

ANNEX 2

**RESOLUTION MSC.288(87)
(adopted on 14 May 2010)**

**PERFORMANCE STANDARD FOR PROTECTIVE COATINGS
FOR CARGO OIL TANKS OF CRUDE OIL TANKERS**

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING regulation II-1/3-11 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended (hereinafter referred to as "the Convention") adopted by resolution MSC.291(87), concerning protective coatings for cargo oil tanks of crude oil tankers,

NOTING ALSO that the aforementioned regulation II-1/3-11 provides that the protective coatings referred to therein shall comply with the requirements of the Performance standard for protective coatings for cargo oil tanks of crude oil tankers (hereinafter referred to as "the Performance standard for protective coatings"),

RECOGNIZING that the Performance standard for protective coatings referred to above is not intended to inhibit the development of new or novel technologies which provide for alternative systems,

HAVING CONSIDERED, at its eighty-seventh session, the text of the proposed Performance standard for protective coatings,

1. ADOPTS the Performance standard for protective coatings for cargo oil tanks of crude oil tankers, the text of which is set out in the Annex to the present resolution;
2. INVITES Contracting Governments to the Convention to note that the Performance standard for protective coatings will take effect on 1 January 2012 upon entry into force of SOLAS regulation II-1/3-11;
3. NOTES that, under the provisions of SOLAS regulation II-1/3-11.3.1, amendments to the Performance standard for protective coatings shall be adopted, brought into force and take effect in accordance with the provisions of article VIII of that Convention concerning the amendment procedure applicable to the Annex to the Convention other than chapter I;
4. REQUESTS the Secretary-General to transmit certified copies of this resolution and the text of the Performance standard for protective coatings contained in the Annex to all Contracting Governments to the Convention;
5. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and the Annex to all Members of the Organization which are not Contracting Governments to the Convention;

6. INVITES Governments to encourage the development of novel technologies aimed at providing for alternative systems and to keep the Organization advised of any positive results;

7. RESOLVES to keep the Performance standard for protective coatings under review and amend them as necessary, in light of experience gained in its application.

ANNEX

PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR CARGO OIL TANKS OF CRUDE OIL TANKERS

1 PURPOSE

This Standard provides technical requirements for the minimum standard for protective coatings to be applied in cargo oil tanks during the construction of new crude oil tankers.

2 DEFINITIONS

For the purpose of this Standard, the following definitions apply:

- 2.1 *Crude oil tanker* is as defined in Annex I of MARPOL 73/78.
- 2.2 *Dew point* is the temperature at which air is saturated with moisture.
- 2.3 *DFT* is dry film thickness.
- 2.4 *Dust* is loose particulate matter present on a surface prepared for painting, arising from blast-cleaning or other surface preparation processes, or resulting from the action of the environment.
- 2.5 *Edge grinding* is the treatment of the edge before secondary surface preparation.
- 2.6 "*GOOD*" *condition* is the condition with minor spot rusting as defined in resolution A.744(18) for assessing the ballast tank coatings for tankers.
- 2.7 *Hard coating* is a coating that chemically converts during its curing process or a non-convertible air drying coating which may be used for maintenance purposes. This can be either inorganic or organic.
- 2.8 *NDFT* is the nominal dry film thickness. 90/10 practice means that 90% of all thickness measurements shall be greater than or equal to NDFT and none of the remaining 10% measurements shall be below 0.9 x NDFT.
- 2.9 *Primer coat* is the first coat of the coating system applied in the shipyard after shop primer application.
- 2.10 *Shop primer* is the prefabrication primer coating applied to steel plates, often in automatic plants (and before the first coat of a coating system).
- 2.11 *Stripe coating* is painting of edges, welds, hard to reach areas, etc., to ensure good paint adhesion and proper paint thickness in critical areas.
- 2.12 *Target useful life* is the target value, in years, of the durability for which the coating system is designed.
- 2.13 *Technical Data Sheet* is the paint manufacturer's Product Data Sheet which contains detailed technical instruction and information relevant to the coating and its application.

3 GENERAL PRINCIPLES

3.1 The ability of the coating system to reach its target useful life depends on the type of coating system, steel preparation, operating environment, application and coating inspection and maintenance. All these aspects contribute to the good performance of the coating system.

3.2 Inspection of surface preparation and coating processes shall be agreed upon between the shipowner, the shipyard and the coating manufacturer and presented to the Administration for review. Clear evidence of these inspections shall be reported and included in the Coating Technical File (CTF) (see subsection 3.4).

3.3 When considering the Standard provided in section 4, the following is to be taken into account:

- .1 it is essential that specifications, procedures and the various different steps in the coating application process (including, but not limited to, surface preparation) are strictly applied by the shipbuilder in order to prevent premature decay and/or deterioration of the coating system;
- .2 the coating performance can be improved by adopting measures at the ship design stage such as reducing scallops, using rolled profiles, avoiding complex geometric configurations and ensuring that the structural configuration permits easy access for tools and to facilitate cleaning, drainage and drying of the space to be coated; and
- .3 the coating performance standard provided in this document is based on experience from manufacturers, shipyards and ship operators; it is not intended to exclude suitable alternative coating systems, providing a performance at least equivalent to that specified in this Standard is demonstrated. Acceptance criteria for alternative systems are provided in section 8.

3.4 Coating Technical File (CTF)

3.4.1 Specification of the cargo oil tank coating system applied, record of the shipyard's and shipowner's coating work, detailed criteria for coating selection, job specifications, inspection, maintenance and repair shall be included in the Coating Technical File required by resolution MSC.215(82).

3.4.2 *New construction stage*

The Coating Technical File shall contain at least the following items relating to this Standard and shall be delivered by the shipyard at new ship construction stage:

- .1 copy of Statement of Compliance or Type Approval Certificate;
- .2 copy of Technical Data Sheet, including:
 - .2.1 product name and identification mark and/or number;
 - .2.2 materials, components and composition of the coating system, colours;

- .2.3 minimum and maximum dry film thickness;
- .2.4 application methods, tools and/or machines;
- .2.5 condition of surface to be coated (de-rusting grade, cleanness, profile, etc.); and
- .2.6 environmental limitations (temperature and humidity);
- .3 shipyard work records of coating application, including:
 - .3.1 applied actual areas (in square metres) of coating in each cargo oil tank;
 - .3.2 applied coating system;
 - .3.3 time of coating, thickness, number of layers, etc.;
 - .3.4 ambient conditions during coating; and
 - .3.5 details of surface preparation;
- .4 procedures for inspection and repair of coating system during ship construction;
- .5 coating log issued by the coating inspector – stating that the coating was applied in accordance with the specifications to the satisfaction of the coating supplier representative and specifying deviations from the specifications (see annex 2);
- .6 shipyard's verified inspection report, including:
 - .6.1 completion date of inspection;
 - .6.2 result of inspection;
 - .6.3 remarks (if given); and
 - .6.4 inspector signature; and
- .7 procedures for in-service maintenance and repair of coating systems.*

3.4.3 ***In-service maintenance and repair***

In-service maintenance and repair activities shall be recorded in the Coating Technical File in accordance with the relevant section of the Guidelines for coating maintenance and repair.

3.4.4 The Coating Technical File shall be kept on board and maintained throughout the life of the ship.

* Guidelines to be developed by the Organization.

3.5 Health and safety

The shipyard is responsible for implementation of national regulations to ensure the health and safety of individuals and to minimize the risk of fire and explosion.

4 COATING STANDARD

4.1 Performance standard

This Standard is based on specifications and requirements to provide a target useful coating life of 15 years, which is considered to be the time period, from initial application, over which the coating system is intended to remain in "GOOD" condition. The actual useful life will vary, depending on numerous variables including actual conditions encountered in service.

4.2 Standard application

Protective coatings for cargo oil tanks applied during the construction of new crude oil tankers shall at least comply with the requirements in this Standard.

4.3 Coating system

An epoxy-based system meeting test and physical properties (table 1.1.3) shall be documented, and a Type Approval Certificate or Statement of Compliance shall be provided.

4.4 Area of application

The following areas are the minimum areas that shall be protected according to this Standard:

- .1 Deckhead with complete internal structure, including brackets connecting to longitudinal and transverse bulkheads. In tanks with ring frame girder construction the underdeck transverse framing to be coated down to level of the first tripping bracket below the upper faceplate.
- .2 Longitudinal and transverse bulkheads to be coated to the uppermost means of access level. The uppermost means of access and its supporting brackets to be fully coated.
- .3 On cargo tank bulkheads without an uppermost means of access the coating to extend to 10% of the tanks height at centreline but need not extend more than 3 m down from the deck.
- .4 Flat inner bottom and all structure to height of 0.3 m above inner bottom to be coated.

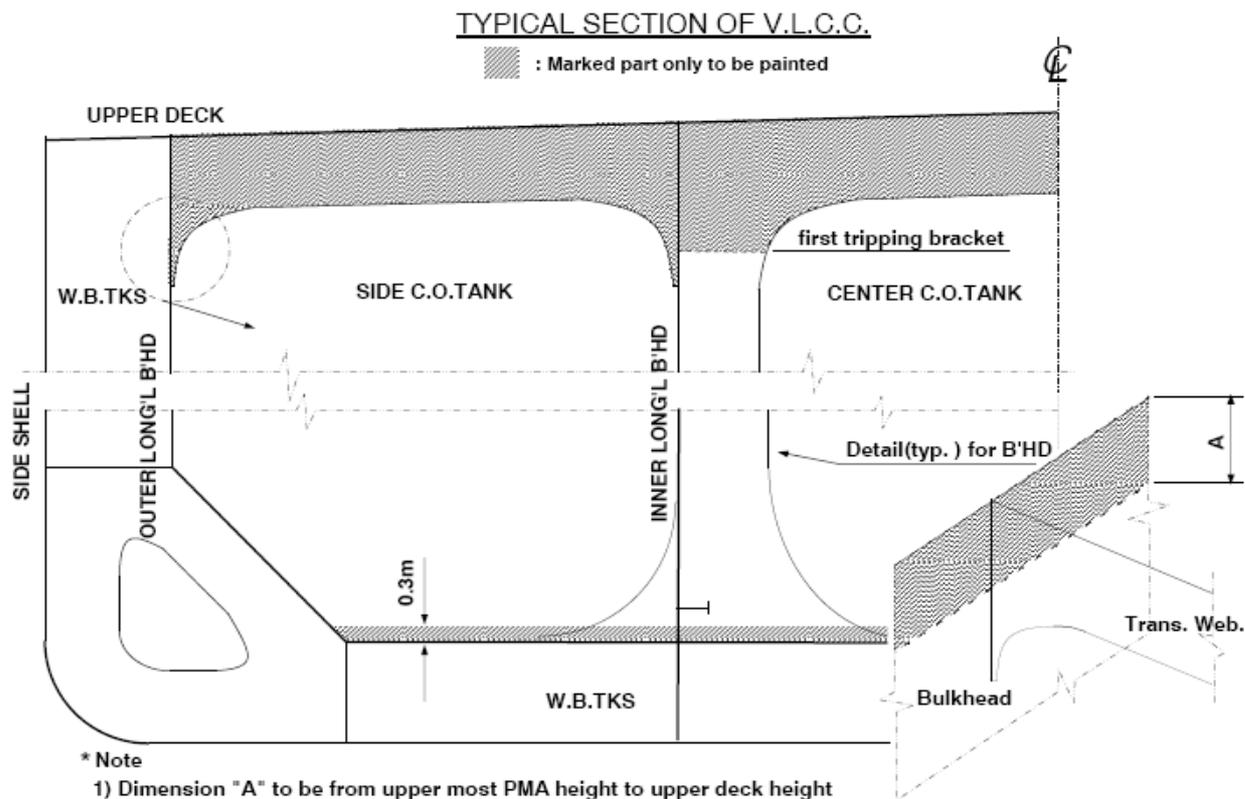


Figure 1

4.5 Special application

4.5.1 This Standard covers protective coating requirements for steel structure within cargo oil tanks. It is noted that there are other independent items that are fitted within the cargo oil tanks and to which coatings are applied to provide protection against corrosion.

4.5.2 It is recommended that this Standard is applied, to the extent practicable, to those portions of means of access provided for inspection within the areas specified in subsection 4.4 that are not integral to the ship structure, such as rails, independent platforms, ladders, etc. Other equivalent methods of providing corrosion protection for non-integral items may also be used, provided they do not impair the performance of the coatings of the surrounding structure. Access arrangements that are integral to the ship structure, such as stiffener depths for walkways, stringers, etc., are to fully comply with this Standard when located within the coated areas.

4.5.3 It is also recommended that supports for piping, measuring devices, etc., be coated as a minimum in accordance with the non-integral items indicated in paragraph 4.5.2.

4.6 Basic coating requirements

4.6.1 The requirements for protective coating systems to be applied at ship construction for the cargo oil tanks of crude oil tankers meeting the performance standard specified in paragraph 4.1 are listed in table 1.

4.6.2 Coating manufacturers shall provide a specification of the protective coating system to satisfy the requirements of table 1 and the operating environment.

4.6.3 The Administration shall verify the Technical Data Sheet and Statement of Compliance or Type Approval Certificate for the protective coating system.

4.6.4 The shipyard shall apply the protective coating in accordance with the verified Technical Data Sheet and its own verified application procedures.

4.7 The referenced standards listed in this Standard are acceptable to the Organization. Test equipment, test methods, preparation methods and/or test results shall conform to performance standards not inferior to those acceptable to the Organization.

Table 1 – Basic coating system requirements for cargo oil tanks of crude oil tankers

	Characteristic	Requirement
1	Design of coating system	
.1	Selection of the coating system	<p>The selection of the coating system shall be considered by the parties involved with respect to the service conditions and planned maintenance. The following aspects, among other things shall be considered:</p> <ul style="list-style-type: none"> .1 location of space relative to heated surfaces; .2 frequency of cargo operations; .3 required surface conditions; .4 required surface cleanliness and dryness; .5 supplementary cathodic protections, if any (where coating is supplemented by cathodic protection, the coating shall be compatible with the cathodic protection system); .6 permeability of the coating and resistance to inert gas and acids; and .7 appropriate mechanical properties (flexibility, impact resistance). <p>The coating manufacturer shall supply products with documented satisfactory performance records and technical data sheets. The manufacturer shall also be capable of rendering adequate technical assistance. Performance records, technical data sheet and any manufacturer's technical assistance provided shall be recorded in the Coating Technical File.</p> <p>Coatings for application underneath sun-heated decks or on bulkheads forming boundaries of heated spaces shall be able to withstand repeated heating and/or cooling without becoming brittle.</p>
.2	Coating type	<p>Epoxy-based systems.</p> <p>Other coating systems with performance according to the test procedure in the annex.</p> <p>A multi-coat system with each coat of a contrasting colour is recommended.</p> <p>The top coat shall be of a light colour to facilitate in-service inspection.</p> <p>Consideration should be given to the use of enhanced coatings in way of suction bellmouths and heating coil downcomers.</p> <p>Consideration should be given to the use of supplementary cathodic protection where there may be galvanic issues.</p>

	Characteristic	Requirement
.3	Coating test	<p>Epoxy-based systems tested prior to the date of entry into force of this Standard in a laboratory by a method corresponding to the test procedure in annex 1 or equivalent, which as a minimum meets the requirements for rusting and blistering, or which have documented field exposure for 5 years with a final coating condition of not less than "GOOD", may be accepted.</p> <p>For epoxy-based systems approved on or after entry into force of this Standard, testing according to the procedure in annex 1, or equivalent, is required.</p>
.4	Job specification	<p>There shall be a minimum of two stripe coats and two spray coats, except that the second stripe coat, by way of welded seams only, may be reduced in scope where it is proven that the NDFT can be met by the coats applied in order to avoid unnecessary over thickness. Any reduction in scope of the second stripe coat shall be fully detailed in the CTF.</p> <p>Stripe coat shall be applied by brush or roller. Roller shall be used for scallops, ratholes, etc., only.</p> <p>Each main coating layer shall be appropriately cured before application of the next coat, in accordance with the coating manufacturer's recommendations.</p> <p>Job specifications shall include the dry-to-recoat times and walk-on time given by the manufacturer.</p> <p>Surface contaminants such as rust, grease, dust, salt, oil, etc., shall be removed prior to painting. The method to be according to the paint manufacturer's recommendations. Abrasive inclusions embedded in the coating shall be removed.</p>
.5	NDFT (nominal total dry film thickness) ¹	<p>NDFT 320 µm with 90/10 rule for epoxy-based systems; other systems to the coating manufacturer's specifications.</p> <p>Maximum total dry film thickness according to the manufacturer's detailed specifications.</p> <p>Care shall be taken to avoid increasing the DFT in an exaggerated way. Wet film thickness shall be regularly checked during application.</p> <p>Thinners shall be limited to those types and quantities recommended by the manufacturer.</p>

¹ Type of gauge and calibration in accordance with SSPC-PA2:2004 Paint Application Specification No.2.

	Characteristic	Requirement
2 PSP (Primary surface preparation)		
.1	Blasting and profile ^{2,3}	<p>Sa 2½; with profiles between 30-75 µm.</p> <p>Blasting shall not be carried out when:</p> <ul style="list-style-type: none"> .1 the relative humidity is above 85%; or .2 the surface temperature of steel is less than 3°C above the dew point. <p>Checking of the steel surface cleanliness and roughness profile shall be carried out at the end of the surface preparation and before the application of the primer, and in accordance with the coating manufacturer's recommendations.</p>
.2	Water soluble salt limit equivalent to NaCl ⁴	≤ 50 mg/m ² of sodium chloride.
.3	Shop primer	<p>Zinc containing inhibitor free zinc silicate based or equivalent.</p> <p>Compatibility with main coating system shall be confirmed by the coating manufacturer.</p>
3 Secondary surface preparation		
.1	Steel condition ⁵	<p>The steel surface to be coated shall be prepared so that the coating selected can achieve an even distribution at the required NDFT and have an adequate adhesion by removing sharp edges, grinding weld beads and removing weld spatter and any other surface contaminant to grade P2.</p> <p>Edges to be treated to a rounded radius of minimum 2 mm, or subjected to three pass grinding or at least equivalent process before painting.</p>

² Refer to standard ISO 8501-1: 1988/Suppl: 1994. Preparation of steel substrate before application of paints and related products – Visual assessment of surface cleanliness.

³ Refer to standard ISO 8503-1/2: 1988. Preparation of steel substrate before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates.

⁴ Conductivity measured in accordance with the following standard ISO 8502-9: 1998. Preparation of steel substrate before application of paints and related products – Test for the assessment of surface cleanliness.

⁵ Refer to standard ISO 8501-3: 2001. Preparation of steel substrate before application of paints and related products – Visual assessment of surface cleanliness.

	Characteristic	Requirement
.2	Surface treatment ⁶	<p>Sa 2½ on damaged shop primer and welds.</p> <p>All surfaces to be coated shall be blasted to Sa 2, removing at least 70% of intact shop primer, which has not passed a pre-qualification certified by test procedures in table 1.3.</p> <p>If the complete coating system comprising epoxy-based main coating and shop primer has passed a pre-qualification certified by test procedures in table 1.3 intact shop primer may be retained provided the same epoxy-based system is used. Retained shop primer shall be cleaned by sweep blasting, high pressure water washing or equivalent method.</p> <p>If a zinc silicate shop primer has passed the pre-qualification test of table 1.3 as part of an epoxy coating system, it may be used in combination with other epoxy coatings certified under table 1.3, provided that the compatibility has been confirmed by the manufacturer by the test with reference to the immersion test of annex 1 or in accordance with the Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers (resolution MSC.215(82)).</p>
.3	Surface treatment after erection	<p>Erection joints St 3 or better or Sa 2½ where practicable.</p> <p><i>For inner bottom:</i></p> <ul style="list-style-type: none"> - Damages up to 20% of the area to be coated to be treated to minimum St 3. - Contiguous damages over 25 m² or over 20% of the area to be coated, Sa 2½ shall be applied. <p><i>For underdeck:</i></p> <ul style="list-style-type: none"> - Damages up to 3% of area to be coated to be treated to minimum St 3. - Contiguous damages over 25 m² or over 3% of the area to be coated, Sa 2½ shall be applied. <p>Coating in overlap to be feathered.</p>
.4	Profile requirements ⁷	In case of full or partial blasting 30-75 µm, otherwise as recommended by the coating manufacturer.
.5	Dust ⁸	<p>Dust quantity rating "1" for dust size class "3", "4" or "5".</p> <p>Lower dust size classes to be removed if visible on the surface to be coated without magnification.</p>

⁶ Refer to standard ISO 8501-1: 1988/Supplement: 1994. Preparation of steel substrate before application of paints and related products – Visual assessment of surface cleanliness.

⁷ Refer to standard ISO 8503-1/2: 1988. Preparation of steel substrate before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates.

⁸ Refer to standard ISO 8502-3:1993. Preparation of steel substrate before application of paints and related products – Test for the assessment of surface cleanliness.

	Characteristic	Requirement
.6	Water soluble salts limit equivalent to NaCl after blasting/grinding ⁹	≤ 50 mg/m ² of sodium chloride.
.7	Contamination	No oil contamination. Paint manufacturer's recommendations should be followed regarding any other contamination between coats.
4 Miscellaneous		
.1	Ventilation	Adequate ventilation is necessary for the proper drying and curing of coating. Ventilation should be maintained throughout the application process and for a period after application is completed, as recommended by the coating manufacturer.
.2	Environmental conditions	Coating shall be applied under controlled humidity and surface conditions, in accordance with the manufacturer's specifications. In addition, coating shall not be applied when: <ul style="list-style-type: none"> .1 the relative humidity is above 85%; or .2 the surface temperature is less than 3°C above the dew point; or .3 any other requirements of the paint manufacturer are not being met.
.3	Testing of coating ¹⁰	Destructive testing should be avoided. Sample dry film thickness shall be measured after each coat for quality control purposes and the total dry film thickness shall be confirmed after completion of the final coat, using appropriate thickness gauges.
.4	Repair	Any defective areas, e.g., pinholes, bubbles, voids, etc., shall be marked up and appropriate repairs effected. All such repairs shall be re-checked and documented.

⁹ Conductivity measured in accordance with standard ISO 8502-9: 1998 – Preparation of steel substrate before application of paints and related products – Test for the assessment of surface cleanliness.

¹⁰ Type of gauge and calibration in accordance with standard SSPC-PA2: 2004 – Paint Application Specification No.2.

5 COATING SYSTEM APPROVAL

Results from prequalification tests (table 1, paragraph 1.3) of the coating system shall be documented, and a Statement of Compliance or Type Approval Certificate shall be issued if found satisfactory by a third party, independent of the coating manufacturer.

6 COATING INSPECTION REQUIREMENTS

6.1 General

6.1.1 To ensure compliance with this Standard, the following shall be carried out by qualified coating inspectors certified to NACE Coating Inspector Level 2, FROSIO Inspector Level III or equivalent as verified by the Administration.

6.1.2 Coating inspectors shall inspect surface preparation and coating application during the coating process by carrying out, as a minimum, those inspection items identified in subsection 6.2 to ensure compliance with this Standard. Emphasis shall be placed on initiation of each stage of surface preparation and coatings application as improper work is extremely difficult to correct later in the coating progress. Representative structural members shall be non-destructively examined for coating thickness. The inspector shall verify that appropriate collective measures have been carried out.

6.1.3 Results from the inspection shall be recorded by the inspector and shall be included in the CTF (see annex 2).

6.2 Inspection items

Construction stage		Inspection items
Primary surface preparation	1	The surface temperature of steel, the relative humidity and the dew point shall be measured and recorded before the blasting process starts and at times of sudden changes in weather.
	2	The surface of steel plates shall be tested for soluble salt checked for oil, grease and other contamination.
	3	The cleanliness of the steel surface shall be monitored in the shop primer application process.
	4	The shop primer material shall be confirmed to meet the requirements of 2.3 of table 1. Verified by manufacturer.
Thickness		If compatibility with the main coating system has been declared, then the thickness and curing of the zinc silicate shop primer to be confirmed to conform to the specified values.
Block assembly	1	After completing construction of the block and before secondary surface preparation starts, a visual inspection for steel surface treatment including edge treatment shall be carried out.
		Any oil, grease or other visible contamination to be removed.

Construction stage	Inspection items
	<p>2 After blasting/grinding/cleaning and prior to coating, a visual inspection of the prepared surface shall be carried out.</p> <p>On completion of blasting and cleaning and prior to the application of the first coat of the system, the steel surface shall be tested for levels of remaining soluble salts in at least one location per block.</p> <p>3 The surface temperature, the relative humidity and the dew point shall be monitored and recorded during the coating application and curing.</p> <p>4 Inspection to be performed of the steps in the coating application process mentioned in table 1.</p> <p>5 DFT measurements shall be taken to prove that the coating has been applied to the thickness as specified.</p>
Erection	<p>1 Visual inspection for steel surface condition, surface preparation and verification of conformance to other requirements in table 1, and the agreed specification to be performed.</p> <p>2 The surface temperature, the relative humidity and the dew point shall be measured and recorded before coating starts and regularly during the coating process.</p> <p>3 Inspection to be performed of the steps in the coating application process mentioned in table 1.</p>

7 COATING VERIFICATION REQUIREMENTS

The following shall be carried out by the Administration prior to reviewing the Coating Technical File for the ship subject to this Standard:

- .1 check that the Technical Data Sheet and Statement of Compliance or Type Approval Certificate comply with the Standard;
- .2 check that the coating identification on representative containers is consistent with the coating identified in the Technical Data Sheet and Statement of Compliance or Type Approval Certificate;
- .3 check that the inspector is qualified in accordance with the qualification standards in paragraph 6.1.1;
- .4 check that the inspector's reports of surface preparation and the coating's application indicate compliance with the manufacturer's Technical Data Sheet and Statement of Compliance or Type Approval Certificate; and
- .5 monitor implementation of the coating inspection requirements.

8 ALTERNATIVE COATING SYSTEMS

8.1 All systems that are not an epoxy-based system applied according to table 1 of this Standard are defined as an alternative system.

8.2 This Standard is based on recognized and commonly used coating systems. It is not meant to exclude other, alternative, systems with proven equivalent performance, for example non-epoxy-based systems.

8.3 Acceptance of alternative systems shall be subject to documented evidence that they ensure a corrosion prevention performance at least equivalent to that indicated in this Standard, by either:

- .1 testing according to this standard; or
- .2 five years' field exposure with documentary evidence of continuous trading with crude oil cargoes.¹¹ The coating condition is not less than "GOOD" after five years.

¹¹ For field exposure the ship should be trading in varied trade routes and carrying substantial varieties of crude oils to ensure a realistic sample: for example, three ships on three different trade areas with different varieties of crude cargoes.

ANNEX 1

TEST PROCEDURES FOR COATING QUALIFICATION FOR CARGO OIL TANKS OF CRUDE OIL TANKERS

1 Scope

This annex provides details of the test procedures for cargo tank coatings for crude oil carriers as referred to in paragraphs 4.6 and 8.3 of this Standard. Both the tank-top and deck-head should be applied with coating systems that have passed the full test protocol as described in this document.

2 Definitions

Coating specification means the specification of coating systems which include the type of coating system, steel preparation, surface preparation, surface cleanliness, environmental conditions, application procedure, inspection and acceptance criteria.

3 Background

It is acknowledged that a crude oil cargo tank on board a ship is exposed to two very different environmental conditions.

3.1 When the cargo tank is loaded there are three distinct vertical zones:

- .1 Lowest part, and horizontal parts on stringer decks, etc., exposed to water that can be acidic and sludge that can contain anaerobic bacteria.
- .2 Mid part where the oil cargo is in contact with all immersed steel.
- .3 Vapour space where the air is saturated with various vapours from the loaded cargo tank such as H₂S, CO₂, SO₂, water vapour and other gases and compounds from the inert gas system.

3.2 When the tank is in a ballast condition:

- .1 Lowest part and horizontal parts on stringer decks, etc., exposed to cargo residues and water that can be acidic and sludge that can contain anaerobic bacteria.
- .2 Tank space where the air contains various vapours from the crude oil residues such as H₂S, CO₂, SO₂, water vapour and other gases and compounds from the inert gas system.

4 Testing

The tests herein are designed to simulate, as far as practicable, the two main environmental conditions to which the crude oil cargo tank coating will be exposed. The coating shall be validated by the following tests: the test procedures shall comply with Appendix 1 (Gas-tight chamber simulating the vapour phase of the loaded tank) and Appendix 2 (Immersion test simulating the loaded condition of the crude oil tank¹²).

¹² Related test method is derived from, but not identical to, standard ISO 2812-1:2007 – Paints and varnishes – Determination of resistance to liquids – Part 1: Immersion in liquids other than water.

5 Test gas composition

The test gas is based on the composition of the vapour phase in crude oil tanks, except that the hydrocarbon components are not included as these have no detrimental effect on epoxy coatings such as those used in cargo oil tanks.

TEST GAS COMPOSITION

N ₂	83 ± 2 per cent by volume of dry gas
CO ₂	13 ± 2 per cent by volume of dry gas
O ₂	4 ± 1 per cent by volume of dry gas
SO ₂	300 ± 20 ppm
H ₂ S	200 ± 20 ppm

6 Test liquid

Crude oil is a complex chemical material which is not stable over time when stocked. Crude oils can also vary in composition over time. In addition the use of crude oil has proven to create practical and HSE barriers for the involved testing institutes. To overcome this, a model immersion liquid is used to simulate crude oil. The formulation of this crude oil model system is given below:

- .1 start with distillate Marine Fuel, DMA Grade¹³ density at 15°C: maximum 890 kg/m³, viscosity of maximum 6 mm²/s at 40°C;
- .2 add naphthenic acid up to an acid number¹⁴ of 2.5 ± 0.1 mg KOH/g;
- .3 add benzene/ toluene (1:1 ratio) up to a total of 8.0 ± 0.2% w/w of the DMA;
- .4 add artificial seawater¹⁵ up to a total of 5.0 ± 0.2% w/w to the mixture;
- .5 add H₂S dissolved in a liquid carrier (in order to get 5 ± 1 ppm w/w H₂S in the total test liquid);
- .6 thoroughly mix the above constituents immediately prior to use; and
- .7 once the mixture is completed, it should be tested to confirm the mixture is compliant with the test mixture concentrations.

Note: To prevent the risk of H₂S release into the test facility, it is recommended to use a stock solution for steps 1 to 4, then fill the test containers and complete the test solution with steps 5 and 6.

¹³ Refer to standard ISO 8217:2005 – Petroleum products – Fuels (class F) – Specifications of marine fuels.

¹⁴ Refer to standard ISO 6618:1997 – Petroleum products and lubricants – Determination of acid or base number – Colour-indicator titration method.

¹⁵ Refer to standard ASTM D1141 – 98(2008) – Standard Practice for the Preparation of Substitute Ocean Water.

APPENDIX 1

GAS-TIGHT CABINET TEST

1 Test condition

The vapour test shall be carried out in a gas-tight cabinet. The dimensions and design of the air tight gas cabinet are not critical, provided the requirements of subparagraphs .6 to .10 below are met. The test gas is designed to simulate the actual crude oil cargo tank environment in ballast condition as well as the vapour conditions of the loaded tank.

- .1 The exposure time is 90 days.
- .2 Testing shall be carried out using duplicate panels; a third panel shall be prepared and stored at ambient conditions to act as a reference panel during final evaluation of the test panels.
- .3 The size of each test panel is 150 mm x 100 mm x 3 mm.
- .4 The panels shall be treated according to the Performance standard table 1, 1.2 and the coating system applied according to table 1, 1.4 and 1.5.
- .5 The zinc silicate shop primer, when used, shall be weathered for at least 2 months and cleaned by low pressure fresh water washing. The exact method of shop primer preparation before being over coated shall be reported, and the judgement issued for that specific system. The reverse side and edges of the test piece shall be coated appropriately, in order not to influence the test results.
- .6 Inside the gas-tight cabinet a trough shall be present. This trough shall be filled with 2 ± 0.2 l of water. The water in the trough shall be drained and renewed prior to each time the test gas is refreshed.
- .7 The vapour spaces inside the gas-tight cabinet shall be filled with a mixture of test gas as per item 5 of the Standard. The cabinet atmosphere shall be maintained over the period of the test. When the gas is outside the scope of the test method, it shall be refreshed. The monitoring frequency and method, and the date and time for refreshing the test gas, shall be in the test report.
- .8 The atmosphere in the test cabinet shall at all times be $95 \pm 5\%$ relative humidity.
- .9 Temperature of the test atmosphere shall be $60 \pm 3^{\circ}\text{C}$.
- .10 A stand for the test panels shall be made of a suitable inert material to hold the panels vertically spaced at least 20 mm between panels. The stand shall be positioned in the cabinet to ensure the lower edge of the panels is at least 200 mm above the height of the water and at least 100 mm from the walls of the cabinet. If two shelves are in the cabinet, care shall be taken to ensure solution does not drip on to the lower panels.

2 Test results

2.1 Prior to testing, the following measured data of each coating composing the coating system, including the zinc silicate shop primer when used under the coating system, shall be reported:

- .1 infrared (IR) identification of the base and hardener components of the coating;
- .2 specific gravity¹⁶ of the base and hardener components of the paint; and
- .3 mean dry film thickness (DFT) (by using a template).¹⁷

2.2 After completion of the test duration, the panels shall be removed from the cabinet and rinsed with warm tap water. The panels shall be dried by blotting with absorbent paper and, then, evaluated for rust and blistering within 24 h of the end of the test.

2.3 After testing, the following measured data shall be reported: blisters and rust.¹⁸

3 Acceptance criteria

3.1 The test results based on section 2 shall satisfy the following criteria, the poorest performing of the duplicate test panels shall be used in the report:

Item	Acceptance criteria for epoxy-based systems	Acceptance criteria for alternative systems
Blisters on panel	No blisters	No blisters
Rust on panel	Ri 0 (0%)	Ri 0 (0%)

3.2 When evaluating test panels, blistering or rusting within 5 mm of the panel edge shall be ignored.

4 Test report

The test report shall include the following information:

- .1 coating manufacturers' name and manufacturing site;¹⁹
- .2 dates of test;

¹⁶ Refer to standard ISO 2811-1/4:1997 – Paints and varnishes. Determination of density.

¹⁷ Six equally distributed measuring points are used on panels size 150 mm x 100 mm.

¹⁸ Refer to the following standards:

- .1 ISO 4628-1:2003 – Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 1: General introduction and designation system;
- .2 ISO 4628-2:2003 – Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 2: Assessment of degree of blistering; and
- .3 ISO 4628:2003 – Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of common types of defect – Part 3: Designation of degree of rusting.

¹⁹ It should be noted that the test is valid irrespective of production site, meaning that no individual testing of product from different production sites is required.

- .3 product name/identification of each coat and, where applicable, zinc silicate shop primer;
- .4 batch numbers of each component of each product;
- .5 details of surface preparation of steel panels, before shop primer application, and treatment of the shop primer before over coating where relevant and at a minimum including the following:
 - .5.1 surface treatment, or treatment of weathered shop primer, and any other important information on treatment influencing the performance; and
 - .5.2 water soluble salt level measured on the steel prior to application of the shop primer;²⁰
- .6 details of coating system, including the following:
 - .6.1 zinc silicate shop primer if relevant, its secondary surface pre-treatment and condition under which applied, weathering period;
 - .6.2 number of coats, including the shop primer, and thickness of each;
 - .6.3 mean dry film thickness (DFT) prior to testing;²¹
 - .6.4 thinner if used;²²
 - .6.5 humidity;²²
 - .6.6 air temperature;²² and
 - .6.7 steel temperature;²²
- .7 details of schedule for refreshing the test gas;
- .8 test results according to section 2; and
- .9 results according to section 3.

²⁰ Refer to the following standards:

- .1 ISO 8502-6:2006. Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method; and
- .2 ISO 8502-9:1998. Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 9: Field method for the conductometric determination of water-soluble salts.

²¹ Both of actual specimen data and manufacturer's requirement/recommendation.

APPENDIX 2

IMMERSION TEST

1 Test condition

The immersion test²² is developed to simulate the conditions in a crude oil tank in loaded condition.

- .1 The exposure time is 180 days.
- .2 The test liquid should be made as per item 6 in the Standard.
- .3 The test liquid should be added to a container with an inside flat bottom until a column of the test liquid of height of 400 mm is reached, resulting in an aqueous phase of 20 mm. Any other alternative test set-up, using an identical test liquid, which will also result in the immersion of the test panel in 20 mm of the aqueous phase, is also accepted. This can be achieved by using, for instance, inert marbles.
- .4 The temperature of the test liquid should be $60 \pm 2^{\circ}\text{C}$ and should be uniform and maintained constant with recognized methods such as water or oil bath or air circulation oven capable of keeping the immersion liquid within the required temperature range.
- .5 Test panels shall be positioned vertically and fully immersed during the test.
- .6 Testing shall be carried out using duplicate panels.
- .7 Inert spacers which do not cover the test area shall be used to separate test panels.
- .8 The size of each test panel is 150 mm x 100 mm x 3 mm.
- .9 The panels shall be treated according to the Performance Standard table 1, 1.2 and the coating system applied according to table 1, 1.4 and 1.5.
- .10 The zinc silicate shop primer, when used, shall be weathered for at least 2 months and cleaned by low pressure fresh water washing. The exact method of shop primer preparation before being over coated shall be reported, and the judgement issued for that specific system. The reverse side, and edges, of the test piece shall be coated appropriately, in order not to influence the test results.
- .11 After the full immersion test period is completed the panels shall be removed from the test liquid and wiped with dry clean cloth before evaluation of the panels.
- .12 Evaluation of the test panels shall be done within 24 h after completion of the test.

²² Related test method is derived from, but not identical to, standard ISO 2812-1:2007 – Paints and varnishes – Determination of resistance to liquids – Part 1: Immersion in liquids other than water.

2 Test results

2.1 Prior to testing, the following measured data of each coating composing the coating system, including the zinc silicate shop primer when used under the coating system, shall be reported:

- .1 infrared (IR) identification of the base and hardener components of the coating;
- .2 specific gravity of the base and hardener components of the paint;²³ and
- .3 mean dry film thickness (DFT) (by using a template).²⁴

2.2 After testing, the following measured data shall be reported: blisters and rust.²⁵

3 Acceptance criteria

3.1 The test results based on section 2 shall satisfy the following criteria, the poorest performing of the duplicate test panels shall be used in the report:

Item	Acceptance criteria for epoxy-based systems	Acceptance criteria for alternative systems
Blisters on panel	No blisters	No blisters
Rust on panel	Ri 0 (0%)	Ri 0 (0%)

3.2 When evaluating test panels, blistering or rusting within 5 mm of the panel edge should be ignored.

4 Test report

The test report shall include the following information:

- .1 coating manufacturers' name and manufacturing site;²⁶
- .2 dates of test;

²³ Refer to standard ISO 2811-1/4:1997 – Paints and varnishes. Determination of density.

²⁴ Six equally distributed measuring points are used on panels size 150 mm x 100 mm.

²⁵ Refer to the following standards:

- .1 ISO 4628-1:2003. Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 1: General introduction and designation system;
- .2 ISO 4628-2:2003. Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 2: Assessment of degree of blistering; and
- .3 ISO 4628:2003. Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of common types of defect – Part 3: Designation of degree of rusting.

²⁶ It should be noted that the test is valid irrespective of production site, meaning that no individual testing of product from different production sites is required.

- .3 product name/identification of each coat and, where applicable, zinc silicate shop primer;
- .4 batch numbers of each component of each product;
- .5 details of surface preparation of steel panels, before shop primer application, and treatment of the shop primer before over coating where relevant and at a minimum including the following:
 - .5.1 surface treatment, or treatment of weathered shop primer, and any other important information on treatment influencing the performance; and
 - .5.2 water soluble salt level measured on the steel prior to application of the shop primer;²⁷
- .6 details of coating system, including the following:
 - .6.1 zinc silicate shop primer if relevant, its secondary surface pre-treatment and condition under which applied, weathering period;
 - .6.2 number of coats, including the shop primer, and thickness of each;
 - .6.3 mean dry film thickness (DFT) prior to testing;²⁸
 - .6.4 thinner if used;²⁹
 - .6.5 humidity;²⁹
 - .6.6 air temperature;²⁹ and
 - .6.7 steel temperature;²⁹
- .7 test results according to section 2; and
- .8 results according to section 3.

²⁷ Refer to the following standards:

- .1 ISO 8502-6:2006. Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method; and
- .2 ISO 8502-9:1998. Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 9: Field method for the conductometric determination of water-soluble salts.

²⁸ Both of actual specimen data and manufacturer's requirement/recommendation.

APPENDIX 3

PRECAUTIONS REGARDING THE USE OF DANGEROUS MATERIALS

1 The test methods involve the use of materials that may be hazardous to health as follows:

- .1 Sulphur Dioxide: Corrosive when wet, toxic if inhaled, causes burns, and is an irritant to the eyes and respiratory system.
- .2 Hydrogen Sulphide: Highly flammable (Flash point of -82°C), can form an explosive mixture with air, corrosive when wet, causes burns, has to be kept away from sources of ignition, irritant and asphyxiant, LTEL 5 ppm, STEL 10 ppm, higher concentrations can be fatal and have no odour. Repeated exposure to low concentrations can result in the sense of smell for the gas being diminished.
- .3 Benzene: Highly flammable (Flash point of -11°C), can form an explosive mixture with air, toxic, carcinogenic, acute health risk.
- .4 Toluene: Highly flammable (Flash point of 4°C), can form an explosive mixture with air, irritant, acute health risk, reprotoxin.

2 Special test apparatus and precautions may be required depending on the regulations in force in the country where the tests are carried out.

3 Although some countries have no specific requirements preventing either of the tests being carried out, it shall anyhow be required that:

- .1 a risk assessment of the working conditions is carried out;
- .2 during the test period, the system shall be enclosed; and
- .3 the environment shall be controlled, particularly at the start and end of the tests, suitable air exhaust shall be available and personal protective equipment shall be worn.

ANNEX 2

EXAMPLE OF DAILY LOG AND NON-CONFORMITY REPORT

DAILY LOG

Sheet No:

Ship:	Tank/Hold No:	Database:							
Part of structure:									
SURFACE PREPARATION									
Method:	Area (m²):								
Abrasive:	Grain size:								
Surface temperature:	Air temperature:								
Relative humidity (max):	Dew point:								
Standard achieved:									
Rounding of edges:									
Comments:									
Job No.:	Date:	Signature:							
COATING APPLICATION:									
Method:									
Coat No.	System	Batch No.	Date	Air temp.	Surf temp.	RH%	Dew point	DFT* Meas.	Specified
* Measured minimum and maximum DFT. DFT readings to be attached to daily log.									
Comments:									
Job No:	Date:	Signature:							

NON-CONFORMITY REPORT

Sheet No:

Ship:	Tank/Hold No:	Database:
Part of structure:		
DESCRIPTION OF THE INSPECTION FINDINGS TO BE CORRECTED		
Description of findings:		
Reference document (daily log):		
Action taken:		
Job No.:	Date:	Signature:
