
Note (2): Only when required by the Classification Societies.		

6.4.2 For Potable Water Tanks the paint system, besides those requirements, it shall be certified according to NSF 61: Drinking water system components - Health effects.

## 6.5 REQUIREMENTS FOR QUALIFICATION OF ELETROSTATIC COATING

6.5.1 The electrostatic coatings are acceptable for electric equipment and instruments. There are a coating for equipment located in controlled rooms and other for outdoors.

### 6.5.2 Type I Coating (Controlled environmental rooms)

6.5.2.1 Apply one primer coat of epoxy powder paint by electrostatic process with minimum thickness of 90 µm. As a finishing paint, apply one coat of polyester paint, using electrostatic process, with minimum thickness of 80 µm.

### 6.5.3 Type II Coating (Outdoor)

6.5.4 Apply one primer coat of epoxy powder paint pigmented with metallic zinc, by means of process electrostatic, with a minimum thickness of 90 µm. As a finishing paint, apply 01 (one) coat of polyester paint, by electrostatic process, with minimum thickness of 80 µm.

6.5.5 The coatings shall meet the requirements of ISO 12944-9 and the additional tests described in TABLE 7.


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TABLE 7 - ELETROSTATIC COATING - DRY FILM CHARACTERISTICS

Tests	Minimum Requirements		Standards to be used
	Type I (130 µm)	Type II (125 µm)	
Cyclic Corrosion	10	25	ISO 12944-9
Resistance to sea water (3,5% NaCl) @40°C h	500	2000	ASTM D 1308
Resistance to distilled water @ 40 °C, h	2000	2000	ASTM D 870
Resistance to 100 % relative humidity, h	1000	1500	ASTM D 2247
Resistance to SO <sub>2</sub> (2L), rounds	10	10	ABNT NBR 8096
Resistance to NaOH 10%, h	500	720	ASTM D 1308
Resistance to H <sub>2</sub> SO <sub>4</sub> 10%, h	500	720	ASTM D 1308
Resistance to MEC, seconds	30	30	
Adhesion (Pull-Off Test), MPa	12	12	ASTM D4541 (See Note 1)
UV-A Radiation and Condensation of Humidity Resistance, h	960	960	ASTM G 154 (See Note 2)

NOTE 1 The pull-off test shall be performed in accordance with ASTM D4541 or ISO 4624 using Pneumatic Equipment Type IV (Test Method D) or Automatic Hydraulic Equipment Type V (Test Method E)

NOTE 2 In this test, the cycle to be used is 8 h under UV-A radiation and 4 h under moisture condensation. After exposure time, the film shall not exhibit chalking. The gloss reduction shall not exceed 10% of the initial value.

6.5.6 Surface preparation shall be done by means of a chemical process of phosphatization using phosphate (zinc or tricationic, as applicable), with mass between 2.0g/m<sup>2</sup> and 4.0g/m<sup>2</sup>.

6.5.7 The responsible for surface preparation shall perform all sequential steps pertinent to a phosphating process as recommended by the manufacturer for pretreatment. The sequential steps are degreasing, washing, pickling, washing, refinement, washing, passivation, washing with deionized water and drying.

6.5.8 Alternatively, conversion process with nanoceramic coatings may be performed at aluminum and stainless steel substrates.