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CARGO OIL TANK COATING AND CORROSION PROTECTION

Report of Industry JWG/COTCPS – Development of Cargo Oil Tank Coating Performance Standard

Submitted by BIMCO, CEFIC, ICS, OCIMF, INTERTANKO, INTERCARGO and IACS

SUMMARY

Executive summary:	This document presents the new draft Performance Standard for protective coatings for cargo oil tanks of crude oil tankers for application with the proposed draft SOLAS regulation II-1/3-[9] – Corrosion protection of cargo oil tanks of crude oil tankers
Action to be taken:	Paragraph 6
Related documents:	MSC 82/23/4; DE 50/25/7, DE 50/25/8, DE 50/27, paragraphs 25.15 to 25.18; DE 51/14 and DE 51/19

Introduction

1 In May 2006 an Industry Joint Working Group for Cargo Oil Tank Coating Performance Standard (JWG/COTCPS) was established to develop a standard to be used with the anticipated draft SOLAS regulation as a result of the work of Correspondence Group on Coatings established by DE 50 (ToR 3). The correspondence group report containing the proposed draft SOLAS regulation to make a cargo oil tank coating performance standard mandatory was submitted by China as document DE 51/19. The proposed draft SOLAS regulation II-1/3-[9] contains, in paragraph 3.1, "the Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers" as a mandatory standard, anticipating future adoption of the same.

2 The JWG met on three occasions in the United Kingdom and the Republic of Korea and was chaired by IACS. With the lessons learned from the development process of coating performance standards for ballast tanks in IMO and in order to minimize possible disagreements amongst different parties during future discussions in IMO, the JWG activities were attended by a wide range of representatives including, in particular, both shipowners and shipbuilders, from the outset of the development of a performance standards for cargo oil tanks. Members of this working group included, in addition to the sponsors of this submission, MARTECMA (Marine Technical Managers Association), KOSHIPA (The Korea Shipbuilder's Association), SAJ (Shipbuilders' Association of Japan), CSNAME (Chinese Society of Naval Architects & Marine Engineers), JSTRA (Japan Ship Technology Research Association) and JPMA (Japanese Paint Manufacturers Association).

Application

3 The application of the draft SOLAS regulation had not been decided while the group was working, so items relating to product tankers have been included in square brackets with the intention of removing either the wording or the brackets after the application has been decided at the SOLAS level. The proposed draft SOLAS regulation now submitted in document DE 51/19 does not include product tankers in the scope of application.

4 The draft standard is based on the Performance standard for ballast tanks adopted at MSC 82 (resolution MSC.215(82)) which was modified to take into account differences between ballast and cargo tanks. In the future, the common items of both standards should be considered together when reviewing or amending. The final agreed version of the draft Performance standard is attached as annex to this document.

Coating test method

5 The testing method included in the draft Performance standard has been developed by experts within the Industry JWG with the best information and knowledge currently available. As no coatings have undergone this test procedure, it may be necessary to review the procedure when experience is gained.

Action requested of the Sub-Committee

6 The Sub-Committee is invited to consider the draft Performance Standard as set out in the annex and take action as appropriate.

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ANNEX

DRAFT 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 and [product carriers]. [It should be noted in practice that many product carriers are coated to a higher standard for cargo protection reasons.]

2 DEFINITIONS

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

2.1 *Crude Oil Tanker* and *Product Carrier* as defined 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 particle 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 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. 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 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 or its recognized organization for review. Clear evidence of these inspections shall be reported and be included in the Coating Technical File (CTF) (see paragraph 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;

.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 additionally 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:

- product name and identification mark and/or number;
- materials, components and composition of the coating system, colours;

- minimum and maximum dry film thickness;
- application methods, tools and/or machines;
- condition of surface to be coated (de-rusting grade, cleanness, profile, etc.); and
- environmental limitations (temperature and humidity);

.3 shipyard work records of coating application, including:

- applied actual areas (in square metres) of coating in each cargo oil tank;
- applied coating system;
- time of coating, thickness, number of layers, etc.;
- ambient conditions during coating; and
- 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 (example of daily log and non-conformity report, see resolution MSC.215(82), annex 2);

.6 shipyard's verified inspection report, including:

- completion date of inspection;
- result of inspection;
- remarks (if given); and
- inspector signature; and

.7 procedures for in-service maintenance and repair of coating system[1].

3.4.3 ***In-service maintenance, repair and partial re-coating***

In-service maintenance, repair and partial re-coating 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 ***Re-coating***

If full re-coating is carried out, the items specified in paragraph 3.4.2 shall be recorded in the Coating Technical File.

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

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.

[1] Guidelines to be developed by IMO.

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 [or Product Carriers] shall at least comply with the requirements in this Standard. [It should be noted that Product Carriers are generally coated to a higher standard than this performance standard.]

4.3 Coating system

An epoxy system meeting test and physical properties (Table 1.1.3) shall be documented, and a Type Approval Certificate or statement of compliance to be provided. [In the case of product tankers, the coating system may be chosen according to the cargoes intended to be carried.]

4.4 Area of application

The following areas are the minimum areas shall be protected:

.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.

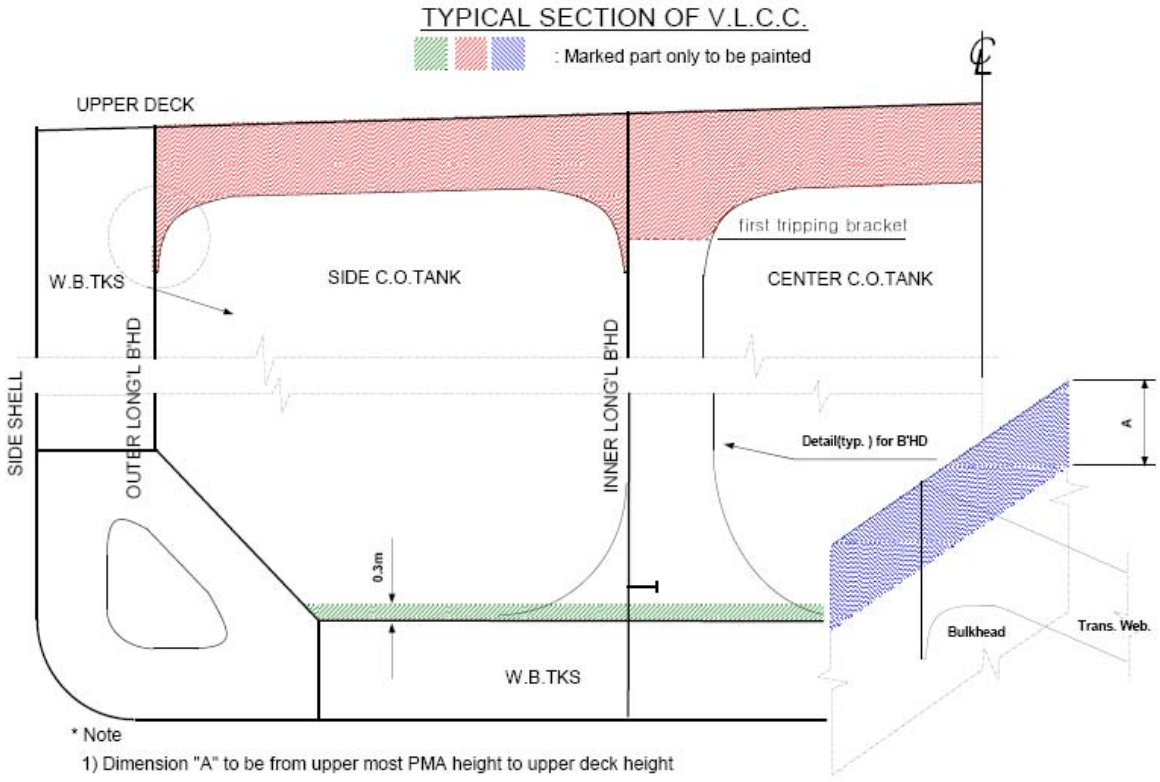

Figure 1

4.5 Special application

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

4.5.2 It is recommended that this Standard is to be applied to the extent practicable, to those portions of means of access provided for inspection within the areas specified in 4.4 that are not integral to the vessel structure, such as rails, independent platforms, ladders, etc. Other equivalent methods of providing corrosion protection for the 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 with the vessel structure, such as increased 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 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 [and Product carriers] 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 Technical Data Sheet for the protective coating system shall be verified.

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 those to be applied.

Table 1 – Basic coating system requirements cargo oil tanks of crude oil tankers [and Product Tankers]

	Characteristic	**Requirement**
.1	**Design of coating system**	
.1	Selection of the coating system	The selection of the coating system should be considered by the parties involved with respect to the service conditions and planned maintenance. The following aspects, among other things should be considered: .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 should 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). The coating manufacturer shall supply products with documented satisfactory performance records and technical data sheets. The manufacturer should 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. 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.
.2	Coating type	Epoxy systems. Other coating systems with performance according to the test procedure in the annex. A multi-coat system with each coat of a contrasting colour is recommended.

		The top coat shall be of a light colour to facilitate in-service inspection. Consideration should be given to the use of enhanced coatings in way of suction bellmouths and heating coil downcomers. Consideration should be given to the use of supplementary cathodic protection where there may be galvanic issues.
.3	Coating Test	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. For all other systems, testing according to the procedure in annex 1, or equivalent, is required.
.4	Job specification	There shall be a minimum of two (2) stripe coats and two (2) 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. Stripe coat shall be applied by brush or roller. Roller shall be used for scallops, ratholes, etc., only. Each main coating layer shall be appropriately cured before application of the next coat, in accordance with coating manufacturer's recommendations. Job specifications shall include the dry-to-recoat times and walk-on time given by the manufacturer. 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.
.5	NDFT (nominal total dry film thickness)[2]	NDFT 320µm with 90/10 rule for epoxy based coatings, other systems to coating manufacturer's specifications. Maximum total dry film thickness according to manufacturer's detailed specifications. Care shall be taken to avoid increasing the DFT in an exaggerated way. Wet film thickness shall be regularly checked during application.

[2] Type of gauge and calibration in accordance with SSPC-PA2:2004 Paint Application Specification No2.

		Thinners shall be limited to those types and quantities recommended by the manufacturer.
.2	**PSP (Primary Surface Preparation)**	
.1	Blasting and profile[3],[4]	Sa 2½; with profiles between Rz 30-75 μm. Blasting should not be carried out when: .1 the relative humidity is above 85%; or .2 the surface temperature of steel is less than 3°C above the dew point. Checking of the steel surface cleanliness and roughness profile should 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.
.2	Water soluble salt limit equivalent to NaCl[5]	≤ 50 mg/m^2 of sodium chloride
.3	Shop primer	Zinc containing inhibitor free zinc silicate based or equivalent. Compatibility with main coating system shall be confirmed by the coating manufacturer. Compatibility of the shop primer with cargo oil and for the influence of the onboard produced inert gas on the coating shall be confirmed.
.3	**Secondary surface preparation**	
.1	Steel condition[6]	The steel surface to be coated should 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 in accordance with ISO 8501-3 grade P2. 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.

[3] Reference standard: ISO 8501-1: 1988/Suppl: 1994. Preparation of steel substrate before application of paints and related products – Visual assessment of surface cleanliness.

[4] Reference 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.

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

[6] Reference standard: ISO 8501-3: 2001 (grade P2). Preparation of steel substrate before application of paints and related products – Visual assessment of surface cleanliness.

.2	Surface treatment[7]	Sa 2½ on damaged shop primer and welds; Sa 2 removing at least 70% of intact shop primer, which has not passed a pre-qualification certified by test procedures in table 1.1.c. If the complete coating system comprising epoxy based main coating and shop primer has passed a pre-qualification certified by test procedures in table 1.1.c intact shop primer may be retained provided the same epoxy coating system is used. Retained shop primer shall be cleaned by sweep blasting, high pressure water washing or equivalent method. Any primer not proven compatible with the coating or cargo tank operational environment shall be removed completely.
.3	Surface treatment after erection	Erection joints St 3 or better or Sa 2½ where practicable. *For Inner Bottom*: - Damages up to 20% of area to be coated to be treated to minimum St 3. - Contiguous damages over 25 m^2 or over 20% of the area to be coated, Sa 2½ should be applied. *For Underdeck*: - Damages up to 2% of area to be coated to be treated to minimum St 3. - Contiguous damages over 25 m^2 or over 2% of the area to be coated, Sa 2½ should be applied. Coating in overlap to be feathered.
.4	Profile requirements[8]	In case of full or partial blasting Rz 30-75 μm, otherwise as recommended by the coating manufacturer.
.5	Dust[9]	Dust quantity rating "1" for dust size class "3", "4" or "5". Lower dust size classes to be removed if visible on the surface to be coated without magnification.
.6	Water soluble salts limit equivalent to NaCl after blasting/ grinding[10]	≤ 50 mg/m^2 of sodium chloride

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

8 Reference 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.

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

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

.7	Contamination	No oil contamination. Paint manufacturers 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: .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.
.3	Testing of coating[11]	Destructive testing should be avoided. Sample dry film thickness shall be measured after each coat for quality control purpose and the total dry film thickness shall be confirmed after completion of final coat, using appropriate thickness gauges.
.4	Repair	Any defective areas, e.g., pin-holes, bubbles, voids, etc., should be marked up and appropriate repairs effected. All such repairs shall be re-checked and documented.

5 COATING SYSTEM APPROVAL

Results from prequalification tests (table 1, paragraph 1c) 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 the qualified coating inspectors certified to NACE Level II, FROSIO level III or equivalent as verified by the Administration or the recognized organization.

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 section 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

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

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 (refer to resolution MSC.215(82), annex 2, Example of Daily Log and Non-conformity Report).

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.c of Table 1. Verify 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.
	2	After blasting/grinding/cleaning and prior to coating, a visual inspection of the prepared surface shall be carried out. 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.
	3	The surface temperature, the relative humidity and the dew point shall be monitored and recorded during the coating application and curing.
	4	Inspection to be performed of the steps in the coating application process mentioned in Table 1.
	5	DFT measurements shall be taken to prove that the coating has been applied to the thickness as specified.
Erection	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.
	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.
	3	Inspection to be performed of the steps in the coating application process mentioned in Table 1.

7 COATING VERIFICATION REQUIREMENTS

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

.1 check that the Technical Data Sheet and Statement of Compliance or Type Approval Certificate comply with the Coating Performance 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 coating system applied according to table 1 of this Standard are defined as an alternative system.

8.2 This Performance 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 will 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 5 years field exposure with documentary evidence of continuous trading with aggressive sour crude oil cargoes. The coating condition is not less than 'GOOD' after 5 years.

ANNEX

TEST PROCEDURES FOR COATING QUALIFICATION FOR CARGO OIL TANKS OF CRUDE OIL TANKERS [AND PRODUCT TANKERS]

1 Scope

These Procedures provide details of the test procedures for cargo tank coatings for crude oil carriers, referred to in paragraphs 4.6 and 8.3 of this Standard.

2 Definitions

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

3 Background

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

- When the cargo tank is loaded there are three distinct vertical zones:
  - lowest part, and horizontal parts on stringer decks, etc., exposed to sea water that can be acidic and sludge that can contain anaerobic bacteria;
  - mid part where the oil cargo is in contact with all immersed steel;
  - vapour space where the air is saturated with various vapours from the loaded cargo tank like H_2S and various other gases as well as CO_2, SO_2 and other gases and compounds from the inert gas system.
- When the tank is in a ballast condition:
  - lowest part and horizontal parts on stringer decks, etc., exposed to cargo residues and sea water that can be acidic and sludge that can contain anaerobic bacteria;
  - tank space where the air contains various vapours from the crude oil residues like H_2S and various other gases as well as CO_2, SO_2 and other gases and compounds from the inert gas system.

3.2 It is further acknowledged that coating manufacturers undertake tests well in excess of the minimum stipulated herein. Each coating manufacturer will undertake additional tests at their own discretion in order to be satisfied that the coating will meet the designed target service life as per this standard. Where service conditions warrant the coating manufacturer will carry out additional tests such as flexibility and impacts tests, permeability, resistance to well designed cathodic protection and cyclic heating and cooling. These additional tests need not be presented for compliance with this standard. Compatibility of the zinc silicate shop primer is verified as

part of the coating system by the immersion and condensation tests of these procedures[12]. Based on many years' experience it is considered that the coating will be resistant to crude oil sequencing.

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 (Condensation chamber tests based on ISO 6270 – simulating the ballast condition as well as the vapour phase of the loaded tank) and Appendix 2 (Crude oil immersion test based on ISO 2812-1 – simulating the loaded condition). For carriage of cargoes not covered by the test requirements the coating manufacturer should be consulted.

5 Cargo oil samples

5.1 From a great number of crude oil samples three characteristics are selected for testing:

.1 High in H_2S (hydrogen sulphide):

Requirement for this type of crude oil: 300 ppm H_2S or higher as measured in the vapour phase of the crude[13]. Example: Qatar Export (see appendix).

.2 High acidity:

Requirement for this type of crude oil: Acid Value greater than 1 mg Potassium Hydroxide/g crude oil (ASTM D 664). Example: Harding (North Sea) (see annex 1).

.3 High BTX (Benzene/Toluene/Xylene) concentration in the crude oil:

Requirement for this type of crude oil: BTX concentration higher than 14 per cent by volume. The content of benzene, toluene and xylene (including ethyl benzene) shall be determined by gas chromatography/mass spectroscopy and/or gas chromatography with a flame ionization detector by suitable conditions according to standardized methods or accepted principles. Example: Oseberg or Statfjord (see annex 1).

5.2 The crude oils used as examples are believed to be representative for crude oil cargo characteristics. It cannot, however, be guaranteed that all samples of the above cargo oils obtained for testing will meet the stated requirements. The properties of the actual crude oil as regards the content of hydrogen sulphide, the acidity and contents of BTX are to be included in the report and the coating is regarded as pre-qualified for service within these limits. The coating manufacturer to be consulted for service beyond the actual test conditions.

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[12] When zinc silicate shop primer is mentioned in this standard it is understood that the shop primer is part of the coatings system and not the shop primer itself as this will not be resistant to water acidified by the crude oil cargo or inert gas.

[13] The amount of hydrogen sulphide to be determined by the method described in T. J. Gunner: "Hydrogen sulphide in bunkers and crude oil". INTERTANKO, June 2002. p. 1 – http://www.intertanko.com/pdf/weeklynews/Hydrogen.doc.

6 Inert gas composition

6.1 The test inert gas composition was composed of merging two different standards, ISGOTT and SIGTTO (see appendix 3).

INERT GAS CONDITION

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±50 ppm

6.2 This atmosphere can be artificially generated and is considered saturated with water after introduction into the condensation cabinet.

7 Repeatability, reproducibility and bias

7.1 The composition of crude oils is very variable with many different constituents that can contribute to properties such as high hydrogen sulphide content, high acid value, and high aromatic hydrocarbon content in the form of benzene, toluene, and xylene. To test all the variables is considered impossible and hence the test methods have been designed to evaluate the effects of the above noted properties on the coating systems in the aqueous phase, the crude oil immersion phase and the vapour phase taking into effect the presence of inert gas which can also vary in composition.

7.2 The results of the tests are hence specific to the test conditions and might not produce the same results if the composition of the crude oil and/or the composition of the inert gas are different from that tested.

7.3 The test methods have not been assessed in the laboratory, no “round robin” testing has been carried out, and hence no statements of repeatability, reproducibility, or bias can be made.

Appendix 1

CONDENSATION CHAMBER TEST

1 Test condition

1.1 Condensation chamber test shall be based on ISO 6270. The vapour environment is, however, modified to better 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 180 days.
2) Testing is to be carried out in duplicate.
3) The size of each test panel is 150 mm x 100 mm x 3 mm. The panels are to be treated according to the Performance Standard Table 1, 2 and 3, and the coating system applied according to Table 1, 1.d and 1.e.
4) The zinc silicate shop primer, when used, is to be weathered for at least 2 months and cleaned by low pressure washing or other mild method as defined by the product supplier. The exact method of shop primer preparation before being over coated shall be reported, and the judgment issued for that specific system. The test shall take into consideration that the system if approved shall be reasonably expected to provide a 15-year target useful life as defined in this standard. To facilitate innovation, alternative preparation, coating systems and dry film thicknesses may be used when clearly defined.
5) The reverse side and edges of the test piece shall be coated appropriately, in order not to influence the test results.
6) The vapour spaces inside the condensation chamber shall be filled with a mixture of inert gas as per item 6 of the standard and vapour from the crude oil mixture comprising one third of each crude oil type as follows:

INERT GAS CONDITIONS

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±50 ppm

1.2 This atmosphere can be artificially generated and is considered saturated with water after introduction into the condensation cabinet.

1.3 The crude oil vapour is obtained by placing an open glass container with the mixture of crude oil in the water bath. The amount of crude oil shall be 3 litres per cubic metre of cabinet volume, or pro-rata for cabinets of different volume. The surface area/oil volume ratio of the glass container(s) must be larger than 250 cm² per litre crude oil.

1.4 The inert gas environment and the crude oil vapour environment are to be maintained inside the condensation chamber during the full testing period. The test panels are located at the top of the test chamber. Water at the bottom evaporates and condenses on the test plates. Actual water temperature at the bottom of the chamber shall be 40±2ºC.

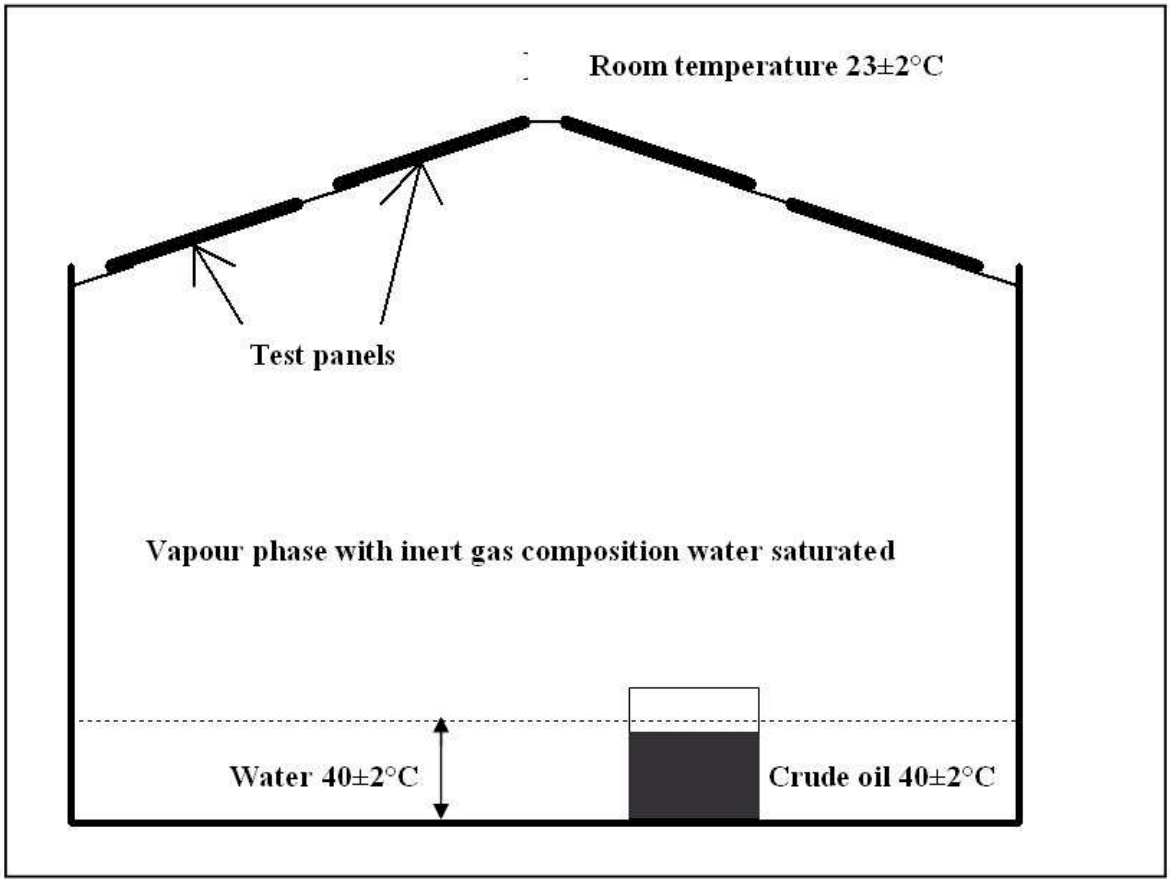

Figure 1 – Schematic example of condensation chamber

2 Test results

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

- Infrared (IR) identification of the base and hardener components of the coating;
- Specific gravity according to ISO 2811-1/4 of the base and hardener components of the paint;
- The coated panels should be inspected for pin holes using a 9V wet sponge pore detector and repaired appropriately;
- Mean dry film thickness (DFT) (6 readings using a template).

2.2 After the testing, the following measured data shall be reported:

- blisters and rust according to ISO 4628/2 and ISO 4628/3;
- adhesion value according to ISO 4624.

3 Acceptance criteria

3.1 The test results based on section 2 shall satisfy the following criteria:

Item	Acceptance criteria for epoxy based systems applied according to table 1 of this Standard	Acceptance criteria for alternative systems
Blisters on panel	No blisters	No blisters
Rust on panel	Ri 0 (0%)	Ri 0 (0%)
Number of pinholes	0	0
Adhesive failure Average of 3 measurements	> 3.5 MPa Adhesive failure between substrate and coating or between coats for 60% or more of the areas.	> 5 MPa Adhesive failure between substrate and coating or between coats for 60% or more of the areas.
Cohesive failure Average of 3 measurements	> 3 MPa Cohesive failure in coating for 40% or more of the area.	> 5 MPa Cohesive failure in coating for 40% or more of the area.

3.2 Epoxy based systems tested prior to the date of entry into force of this Standard shall satisfy only the criteria for blistering and rust in the table above.

3.3 Epoxy based systems tested when applied according to table 1 of this Standard shall satisfy the criteria for epoxy based systems as indicated in the table above.

3.4 Alternative systems not necessarily epoxy based and/or not necessarily applied according to table 1 of this Standard shall satisfy the criteria for alternative systems as indicated in the table above.

4 Test report

The test report shall include the following information:

.1 name of the manufacturer;
.2 date of tests;
.3 product name/identification of both paint and primer;
.4 batch number;
.5 data of surface preparation on steel panels, including the following:
- surface treatment;
- water soluble salts limit;
- dust; and
- abrasive inclusions;

.6 application data of coating system, including the following:
- shop primed;
- number of coats;
- recoat interval*
- dry film thickness (DFT) prior to testing;
- thinner
- humidity*;
- air temperature*; and
- steel temperature;

.7 test results according to section 2; and
.8 judgment according to section 3.

* Both of actual specimen data and manufacturer's requirements/recommendations.

Appendix 2

CRUDE OIL IMMERSION TEST

1 Test condition

1.1 Immersion test shall be based on ISO 2812-1 – Modified to simulate the conditions in a crude oil tank in loaded condition.

- Exposure shall be in three different crude oil types at 60ºC for a period of 180 days;

- Crude oil types, or equivalent, to be used:

Typical characteristic of the crude oil to be tested:

.1 High in H_2S (Hydrogen Sulphide):

Requirement for this type of crude oil: 300 ppm H_2S or higher as measured in the vapour phase of the crude[14]. Example: Qatar Export (see Appendix 3).

.2 High acidity:

Requirement for this type of crude oil: Acid Value greater than 1 mg Potassium Hydroxide/g crude oil (ASTM D 664). Example: Harding (North Sea) (see appendix 3).

.3 High BTX (Benzene/Toluene/Xylene) concentration in the crude oil:

Requirement for this type of crude oil: BTX concentration higher than 14 per cent by volume. The content of benzene, toluene and xylene (including ethyl benzene) shall be determined by gas chromatography/mass spectroscopy and/or gas chromatography with a flame ionization detector by suitable conditions according to standardized methods or accepted principles. Example: Oseberg or Statfjord (see Appendix 3).

1.2 The panels shall be exposed to three different conditions. Sea water condition, crude oil cargo condition, vapour space condition.

- The panels should be exposed to the water:oil:vapour phases in an area ratio of 2:10:3.
- The water phase to be obtained by preconditioning artificial sea water with crude oil by vigorously shaking to ensure that most of the water soluble components in the crude oil are present in the seawater zone.
- The pH of the water phase to be adjusted to 4.2 using sulphuric acid.
- The ratio water:oil for extraction shall be 1:20 by volume.
- The test container shall be purged with inert gas, closed and maintained at 60±3°C.
- For crude oils carried at higher temperatures the coating manufacturer should be consulted.

[14] The amount of hydrogen sulphide to be determined by the method described in T. J. Gunner: "Hydrogen sulphide in bunkers and crude oil". INTERTANKO, June 2002. p. 1 – http://www.intertanko.com/pdf/weeklynews/Hydrogen.doc.

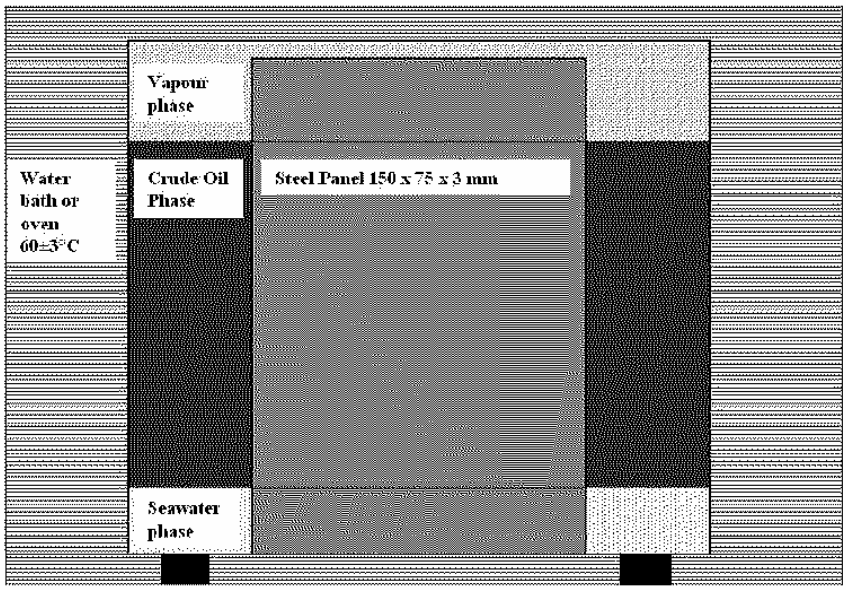

Figure 2 – Schematic example of immersion test set up

- Testing is to be carried out in duplicate for each crude oil sample;
- The size of each test panel is minimum150 mm x 75 mm x 3 mm;
- The panels are to be treated according to the Performance Standard Table 1, 2 and 3, and coating system applied according to Table 1, 1 .d and .e;
- The zinc silicate shop primer, when used, to be weathered for at least 2 months and cleaned by low pressure washing or other mild method as defined by the product supplier;
- The exact method of shop primer preparation before being over coated shall be reported, and the judgment issued for that specific system;
- The reverse side and edges of the test piece shall be painted appropriately, in order not to affect the test results.

1.3 The test shall take into consideration that the system if approved shall be reasonably expected to serve to a 15 years target life as defined in this standard. To facilitate innovation, alternative preparation, coating systems and dry film thicknesses may be used when clearly defined.

2 Test results

2.1 Prior to the testing, the following measured data of all of the coatings composing the coating system, including the zinc silicate shop primer, shall be reported:

- infrared (IR) identification of the base and hardener components of the coating;
- specific gravity according to ISO 2811-1/4 of the base and hardener components of the paint;
- coated panels should be inspected for pin holes using a 9V wet sponge pore detector and repaired appropriately;
- mean dry film thickness (DFT) (6 readings using a template).

2.2 After the testing, the following measured data shall be reported:

.1 blisters and rust for each of the three areas per panel according to ISO 4628/2 and ISO 4628/3;

3 Acceptance criteria

3.1 The test results based on section 2 shall satisfy the following criteria on the worst performing test panel (including all crude oil cargo samples):

Item	Acceptance criteria for epoxy based systems applied according to table 1 of this Standard	Acceptance criteria for alternative systems
Blisters on panel	No blisters	No blisters
Rust on panel	Ri 0 (0%)	Ri 0 (0%)

3.2 Epoxy based systems tested prior to the date of entry into force of this Standard shall satisfy only the criteria for blistering and rust in the table above.

3.3 Epoxy based systems tested when applied according to table 1 of this Standard shall satisfy the criteria for epoxy based systems as indicated in the table above.

3.4 Alternative systems not necessarily epoxy based and/or not necessarily applied according to table 1 of this Standard shall satisfy the criteria for alternative systems as indicated in the table above.

4 Test report

The test report shall include the following information:

.1 name of the manufacturer;
.2 date of tests;
.3 product name/identification of both paint and primer;
.4 batch number;
.5 data of surface preparation on steel panels, before zinc silicate shop primer application, and treatment of the shop primer before over coating where relevant, and otherwise as per ISO 8501, at a minimum including the following:
- surface treatment, or treatment of weathered zinc silicate shop primer, and
- any other important information on treatment influencing the performance;
- actual water soluble salts amount measured on the steel prior to application (ISO- 8502-6 and ISO 8502-9);
- dust observed; and
- abrasive inclusions observed;

.6 application data of coating system, including the following:
- shop primed;
- number of coats;
- recoat interval*
- dry film thickness (DFT) prior to testing;
- thinner*
- humidity;*
- air temperature*; and
- steel temperature;

.7 test results according to section 2; and
.8 judgment according to section 3.

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

Appendix 3

EXPLANATIONS OF CRUDE OIL SAMPLE SELECTION AND INERT GAS COMPOSITION

Establishment: Cross section of crude oils reviewed for testing consideration:

Crude Name	H_2S Vapour ppm	Acidity mg KOH/g
Arab Lt	50-100	
Brent Blend	approx 50	0.05
Djeno	above 200	1.10
Dubai Export	approx 40	
Es-Sider	approx 100	
Forozan	above 200	0.70
Iran Lt	approx 200	
Kuwait Export	approx 100	0.17
Maya	above 200	0.28
Olmeca	above 200	0.29
Qatarland	approx 200	
Qatarmarine	approx 200	
Qatar Export	approx 1000	
Syrian Blend	approx 200	
Ras Gharib		0.21
Khafji		0.26
Oman Export		0.25
Shengli		0.53 to 1.16
Cinta		0.49
Duri		1.19
Gullfaks		0.22
Harding		2.8
Helm		1.55
Oseberg		0.22

The compositions above are examples only and it cannot be guaranteed that samples obtained for testing will meet the criteria in section 5 of the annex.

Flue Gas Inert Gas Composition

Parameter	ISGOTT	SIGTTO
Nitrogen	83%	83%
CO_2	12-14%	13%
CO	Trace present	
Oxygen	2-4%	4%
SO_2	50 ppm	300 ppm
NO_x	200 ppm	present

An equation has been developed from the SIGTTO curve for water concentration of inert gas, which is dependent upon its temperature. This equation is not used in this test protocol, as the test gas shall be saturated with water vapour to ensure that the coating is exposed to a liquid condensation phase.

Appendix 4

PRECAUTIONS REGARDING THE USE OF DANGEROUS GASES

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

Sulphur Dioxide: Corrosive when wet, toxic if inhaled, causes burns, and is an irritant to the eyes and respiratory system.

Hydrogen Sulphide: Highly flammable (Flash point -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 5ppm, STEL 10ppm, higher concentrations can be fatal and have no odour.

2 Repeated exposure to low concentrations can result in the sense of smell for the gas being diminished.

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

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

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