INTRODUCTION

1 The Working Group on Performance Standards for Protective Coatings met from 5 to 7 March 2007 under the chairmanship of Mr. W. Lundy (United States).

2 The group was attended by delegations from the following Member Governments:

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<th>Country</th>
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<td>BAHAMAS</td>
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<td>BRAZIL</td>
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<td>CHINA</td>
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<td>DENMARK</td>
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<td>GREECE</td>
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<td>IRAN (ISLAMIC REPUBLIC OF)</td>
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<td>REPUBLIC OF KOREA</td>
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<td>SAUDI ARABIA</td>
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<td>SPAIN</td>
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<td>UNITED KINGDOM</td>
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<td>UNITED STATES</td>
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the following Associate Member of IMO:

HONG KONG, CHINA

and observers from the following non-governmental organizations:

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<thead>
<tr>
<th>Organization</th>
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<tr>
<td>BIMCO</td>
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<tr>
<td>INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)</td>
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<tr>
<td>EUROPEAN CHEMICAL INDUSTRY COUNCIL (CEFIC)</td>
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<tr>
<td>COMMUNITY OF EUROPEAN SHIPYARDS’ ASSOCIATIONS (CESA)</td>
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<tr>
<td>INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS (INTERTANKO)</td>
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<tr>
<td>THE ROYAL INSTITUTION OF NAVAL ARCHITECTS (RINA)</td>
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TERMS OF REFERENCE

3 The group was instructed, taking into account comments made and decisions taken in plenary, to:

.1 finalize the draft performance standard for protective coatings for void spaces on bulk carriers and oil tankers on the basis of the report of the correspondence group (DE 50/4), taking into account documents DE 50/4/1, DE 50/4/2, DE 50/4/3, DE 50/INF.3 and DE 50/INF.5;
.2 finalize the categorization of void spaces including alternative approaches for the consideration of the Sub-Committee and advise whether this should become part of the performance standard;

.3 consider whether a correspondence group should be established and, if so, prepare terms of reference for the group;

.4 submit a report to plenary on Thursday, 8 March 2007.

4 The group had for its consideration documents submitted by China (DE 50/4/3 and DE 50/INF.5), Japan (DE 50/4/1 and DE 50/INF.3) and CESA (DE 50/4/2).

DISCUSSION

5 In starting consideration of the development of the draft Performance standard, the group recalled the Sub-Committee’s discussion and agreed to to develop the standard with the assumption that it would be mandatory. The group also recognized that if the Sub-Committee finds it appropriate that the standard should not be made mandatory then further revisions would be necessary.

Void spaces to be considered

6 Having considered the report of the correspondence group (DE 50/4) regarding void spaces to be considered under the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers, the majority of the group agreed to the classification of void spaces, as set out in annex 2, tables 1 (Void spaces in bulk carriers) and 2 (Void spaces in oil tankers), for consideration of the Sub-Committee, and as defined in section 2.14 of the draft Performance standard, set out in annex 1.

Categorization of void spaces

7 Based on the void spaces to be considered under the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers (see annex 2 to the report), the group categorized the void spaces, as follows:

.1 void spaces to be coated 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));

.2 void spaces to be coated in accordance with the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers; and

.3 void spaces to which the Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers and the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers do not apply.

8 The majority of the group agreed to the categorization of the spaces, as set out in annex 2, table 1 (Void spaces in bulk carriers) and table 2 (Void spaces in oil tankers), some members of the group did not agree with the complete categorization and, therefore, with which standard to be applied to specific void spaces. The delegation of Greece strongly advocated the coating of
bulkheads stools spaces, which was supported by the delegation of Bahamas. The observer from RINA stated that they did not agree with the decision to allow bulkhead stools on bulk carriers to be categorized as totally closed (dead) spaces, inaccessible for inspection and exempt from any coating requirement.

9 The delegation of Greece strongly objected to the development of totally enclosed spaces located behind gusset and shedder plates at the bottom of corrugated bulkheads as these will be potential explosive spaces and stated that class rules do not allow such spaces without inspection holes covered by removable plugs. Furthermore, the delegation reiterated its consideration that lower stools and upper stools of bulkheads in bulk carriers and oil tankers are extremely important primary structural members for the support of double bottoms and deck structure for the ship survivability where moist and temperature produce a highly corrosive atmosphere and reduced CSR corrosion additions apply. Therefore, the Greek delegation supported by INTERTANKO proposed that items 1.4.2, 1.5.2, 2.7 and 2.8 in tables 1 and 2 of annex 2 should be required to be coated to the PSPC/DSBWT standard and paragraph 4.2 (Application) of the draft Performance standard should be amended accordingly.

10 Notwithstanding the above, the group amended item 4.2 (Standard application) of the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers, as set out in annex 1, to reflect the categorization of void spaces as agreed by the group. As part of this effort, the group recognized that the draft standard for void spaces will be different from those for ballast water tanks since the environmental conditions will not be as harsh. Therefore, the focus of the group’s efforts were on writing a standard for void spaces and not replicating the ballast water tank standard for void spaces.

Draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers

Coating technical file

11 The group decided to retain the square brackets around paragraphs 3.2 and 3.4 regarding Coating Technical File (CFT) in light of the Sub-Committee’s pending discussion on whether this standard would be mandatory or non-mandatory. The group determined that if it is decided that the standard should be non-mandatory, then the requirements for a Coating Technical File should be deleted. The BIMCO observer, supported by the delegation of Greece, also proposed that if the CTF is retained, that conditions for maintenance in paragraphs 3.4.3 to 3.4.5 be deleted, in light of the fact that this is a new building standard. The CESA observer, supported by several delegations, proposed to maintain paragraphs 3.4.3 to 3.4.5 to ensure consistency of the General Principles in both standards, although, the technical requirements differ between PSPC/DSBWT and PSPC/VS. The delegation of Bahamas added that feedback from the ship operation phase is needed in order to access the coating performance in service. IACS, supported by other delegations, had proposed a summary of the DFT readings, instead of detailed readings.

Job specification

12 In considering the minimum coating requirements and the job specification (paragraph 1.d of table 1), the group had two proposals, one proposal was one stripe coat and one spray coat and the other one stripe coat and two spray coats. There was concern by some members that using one stripe coat and one spray coat combination could result in “holidays” (uncoated spots) in the coating, which could lead to corrosion. Other member stated that from their experiences they have not found any significant coating failures using a one stripe coat and
one spray coat combination in void spaces. These members considered that one spray and one stripe coat should be a minimum requirement and multi-spray coats should be applied if the product requires multi-spray coats to achieve the specified dry film thickness. Consequently, the group remained with the two proposals for the Sub-Committee to decide as appropriate.

Nominal total dry film thickness (NDFT)

13 Having considered the report of the correspondence group (DE 50/4), the group agreed to the NDFT of 200 µm with 90/10 rule. Some members considered that the 80/20 rule would be appropriate for void spaces. Some members noted that 200 µm is not compatible with the test in annex 1 to the draft Performance standard, if the exposure time limit in paragraph 3.1.1 is maintained at 180 days and, therefore, supported 240 µm or a reduction of the exposure time to 30 days for compatibility with the tests required (see paragraph 18). The delegation of Greece stated that 240 µm in two spray and one stripe coat with 90/10 rule should be required as a minimum to safeguard a target useful life of 15 years, which is required by the present standard.

Water soluble salt limit

14 Having considered the water soluble salt limit equivalent to NaCl, in table 1 (Basic coating system requirements for void spaces in bulk carriers and oil tankers), item .2.b, some members had concerns about correctness of the text, which reads: “≤ 50 mg/m² of sodium chloride”. Some members were of opinion that the words “of sodium chloride” should be deleted to have the same water soluble salt limit as previously agreed. A clear majority of the members were of the opinion that the words “of sodium chloride” should remain in the text as the section was technically correct. Several delegations were of the opinion that the level of 50 mg/ m² was too stringent for void spaces, and consequently the requirement in Table 1, item .3.f was changed to 100 mg/ m², whereas the levels in Table 1, item .2.b were maintained at 50 mg/m².

Secondary surface preparation – surface treatment

15 Having considered the secondary surface preparation (surface treatment), in table 1 (Basic coating system requirements for void spaces in bulk carriers and oil tankers), item .3.b, some members were of the opinion that a very good surface preparation is important to guarantee that the coating will have an acceptable adherence to the surface, preventing corrosion in the contact area. The observer from CEFIC stated that from analysis of coating applications in ballast tanks they did not find any statistical correlation between the secondary surface preparation and corrosion. Therefore, the majority of the group agreed that for damaged shop primer, the surface treatment should be Sa 2 or St 3 on damaged shop primer and welds. Few members did not consider that the surface treatment proposed was adequate for void spaces, taking into consideration the 15 years life time. To this end, the delegation of Greece stated that Sa 2 ½ standard only should be required on damaged shop primer and welds.

Coating inspection requirements

16 The group recalled discussion in plenary at MSC 81, when IACS stated that it was not possible for its members to provide coating inspections as a standard service. In that regard, the delegation of Greece indicated that some IACS members are already inspecting coatings and issuing class notations. The observer from IACS responded that as stated previously, that IACS members are not performing inspections of coatings in accordance with the standards developed by the Organization. Individual members may include surveys or inspections on a sample basis, in accordance with additional voluntary class notations based upon their own rules.
Alternative systems

17 The group considered the Japanese proposal (DE 50/4/1) to amend item 8 (alternative systems) of the draft Performance standard, to allow Administrations to perform 5 years field test of alternative systems, and decided not to amend the draft Performance standard, based on the possible implications of having a ship without an approved coating protection system for such a long period. The group also noted that there was a provision in SOLAS chapter 1, part A, regulation 4(b) which allows exemptions.

Test procedure for coating qualification for void spaces of bulk carriers and oil tankers

18 Having considered annex 1 to the draft Performance standard, a number of members of the group expressed the need to reduce the exposure time to 30 days, based on the standard ISO 12944-6:1998 (Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 6: Laboratory performance test methods) and the Chinese National Standards (1000 hours), the relevant sections of the standard ISO 12944-6:1998 are set out in annex 3. However, other members stated that the coating material used is the same for ballast water tanks and void spaces, therefore, only one test method is required for those spaces and it has already been adopted by resolution MSC.215(82). Notwithstanding the above, the group decided to amend annex 1 to the draft Performance standard for 30 days exposure time to be consistent with the DFT requirements (see paragraph 13) and also to have 3 test panels, instead of 2, to be consistent with the surface treatment agreed by the group (see paragraph 15). The delegation of Greece note that the aforementioned ISO standard refers to land and offshore structures and not to ships, and therefore, stated that the exposure time in annex 1 should remain 180 days to simulate longevity of 15 years in actual ship condition.

Dry film thickness measurements

19 Having considered the dry film thickness measurements (annex 3 to the draft Performance standard), some members supported CESA’s proposal (DE 50/4/2) to delete annex 3 and make measurements according to the standard on Paint application specification No. 2 – Measurement of dry coating thickness with magnetic gages (SSPC-PA2), based on the fact that annex 3 implies a too high number of measurements that does not necessarily result in better inspection results. Other members supported the method in annex 3, based on the fact that annex 3 specifies critical measurement points on the actual structure of bulk carriers and oil tankers, while the standard SSPC-PA2 uses a statistical approach, defines the measurements on random points, and generally requires significantly less measurements. The standard SSPC-PA2 is set out in annex 4 for information.

20 After an extensive discussion, the group prepared the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers, and associated draft MSC resolution, as set out in annex 1, for consideration by the Sub-Committee with a view to submission to MSC 83 for adoption, bearing in mind the relevant decision on the mandatory status.

Establishment of a correspondence group

21 The group considered the terms of reference for a correspondence group, and having finalized its work on this item and having agreed that there was no need to develop standards for spaces on other ship types, recommended that there is no need to re-establish the correspondence group.
ACTION REQUESTED OF THE SUB-COMMITTEE

22 The Sub-Committee is invited to approve the report in general and, in particular, to:

.1 consider whether the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers should be made mandatory and take action as appropriate (paragraph 5);

.2 note that if the decision in subparagraph .1 above is to make the draft Performance standard non-mandatory then revisions to the draft Performance standards are necessary (paragraph 5);

.3 consider the group’s decision regarding the classification of void spaces to be considered under the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers and take action as appropriate (paragraph 6 and annex 2);

.4 note the group’s decisions regarding the categorization of void spaces (paragraphs 7 to 10 and annex 2);

.5 decide on the number of spray coats in item .1.d of table 1 of the draft Performance standard (paragraph 12);

.6 agree to the draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers, and associated draft MSC resolution for submission to MSC 83 for adoption (paragraphs 11 to 20 and annex 1); and

.7 endorse the group’s recommendations regarding the establishment of the correspondence group (paragraph 21).

***
ANNEX 1

DRAFT RESOLUTION MSC.[…](83)
(adopted on … October 2007)

ADOPTION OF PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR VOID SPACES ON BULK CARRIERS AND 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 that it adopted the Performance standard for protective coatings for dedicated seawater ballast tanks and double-side skin spaces and SOLAS regulation II-1/3-7 to make the performance standard mandatory;

RECOGNIZING the need to also develop the Performance standard for protective coatings for void spaces on bulk carriers and oil tankers,

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

1. ADOPTS the Performance standard for protective coatings for void spaces on bulk carriers and oil tankers, the text of which is set out in the annex to the present resolution;

2. INVITES Contracting Governments to the Convention to apply the Performance standard for protective coatings for void spaces when installing the protective coating on bulk carriers and oil tankers.
ANNEX

PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR VOID SPACES ON BULK CARRIERS AND OIL TANKERS

1 PURPOSE

This Standard provides technical requirements for protective coatings in void spaces constructed of steel in bulk carriers and oil tankers.

2 DEFINITIONS

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

2.1 Dew point is the temperature at which air is saturated with moisture.

2.2 DFT is dry film thickness.

2.3 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.

2.4 Edge grinding is the treatment of edge before secondary surface preparation.

2.5 “GOOD” condition is the condition with minor spot rusting as defined in resolution A.744(18).

2.6 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.

2.7 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.

2.8 Primer coat is the first coat of the coating system applied in the shipyard after shop primer application.

2.9 Shop-primer is the prefabrication primer coating applied to steel plates, often in automatic plants (and before the first coat of a coating system).

2.10 Stripe coating is painting of edges, welds, hard to reach areas, etc., to ensure good paint adhesion and proper paint thickness in critical areas.

2.11 Target useful life is the target value, in years, of the durability for which the coating system is designed.

2.12 Technical Data Sheet is paint manufacturers’ Product Data Sheet which contains detailed technical instruction and information relevant to the coating and its application.
2.13  *Totally enclosed space* is a space which has no means of access and no ventilation.

2.14  *Void space* is an enclosed space below the bulkhead deck, within and forward of, the cargo area of oil tankers or the cargo length area of bulk carriers, excluding:

1. a dedicated seawater ballast tank;
2. a space for the carriage of cargo;
3. a space for the storage of any substance (e.g. oil fuel, fresh water, provisions);
4. a space for the installation of any machinery (e.g. cargo pump, ballast pump, bow thruster);
5. any space in normal use by personnel; and
6. a double-side skin space of bulk carriers of 150 m in length and upwards which shall comply with the Performance standard for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers adopted by MSC.215(82).

For the purpose of this regulation, “cargo area” and “cargo length area” are as defined in resolution A.744(18).

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, 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; 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

3.4.1 Specification of the coating system applied to void spaces in bulk carriers and oil tankers, record of the shipyard’s and shipowner’s coating work, detailed criteria for coating selection, job specifications, inspection, maintenance and repair shall be documented in the Coating Technical File, and the Coating Technical File shall be reviewed by the Administration or an organization recognized by the Administration.

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 space and area (in square metres) of each void space;
   - applied coating system;
   - time of coating, thickness, number of layers, etc.;
   - ambient condition during coating; and
   - method 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 annex 2);

.6 shipyard’s verified inspection report, including:
   - completion date of inspection;
   - result of inspection;
   - remarks (if given);
   - inspector signature; and

.7 procedures for in-service maintenance and repair of coating system.
3.4.3 Maintenance, repair and partial re-coating

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.

4 COATING STANDARD

4.1 Performance standard

This Standard is based on specifications and requirements which intend 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

4.2.1 Protective coatings for the following void spaces shall comply with the requirements in this Standard:

.1 in bulk carriers:
   .1 double bottom pipe passages / pipe tunnels;
   .2 small void spaces located behind gusset or shredder plates at the bottom of corrugation bulkheads with the exception of totally enclosed spaces;
   .3 other small void spaces in cargo tanks, with the exception of totally enclosed spaces;
   .4 lower transverse stool of transverse bulkheads, with the exception of totally enclosed spaces; and
   .5 upper transverse stool of transverse bulkheads, with the exception of totally enclosed spaces; and

* Guidelines to be developed by the Organization.
4.2.2 Protective coatings for the following void spaces shall comply with the requirements in Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers (MSC.215(82)):

.1 in bulk carriers:
   .1 double-side skin spaces in ships of less than 150 m in length; and
   .2 upper and lower side void spaces and double bottoms void spaces in cargo area; and

.2 in oil tankers:
   .1 DSS (double side skin) voids including sides, bottoms/double hull voids spaces protecting cargo oil tanks.

4.2.3 No requirements are made in this standard for protective coatings for the following void spaces in oil tankers and bulk carriers:

.1 totally enclosed spaces located behind gusset or shedder plates at the bottom of corrugation bulkheads and other small totally enclosed spaces in cargo tanks;
.2 lower transverse stool of transverse bulkheads that are totally enclosed spaces;
.3 upper transverse stool of transverse bulkheads that are totally enclosed spaces;
.4 transducer voids; and
.5 any spaces not specifically mentioned in paragraphs 4.2.1 and 4.2.2.

4.3 Special application

4.3.1 This Standard covers protective coating requirements for the ship steel structure. It is noted that other independent items are fitted within the tanks to which coatings are applied to provide protection against corrosion.
4.3.2 It is recommended that this Standard is to be applied to the extent possible, to those portions of permanent means of access provided for inspection, not integral to the ship 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 ship structure, such as increased stiffener depths for walkways, stringers, etc. are to fully comply with this Standard.

4.3.3 It is also recommended that supports for piping, measuring devices, etc., be coated in accordance with the non-integral items indicated in 4.3.2.

4.4 Basic coating requirements

4.4.1 The requirements for protective coating systems to be applied at ship construction for void spaces in bulk carriers and oil tankers meeting the performance standard specified in paragraph 4.1 are listed in table 1.

4.4.2 Coating manufacturers shall provide a specification of the protective coating system to satisfy the requirements of table 1.

4.4.3 The Administration or an organization recognized by the Administration shall verify the Technical Data Sheet and Statement of Compliance or Type Approval Certificate for the protective coating system.

4.4.4 The shipyard shall apply the protective coating in accordance with the verified Technical Data Sheet and its own verified application procedures.
Table 1 - Basic coating system requirements for void spaces in bulk carriers and oil tankers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
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<tbody>
<tr>
<td>.1 Design of coating system</td>
<td>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:</td>
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<tr>
<td>.a Selection of the coating system</td>
<td>.1 location of space relative to heated surfaces;</td>
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<td></td>
<td>.2 required surface conditions;</td>
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<td></td>
<td>.3 required surface cleanliness and dryness;</td>
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<td>.4 relative humidity;</td>
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<td></td>
<td>.5 access and maintenance;</td>
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<td></td>
<td>.6 mechanical ventilation;</td>
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<td></td>
<td>Coating manufacturers shall have products with documented satisfactory performance records and technical data sheets. The manufacturers should also be capable of rendering adequate technical assistance. Performance records, technical data sheet and technical assistance (if given) shall be recorded in the Coating Technical File.</td>
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<tr>
<td></td>
<td>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.</td>
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<tr>
<td>.b Coating type</td>
<td>Epoxy-based systems.</td>
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<td></td>
<td>Other coating systems with performance according to the test procedure in annex 1.</td>
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<td></td>
<td>When a multi-coat system is applied, contrasting colour is recommended for each coat.</td>
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<td></td>
<td>The top coat shall be of a light colour in order to facilitate in-service inspection.</td>
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<tr>
<td>Characteristic</td>
<td>Requirement</td>
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<tr>
<td>.c Coating pre-qualification test</td>
<td>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 may be accepted; or any coating system which meets the requirements in table 1.1.3 of the Performance standard for protective coating for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers adopted by resolution MSC.215(82), is accepted and may be applied in accordance with this Standard; or which have been documented field exposure for 5 years with a final coating condition of not less than “GOOD” may also be accepted. For other systems, including epoxy based systems tested after the entry into force of this standard, testing according to the procedure in annex 1 to this Standard.</td>
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<tr>
<td>.d Job specification</td>
<td>There shall be a minimum of one stripe coat and [one] [two] spray coat. The stripe coat shall be applied on thermally cut free edges and small holes only. Surface contaminants such as rust, grease, dust, salt, oil, etc. shall be removed prior to painting with proper method according to the paint manufacturer’s recommendation. Abrasive inclusions embedded in the coating shall be removed. Job specifications shall include the dry-to-recoat times and walk-on time given by the manufacturer.</td>
</tr>
<tr>
<td>.e NDFT (nominal total dry film thickness)</td>
<td>NDFT 200 µm 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 thickness in an exaggerated way. Wet film thickness shall be regularly checked during application. Thinner shall be limited to those types and quantities recommended by the manufacturer.</td>
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1 Type of gauge and calibration in accordance with SSPC-PA2:2004. Paint Application Specification No.2.
###Characteristic Requirement

<table>
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<tr>
<th>Characteristic</th>
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<tr>
<td>.2 PSP (Primary Surface Preparation)</td>
<td></td>
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<tr>
<td>.a Blasting and profile²³</td>
<td>Sa 2½; with profiles between 30-75 µm.</td>
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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, in accordance with the manufacturer’s recommendations.

| .b Water soluble salt limit equivalent to NaCl⁴ | ≤ 50 mg/m² of sodium chloride. |
| .c Shop primer | Zinc containing inhibitor free zinc silicate based or equivalent. |
| Compatibility with main coating system shall be confirmed by the coating manufacturer. |

###Secondary surface preparation

| .a Steel condition | The steel surface 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 contaminant⁵. |

Edges to be smooth, subject to one pass grinding or at least equivalent process before painting⁶.

---


<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| .b Surface treatment<sup>2</sup> | For damaged shop primer:  
Sa 2 or St 3 on damaged shop primer and welds;  
For intact shop primer:  
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. The retained shop primer shall be cleaned by sweep blasting, high pressure water washing or other methods in accordance with the manufacturer’s recommendation.  
If a zinc silicate shop primer has passed the pre-qualification test of table 1.1.c as part of an epoxy coating system, it may be used in combination with other epoxy coatings certified under table 1.1.c, provided that the compatibility has been confirmed by the manufacturer by the test in accordance with paragraph 1.7 of appendix 1 to annex 1 of the Performance standard for protective coating for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers without wave movement. |
| .c Surface treatment after erection<sup>2</sup> | St 3 or better or Sa 2 where practicable on butts and damages.  
Coating in overlap to be feathered. |
| .d Profile requirements<sup>3</sup> | In case of full or partial blasting 30-75 µm, otherwise as recommended by the coating manufacturer. |
| .e Dust<sup>7</sup> | Dust quantity rating “2” for dust size class “3”, “4” and “5”. |
| .f Water soluble salts limit equivalent to NaCl after blasting/grinding<sup>4</sup> | ≤ 100 mg/m² of sodium chloride. |

### Characteristic Requirement

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>.g Oil contamination</td>
<td>No oil contamination.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>.4 Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>.a Ventilation</td>
</tr>
</tbody>
</table>
| .b 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. |
| .c Testing of coating | Destructive testing should be avoided.  
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. |
| .d 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 1.1.c) 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 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 section 6.2 to

---

8 In accordance with SOLAS regulation I/6, for the purposes of this Standard, the Administration may entrust a recognized organization acting on its behalf to determine compliance with the provisions of this Standard.
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 (refer to annex 2, Example of Daily Log and Non-conformity Report).

6.2 Inspection items

<table>
<thead>
<tr>
<th>Construction stage</th>
<th>Inspection items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary surface preparation</td>
<td>a. 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.</td>
</tr>
<tr>
<td></td>
<td>b. The surface of steel plates shall be tested for soluble salt checked for oil, grease and other contamination.</td>
</tr>
<tr>
<td></td>
<td>c. The cleanliness of the steel surface shall be monitored in the shop primer application process.</td>
</tr>
<tr>
<td></td>
<td>d. The shop primer material shall be confirmed to meet the requirements of 2.c of Table 1.</td>
</tr>
<tr>
<td>Thickness</td>
<td>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.</td>
</tr>
<tr>
<td>Block assembly</td>
<td>a. 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.</td>
</tr>
<tr>
<td></td>
<td>Any oil, grease or other visible contamination to be removed.</td>
</tr>
<tr>
<td></td>
<td>b. After blasting/grinding/cleaning and prior to coating, a visual inspection of the prepared surface shall be carried out.</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>c. The surface temperature, the relative humidity and the dew point shall be monitored and recorded during the coating application and curing.</td>
</tr>
<tr>
<td></td>
<td>d. Inspection to be performed of the steps in the coating application process mentioned in Table 1.</td>
</tr>
</tbody>
</table>
### Construction stage

<table>
<thead>
<tr>
<th>Inspection items</th>
</tr>
</thead>
<tbody>
<tr>
<td>e DFT measurements shall be taken to prove that the coating has been applied</td>
</tr>
<tr>
<td>to the thickness as specified and outlined in annex 3.</td>
</tr>
</tbody>
</table>

### Erection

<table>
<thead>
<tr>
<th>Inspection items</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Visual inspection for steel surface condition, surface preparation and</td>
</tr>
<tr>
<td>verification of conformance to other requirements in Table 1, and the agreed</td>
</tr>
<tr>
<td>specification to be performed.</td>
</tr>
<tr>
<td>b The surface temperature, the relative humidity and the dew point shall be</td>
</tr>
<tr>
<td>measured and recorded before coating starts and regularly during the coating</td>
</tr>
<tr>
<td>process.</td>
</tr>
<tr>
<td>c Inspection to be performed of the steps in the coating application process</td>
</tr>
<tr>
<td>mentioned in Table 1.</td>
</tr>
</tbody>
</table>

7 **VERIFICATION REQUIREMENTS**

The following shall be carried out by the Administration or recognized organization 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 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 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.
8.4 As a minimum, the documented evidence shall consist of satisfactory performance corresponding to that of a coating system which conforms to the Coating Standard described in section 4, a target useful life of 15 years in either actual field exposure for five years with final coating condition not less than “GOOD” or laboratory testing. Laboratory test shall be conducted in accordance with the test procedure given in annex 1 of this Standard.
TEST PROCEDURE FOR COATING QUALIFICATION FOR VOID SPACES OF BULK CARRIERS AND OIL TANKERS

1 Scope

This Procedure provides details of the test procedure referred to in paragraphs 5 and 8.3 of this Standard.

2 Definition

*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 Test

Coating specification shall be verified by a Condensation chamber test in accordance with the procedures specified in this section.

3.1 Test condition

Condensation chamber test shall be conducted in accordance with ISO 6270.

.1 The exposure time is 30 days.

.2 There are to be 3 test panels.

.3 The size of each test panel is 150 mm x 150 mm x 3 mm. All of 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 1.1.e. At the primer stage, two of the panels are to be weathered for at least 2 months and cleaned by low pressure washing or other mild method. Blast sweep or high pressure washing, or other primer removal methods not to be used. The third plate is to have the primer removed to St3 before the top coat is applied. Weathering method and extent shall take into consideration that the primer is to be the foundation for a 15 year target life system. To facilitate innovation, alternative preparation, coating systems and dry film thicknesses may be used when clearly defined.

.4 The reverse side of the test piece shall be painted appropriately, in order not to affect the test results.
3.2 Test results

3.2.1 Prior to the testing, the following measured data of the coating system shall be reported:

.1 infrared (IR) identification of the base and hardener components of the coating;

.2 specific gravity, according to ISO 2811-74, of the base and hardener components of the paint; and

.3 number of pinholes, low voltage detector at 90 Volt.

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

.1 blisters and rust according to ISO 4628/2 and ISO 4628/3;

.2 dry film thickness (DFT) (use of a template);

.3 adhesion value according to ISO 4624;

.4 flexibility according to ASTM D4145, modified according to panel thickness (3 mm steel, 300 µm coating, 150 mm cylindrical mandrel gives 2% elongation) for information only.
3.3 Acceptance criteria

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Acceptance criteria for epoxy based systems applied according to table 1 of this standard</th>
<th>Acceptance criteria for alternative systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blisters on panel</td>
<td>No blisters</td>
<td>No blisters</td>
</tr>
<tr>
<td>Rust on panel</td>
<td>Ri 0 (0%)</td>
<td>Ri 0 (0%)</td>
</tr>
<tr>
<td>Number of pinholes</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adhesive failure</td>
<td>&gt; 3.5 MPa</td>
<td>&gt; 5.0 MPa</td>
</tr>
<tr>
<td></td>
<td>Adhesive failure between substrate and coating or between coats for 60% or more of the areas</td>
<td>Adhesive failure between substrate and coating or between coats for 60% or more of the areas</td>
</tr>
<tr>
<td>Cohesive failure</td>
<td>&gt; 3.0 MPa</td>
<td>&gt; 5.0 MPa</td>
</tr>
<tr>
<td></td>
<td>Cohesive failure in coating for 40% or more of the area</td>
<td>Cohesive failure in coating for 40% or more of the area</td>
</tr>
</tbody>
</table>

3.3.2 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.

3.3.3 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.

3.3.4 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.

3.4 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;

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

.7 test results according to section 2; and

.8 judgment according to section 3.
### EXAMPLE OF DAILY LOG AND NON-CONFORMITY REPORT

#### DAILY LOG

<table>
<thead>
<tr>
<th>Ship:</th>
<th>Void No:</th>
<th>Database:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Part of structure:**

#### SURFACE PREPARATION

<table>
<thead>
<tr>
<th>Method:</th>
<th>Area (m²):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abrasive:</th>
<th>Grain size:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface temperature:</th>
<th>Air temperature:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relative humidity (max):</th>
<th>Dew point:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Standard achieved:**

**Rounding of edges:**

**Comments:**

---

<table>
<thead>
<tr>
<th>Job No.:</th>
<th>Date:</th>
<th>Signature:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### COATING APPLICATION:

**Method:**

<table>
<thead>
<tr>
<th>Coat No.</th>
<th>System</th>
<th>Batch No.</th>
<th>Date</th>
<th>Air temp.</th>
<th>Surf temp.</th>
<th>RH%</th>
<th>Dew point</th>
<th>DFT* Meas.*</th>
<th>Specified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Measured minimum and maximum DFT. DFT readings to be attached to daily log

**Comments:**

---

<table>
<thead>
<tr>
<th>Job No.:</th>
<th>Date:</th>
<th>Signature:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## NON-CONFORMITY REPORT

<table>
<thead>
<tr>
<th>Ship:</th>
<th>Void No:</th>
<th>Database:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part of structure:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DESCRIPTION OF THE INSPECTION FINDINGS TO BE CORRECTED

**Description of findings:**

**Reference document (daily log):**

**Action taken:**

<table>
<thead>
<tr>
<th>Job No.:</th>
<th>Date:</th>
<th>Signature:</th>
</tr>
</thead>
</table>
ANNEX 3

DRY FILM THICKNESS MEASUREMENTS

The following verification check points of DFT are to be taken:

.1 one gauge reading per 5 m² of flat surface areas;

.2 one gauge reading at 2 to 3 metre intervals and as close as possible to tank boundaries, but not further than 15 mm from edges of tank boundaries;

.3 longitudinal and transverse stiffener members:

One set of gauge readings as shown below, taken at 2 to 3 metres run and not less than two sets between primary support members;

![Diagram of Primary support members and Longitudinal and transverse stiffeners]

*Note:* Arrows of diagram indicate critical areas and should be understood to mean indication for both sides.

.4 three gauge readings for each set of primary support members and two gauge readings for each set of other members as indicated by the arrows in the diagram;

.5 for primary support members (girders and transverses) one set of gauge readings for 2 to 3 metres run as shown in figure 3 above but not less than three sets;

.6 around openings one gauge reading from each side of the opening;

.7 five gauge readings per square metre (m²) but not less than three gauge readings taken at complex areas (i.e. large brackets of primary support members); and

.8 Additional spot checks to be taken to verify coating thickness for any area considered necessary by the coating inspector.

***
ANNEX 2

CATEGORIZATION OF VOID SPACES IN BULK CARRIERS AND OIL TANKERS

Table 1 – Void spaces in bulk carriers

<table>
<thead>
<tr>
<th>No</th>
<th>Void spaces</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Double-side skin space (For ships L &lt; 150m)</td>
<td>PSPC/DSBWT</td>
</tr>
<tr>
<td>1.2</td>
<td>Double bottom pipe passage/ Pipe tunnel</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>1.3</td>
<td>Small void spaces located behind gusset or shedder plates at the bottom of corrugation bulkheads and other small void spaces in cargo area</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>.1 totally enclosed space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.2 [non totally enclosed space]</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>1.4</td>
<td>Lower transverse stool of transverse bulkheads</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>.1 totally enclosed space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.2 [non totally enclosed space]</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>1.5</td>
<td>Upper transverse stool of transverse bulkheads</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>.1 totally enclosed space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.2 [non totally enclosed space]</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>1.6</td>
<td>Top wing void and hopper void spaces and double bottoms in cargo area (see figure 1)</td>
<td>PSPC/DSBWT</td>
</tr>
</tbody>
</table>

Table 2 – Void spaces in oil tankers

<table>
<thead>
<tr>
<th>No</th>
<th>Void spaces</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Fwd cofferdam/Cofferdams separating cargo tank from forepeak</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>2.2</td>
<td>Cofferdam in cargo area/Cofferdams separating incompatible cargoes</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>2.3</td>
<td>Aft cofferdam</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>2.4</td>
<td>DSS (Double Side Skin) voids- includes sides, bottoms/Double hull void space protecting COT</td>
<td>PSPC/DSBWT</td>
</tr>
<tr>
<td>2.5</td>
<td>Transducer voids (if any)</td>
<td>NR</td>
</tr>
<tr>
<td>2.6</td>
<td>Duct Keel/Pipe tunnels</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>2.7</td>
<td>Lower bulkhead stools</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>2.8</td>
<td>Upper bulkhead stools</td>
<td>PSPC/VS</td>
</tr>
<tr>
<td>2.9</td>
<td>Small void spaces located behind gusset or shedder plates at the bottom of corrugation bulkheads and other small void spaces in cargo area</td>
<td>NR</td>
</tr>
</tbody>
</table>

Notes:

1. PSPC/DSBWT: 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)).
2. PSPC/VS: Draft Performance standard for protective coatings for void spaces on bulk carriers and oil tankers
3. NR: [No standards required] [PSPC/DSBWT and PSPC/VS do not apply].
Figure 1 – Sketch of Midship Section of a Bulk Carrier
### ANNEX 3


#### Table 1 — Atmospheric-corrosivity categories and examples of typical environments

<table>
<thead>
<tr>
<th>Category</th>
<th>Mass loss (g/m²)</th>
<th>Thickness loss (µm)</th>
<th>Examples of typical environments in a temperate climate (informative only)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low-carbon steel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very low</td>
<td>$&lt; 10$</td>
<td>$&lt; 1.3$</td>
<td>—</td>
</tr>
<tr>
<td>C2 low</td>
<td>$&gt; 10$ to $200$</td>
<td>$&gt; 1.3$ to $25$</td>
<td>Atmospheres with low level of pollution. Mostly rural areas.</td>
</tr>
<tr>
<td>C3 medium</td>
<td>$&gt; 200$ to $400$</td>
<td>$&gt; 25$ to $50$</td>
<td>Urban and industrial atmospheres, moderate sulfur dioxide pollution. Coastal areas with low salinity. Production rooms with high humidity and some air pollution. E.g., food-processing plants, laundries, breweries, diners.</td>
</tr>
<tr>
<td>C4 high</td>
<td>$&gt; 400$ to $650$</td>
<td>$&gt; 50$ to $80$</td>
<td>Industrial areas and coastal areas with moderate salinity. Chemical plants, swimming pools, coastal ship- and boatyards.</td>
</tr>
<tr>
<td>C5-M very high (industrial)</td>
<td>$&gt; 650$ to $1500$</td>
<td>$&gt; 80$ to $200$</td>
<td>Industrial areas with high humidity and aggressive atmosphere. Buildings or areas with almost permanent condensation and with high pollution.</td>
</tr>
<tr>
<td>C5-M very high (marine)</td>
<td>$&gt; 650$ to $1500$</td>
<td>$&gt; 80$ to $200$</td>
<td>Coastal and offshore areas with high salinity. Buildings or areas with almost permanent condensation and with high pollution.</td>
</tr>
</tbody>
</table>

**NOTES**
1. The loss values used for the corrosivity categories are identical to those given in ISO 9223.
2. In coastal areas in hot, humid zones, the mass or thickness losses can exceed the limits of category C5-M. Special precautions must therefore be taken when selecting protective paint systems for structures in such areas.

#### 5.2 Categories for water and soil

For structures immersed in water or buried in soil, corrosion is normally local in nature and corrosivity categories are difficult to define. However, for the purpose of this International Standard, various environments can be described. In Table 2, three different environments are given together with their designations. See 4.2 for more detail.

**NOTE** — In many such situations, cathodic protection is involved and this should be borne in mind.

#### Table 2 — Categories for water and soil

<table>
<thead>
<tr>
<th>Category</th>
<th>Environment</th>
<th>Examples of environments and structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Im1</td>
<td>Fresh water</td>
<td>River installations, hydro-electric power plants</td>
</tr>
<tr>
<td>Im2</td>
<td>Sea or brackish water</td>
<td>Harbour areas with structures like sluice gates, locks, jetties: offsho-re structures</td>
</tr>
<tr>
<td>Im3</td>
<td>Soil</td>
<td>Buried tanks, steel piles, steel pipes</td>
</tr>
</tbody>
</table>
Table 1 — Test procedures for paint systems applied to steel

<table>
<thead>
<tr>
<th>Corrosivity category as defined in ISO 12944-2</th>
<th>Durability ranges</th>
<th>ISO 2812-1 1) (chemical resistance)</th>
<th>ISO 2812-2 (water immersion)</th>
<th>ISO 6270 (water condensation)</th>
<th>ISO 7253 (neutral salt spray)</th>
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<td>3 000</td>
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1) Use method 1 (see 5.6 for the chemicals used). The purpose of the chemical-resistance test is not the assessment of corrosion protection properties but to assess the ability of a system to withstand highly industrial environments. Thus, the test duration remains the same whatever the durability range is.

For corrosivity category CS-I, the ISO 2812-1 procedure can be replaced or supplemented by the ISO 3231 test (10 cycles, 240 h for “low” durability, 20 cycles, 480 h for “medium” durability, and 30 cycles, 720 h for “high” durability).
Unless agreed otherwise, individual dry film thicknesses of less than 80 % of the nominal dry film thickness are not acceptable. If agreed otherwise individual values between 80 % and 100 % of the nominal dry film thickness are acceptable, provided that the overall average (mean) is equal to or greater than the nominal dry film thickness.

Special care should be taken to achieve the nominal dry film thickness and to avoid areas of excessive thickness. It is recommended that the maximum dry film thickness is not greater than 3 times the nominal film thickness. In the case of excessive maximum dry film thickness, expert agreement shall be found between the parties. For products or systems which have a critical maximum dry film thickness or, in special cases, information given in the paint manufacturer's technical data sheet shall be observed.

The number of coats and the dry film thicknesses quoted in annex A are based on the use of airless spray application. Application by roller, brush or conventional spraying equipment will produce lower film thicknesses, and more coats will be needed to produce the same dry film thickness for the system. Consult the manufacturer for more information.

5.5 Durability

Definitions of both durability and durability ranges are given in ISO 12944-1.

The durability of a protective paint system depends on several parameters, such as:
- the type of paint system;
- the design of the structure;
- the condition of the substrate before preparation;
- the effectiveness of the surface preparation;
- the standard of the application work;
- the conditions during application;
- the exposure conditions after application.

The condition of the paint system applied can be assessed by means of ISO 4628-1 to ISO 4628-6. It has been assumed in compiling the tables in annex A that the first major maintenance painting would normally need to be carried out for reasons of corrosion protection once the coating has reached the level R 3 as defined in ISO 4628-3.

Based on this precondition, durability has been indicated in this part of ISO 12944 in terms of three ranges:

- low (L) 2 to 5 years
- medium (M) 5 to 15 years
- high (H) more than 15 years

The durability range is not a "guarantee time". Durability is a technical consideration that can help the owner set up a maintenance programme. A guarantee time is a consideration that is the legal subject of clauses in the administrative part of the contract. The guarantee time is usually shorter than the durability range. There are no rules that link the two periods of time.

Maintenance is often required at more frequent intervals because of fading, chalking, contamination or wear and tear, or for aesthetic or other reasons.

5.6 Shop and site application

To ensure maximum performance of a paint system, the majority of the coats of the system or, if possible, the complete system, should preferably be applied in the shop. The advantages and disadvantages of shop application are as follows:

**Advantages**
- a) Better control of application
- b) Controlled temperature
- c) Controlled relative humidity
- d) Easier repair of damage
- e) Greater output
- f) Better waste and pollution control

**Disadvantages**
- a) Possible limitation of the size of the building components
- b) Damage due to handling, transport and erection
- c) Overcoating time can be exceeded
- d) Possible contamination of the last coat
ANNEX 4

INFORMATION ON MEASUREMENT OF DRY COATING THICKNESS
WITH MAGNETIC GAGES (SSPC-PA2)

SSPC: The Society for Protective Coatings

PAINT APPLICATION SPECIFICATION NO. 2

Measurement of Dry Coating Thickness with Magnetic Gages

1. Scope

1.1 GENERAL: This standard describes the procedures to measure the thickness of a dry film of a nonmagnetic coating applied on a magnetic substrate using commercially available magnetic gages. These procedures are intended to supplement manufacturer's operating instructions for the manual operation of the gages and are not intended to replace them.

1.2 The procedures for adjustment and measurement are described for two types of gages: pull-off gages (Type 1) and electronic gages (Type 2).

1.3 The standard defines a procedure to determine if the film thickness over an extended area conforms to the minimum and the maximum levels specified. This procedure may be modified when measuring dry film thickness on overcoated surfaces (see Note 7.1).

2. Description and Use

2.1 DEFINITIONS

2.1.1 Gage Reading: A single reading at one point.
2.1.2 Spot Measurement: The average of at least three gage readings made within a 4 cm (1.5 inch) diameter circle.
2.1.3 Calibration: The controlled and documented process of measuring traceable calibration standards and verifying that the results are within the stated accuracy of the gage. Calibrations are typically performed by the gage manufacturer or by a qualified laboratory in a controlled environment using a documented process. The standards used in the calibration are such that the combined uncertainties of the resultant measurement are less than the stated accuracy of the gage.
2.1.4 Verification: An accuracy check performed by the user using known reference standards.
2.1.5 Adjustment: The act of aligning the gage's thickness readings to match those of a known sample in order to improve the accuracy of the gage on a specific surface or in a specific portion of its measurement range. Most Type 2 gages can be adjusted on a coated part or on a shim, where the thickness of the coating or of the shim is known.

2.1.6 Coating Thickness Standard (Test Block): A smooth ferromagnetic substrate with a nonmagnetic coating of known thickness that is traceable to national standards.

2.1.7 Shim (Foil): A thin strip of non-magnetic plastic, metal, or other material of known uniform thickness used to verify the accuracy of coating dry film thickness gages.

2.1.8 Dry Film Thickness Reference Standard: A sample of known thickness used to verify the accuracy of the gage, such as coated thickness standards or shims. In some instances with the owner's permission, a sample part (a particular piece of coated steel) is used as a thickness standard for a particular job.

2.1.9 Accuracy: Consistency between a measured value and the true value of the thickness standard.

2.1.10 Structure: A unit composed of one or more connected steel members comprising a bridge, tank, ship, etc. It is possible for a single steel shape (beam, angle, tee, pipe, channel, etc.) to be considered a structure, if it is painted in a shop.

2.2 DESCRIPTION OF GAGES

2.2.1 Gage Types: The gage type is determined by the specific magnetic properties employed in measuring the thickness and is not determined by the mode of data readout, i.e., digital or analog. This standard does not cover gages that measure the effect of eddy currents produced in the substrate (see Note 7.2).

2.2.2 Type 1 - Pull-Off Gages: In pull-off gages, a permanent magnet is brought into direct contact with the coated surface. The force necessary to pull the magnet from the surface is measured and interpreted as the coating thickness value on a scale or display on the gage. Less force is required to remove the magnet from a thick coating. The scale is nonlinear.
2.2.3 Type 2—Electronic Gages: An electronic gage uses electronic circuitry to convert a reference signal into coating thickness.

2.3 USE OF PAINT APPLICATION STANDARD NO. 2:
This document contains the following:
- Calibration, verification, adjustment, and measurement procedures (Section 3);
- Required number of measurements for conformance to a thickness specification (Section 4);
- Notes on gage principles and various factors affecting thickness measurement (Notes 7.2 to 7.16);
- An example of a gage calibration measurement over an extended area (Appendix 1);
- A numerical example of the calibration adjustment of Type 2 gages using plastic shims (Appendix 2);
- An example protocol for measuring DFT on beams or grinders (Appendix 3);
- An example protocol for measuring DFT on a laydown painted in a shop (Appendix 4);
- An example protocol for measuring DFT on test panels (Appendix 5);
- An example protocol for measuring DFT of thin coatings on blast cleaned test panels (Appendix 6).

3. Calibration, Verification, Adjustment, and Measurement Procedures

3.1 GENERAL

3.1.1 ACCESS TO BARE SUBSTRATE: All gages are affected to some degree by substrate conditions such as roughness, shape, thickness, and composition (see Notes 7.3 to 7.8). To correct for this effect, access to the uncoated substrate is recommended. Another option is to use separate uncoated reference panels with similar roughness, shape, thickness, and composition (see Notes 7.3 to 7.6). These would be used as the bare substrate in the procedures of Sections 3.2, 3.3 and 3.4. Reference panels should be of sufficient size to produce edge effects (see Note 7.8). Other conditions that could affect measurements are described in Notes 7.10 to 7.14. Measurements on the bare substrate are taken before the coating is applied or by masking off small representative areas during painting. If the coating has already been applied to the entire surface, it is customary to remove small areas of coating for measurement and later patch them. Do not allow the removal process to alter the condition of the substrate. If chemical paint strippers are used, the existing profile will be retained (see Section A2.3).

3.1.2 SPOT MEASUREMENT: Repeated gage readings, even at points close together, often differ due to small surface irregularities of the coating and the substrate. Therefore, a minimum of three (3) gage readings shall be made for each spot measurement of either the substrate or the coating. For each new gage reading, move the probe to a new location within the 4 cm (1.5 inch) diameter circle defining the spot. Discard any unusually high or low gage reading that is not repeated consistently. Take the average of the acceptable gage readings as the spot measurement.

3.1.3 CALIBRATION: Gages must be calibrated by the manufacturer or a qualified lab. A Certificate of Calibration or other documentation showing traceability to a national standard is required. There is no standard time interval for re-calibration, nor is one absolutely required. Calibration intervals are usually established based upon experience and the work environment. A one-year calibration interval is a typical starting point suggested by gage manufacturers.

3.2 VERIFICATION OF ACCURACY

3.2.1 Measure the thickness of a series of reference standards covering the expected range of coating thickness (see Note 7.15). To guard against measuring with an inaccurate gage, the gage shall be checked at least at the beginning and the end of each work shift with one or more of the reference standards. If the gage is dropped or suspected of giving erroneous readings during the work shift, its accuracy shall be rechecked.

3.2.2 Record the serial number of the gage, the reference standard used, the stated thickness of the reference standard as well as the measured thickness value obtained, and the method used to verify gage accuracy. If the same gage, reference standard, and method of verification are used throughout a job, they need to be recorded only once. The stated value of the standard and the measured value must be recorded each time calibration is verified.

3.2.3 If readings do not agree with the reference standard, all measurements made since the last accuracy check are suspect. In the event of physical damage, wear, or high usage, or after an established calibration interval, the gage shall be rechecked for accuracy of measurement. If the gage is not measuring accurately, it shall not be used until it is repaired and/or recalibrated (usually by the manufacturer).

3.2.4 Shims of plastic or of non-magnetic metals which are acceptable for verifying the accuracy of Type 2 (electronic) gages are not used for verifying the accuracy of the Type 1 gages (see Note 7.2.1).

3.3 ADJUSTMENT AND MEASUREMENT - TYPE 1, PULL-OFF GAGES

3.3.1 Type 1 gages have nonlinear scales and any adjusting feature is linear in nature. Any adjustment of these gages will limit the DFT range for which the gage will provide accurate readings, and is not recommended.

3.3.2 Measure the bare substrate at a number of spots to obtain a representative average value. This average value
is the base metal reading (BMR). CAUTION: the gage is not to be adjusted to read zero on the bare substrate.

3.3.3 Measure the dry coating at the number of spots specified in Section 4.

3.3.4 Subtract the base metal reading from the gage reading to obtain the thickness of the coating.

3.4 ADJUSTMENT AND MEASUREMENT - TYPE 2, ELECTRONIC GAGES

3.4.1 Different manufacturers of Type 2 (electronic) gages follow different methods of adjustment for measuring dry film thickness over a blast-cleaned surface. Adjust the gage according to the manufacturer’s instructions (see Appendix 2).

3.4.2 Measure the dry coating at the number of spots specified in Section 4.

4. Required Number of Measurements for Conformance to a Thickness Specification

4.1 NUMBER OF MEASUREMENTS: Make five (5) separate spot measurements (average of the gage readings, see Section 3.1.2) spaced arbitrarily over each 10 m² (100 ft²) area to be measured. If the contracting parties agree, more than five (5) spot measurements may be taken in a given area (see Section 4.1.6). The five spot measurements shall be made for each 10 m² (100 ft²) area of area as follows:

4.1.1 For structures not exceeding 30 m² (300 ft²) in area, each 10 m² (100 ft²) area shall be measured.

4.1.2 For structures not exceeding 100 m² (1,000 ft²) in area, three 10 m² (100 ft²) areas shall be arbitrarily selected by the inspector and measured.

4.1.3 For structures exceeding 100 m² (1,000 ft²) in area, the first 100 m² (1,000 ft²) shall be measured as stated in Section 4.1.2 and for each additional 100 m² (1,000 ft²) of area or increment thereof, one 10 m² (100 ft²) area shall be arbitrarily selected by the inspector and measured.

4.1.4 If the dry film thickness for any 10 m² (100 ft²) area (see Sections 4.1.2 and 4.1.3) is not in compliance with the requirements of Sections 4.3.1 and 4.3.2, then additional measurements must be made to isolate the non-conforming area, and each 10 m² (100 ft²) area painted during that work shift shall be measured.

4.1.5 Other size areas or number of spot measurements may be specified by the owner in the job specifications as appropriate for the size and shape of the structure to be coated (see Appendices 3, 4, 5, and 6).

4.2 SPECIFYING THICKNESS: It is recommended that both a maximum and a minimum DFT thickness be specified for the coating. If a maximum thickness value is not explicitly specified, the specified thickness shall be the minimum and Section 4.3.2 would not apply.

4.3 CONFORMANCE TO SPECIFIED THICKNESS

4.3.1 Minimum Thickness: The average of the spot measurements for each 10 m² (100 ft²) area shall not be less than the specified minimum thickness. Although no single spot measurement in any 10 m² (100 ft²) area shall be less than 80% of the specified minimum thickness, it is possible for any single gage reading to under-run by a greater amount. If the average of the spot measurements for a given 10 m² (100 ft²) area meets or exceeds the specified minimum thickness, but one or more spot measurements is less than 80% of the specified minimum thickness, additional measurements will more precisely define the non-conforming area and facilitate repair (see Appendix 1 and Notes 7.16 and 7.17).

4.3.2 Maximum Thickness: The average of the spot measurements for each 10 m² (100 ft²) area shall not be more than the specified maximum thickness. Although no single spot measurement in any 10 m² (100 ft²) area shall be more than 120% of the specified maximum thickness, it is possible for any single gage reading to over-run by a greater amount. If the average of the spot measurements for a given 10 m² (100 ft²) area meets or falls below the specified maximum thickness, but one or more spot measurements is more than 120% of the specified maximum thickness, additional measurements will more precisely define the non-conforming area and facilitate repair (see Appendix 1 and Notes 7.16 and 7.17).

5. Accuracy

5.1 To qualify under this standard, a gage must have an accuracy at least within ±5% (see Note 7.16). For thicknesses less than 25 μm (1 mil), the gage must have an accuracy at least within ±2.5 μm (0.1 mil).

6. Disclaimer

6.1 While every precaution is taken to ensure that all information furnished in SSPC standards and specifications is as accurate, complete, and useful as possible, SSPC cannot assume responsibility nor incur any obligation resulting from the use of any material, coatings or methods specified therein, or of the specification or standard itself.

6.2 This standard does not attempt to address problems concerning safety associated with its use. The user of this standard, as well as the user of all products or practices described herein, is responsible for instituting appropriate health and safety practices and for ensuring compliance with all governmental regulations.
7. Notes

Notes are not requirements of this standard.

7.1 OVERCOATING: Maintenance painting often involves application of a new coating over an existing coating system. It is very difficult to accurately measure the DFT of the newly applied coating using non-destructive methods. First, access to the profile is not available, compromising the accuracy of the BMR or the adjustment of a Type 2 gage. Second, unevenness in the DFT at the existing coating necessitates careful mapping of the "before and after" DFT readings. This unevenness also adds to the statistical variation in trying to establish a base DFT reading to be subtracted from the final DFT.

A paint inspection gage (sometimes called a Toole or PIG gage) will give accurate DFT measurements, but it cuts through the coating so each measurement site must be repaired. Ultrasound gages may be used, but their accuracy is much less than a Type 1 or a Type 2 gage. A practical approach to monitoring DFT when overcoating is to compute DFT from wet film thickness readings and the volume solids of the coating being applied.

If the DFT of the existing coating is not too uneven, the average DFT of the existing coating can be measured to establish a base DFT. This base DFT is then subtracted from the total DFT to get the thickness of the overcoat(s).

7.2 PRINCIPLES OF THE MAGNETIC GAGE: Each of these gages can sense and indicate only the distance between the magnetic surface of the steel and the small rounded tip of the magnet or probe that rests on the top surface of the coating. For this measured distance (from the top surface of the coating to the magnetic zero) to equal the coating thickness above the peak, the gage readings must be corrected for the profile of the steel surface and to a lesser extent the composition and shape of the steel. Such correction is made as described in Section 3.3 for Type 1 gages and Section 3.4 for Type 2 gages.

7.2.1 Type 1 (pull-off) gages measure the force needed to pull a small permanent magnet from the surface of the coated steel. The magnetic force holding the magnet to the surface varies inversely as a non-linear function of the distance between magnet and steel, i.e., the thickness of the dry coating (plus any new films present).

Normally, Type 1 gages are not adjusted or reset for each new series of measurements. Shims of sheet plastic or of non-magnetic metals, which are permissible for adjusting Type 2 (electronic) gages should not be used for adjusting Type 1 gages. Such shims are usually fairly rigid and curved and do not lie perfectly flat, even on a smooth steel test surface. Near the pull-off point of the measurement with any Type 1 gage, the shim frequently spring back from the steel surface, raising the magnet too soon and causing an erroneous reading.

7.2.2 Type 2 (electronic) gages operate on two different magnetic principles. Some Type 2 gages use a permanent magnet. When the magnet is brought near steel, the magnetic flux density at the tip of the magnet is increased. By measuring this change in flux density, which varies inversely to the distance between the magnet and the steel substrates, the coating thickness can be determined. Hall elements and magnet resistance elements positioned at the tip of the magnet are the most common ways that this change in magnetic flux density is measured. Other Type 2 gages operate on the principle of electromagnetic induction. A coil containing a soft iron rod is energized with an AC current thereby producing a changing magnetic field at the tip of the probe. As with a permanent magnet, the magnetic flux density within the rod increases when the probe is brought near the steel substrate. This change is easy to detect by using additional coils. The output of these coils is related to coating thickness.

7.3 REPEATABILITY: Magnetic gages are necessarily sensitive to very small irregularities of the coating surface or of the steel surface directly below the probe center. Repeated gage readings on a rough surface, even at points very close together, frequently differ considerably, particularly for thin films over a rough surface with a high profile.

7.4 ZERO SETTING: Type 1 magnetic gages should not be adjusted or set at the scale zero (0) with the gage applied to either a rough or a smooth uncoated steel surface. Some Type 2 gages can be adjusted to read zero (0) on an uncoated blast cleaned surface. In all cases follow the manufacturer's recommendations.

7.5 ROUGHNESS OF THE STEEL SURFACE: If the steel surface is smooth and even, its surface plane is the effective magnetic surface. If the steel is roughened, as by blast cleaning, the "apparent" or effective magnetic surface that the gage senses is an imaginary plane located between the peaks and valleys of the surface profile. Gages read thickness above this imaginary magnetic plane. If a Type 1 gage is used, the coating thickness above the peaks is obtained by subtracting the base metal reading (see Section 3.3). With a correctly calibrated and adjusted Type 2 gage, the reading obtained indicates the coating thickness above the peaks (see Section 3.4).

7.6 DIRTY, TACKY, OR SOFT FILMS: The surface of the coating and the probe of the gage must be free from dust, grease, and other foreign matter in order to obtain close contact of the probe with the coating. The accuracy of the measurement will be affected if the coating is tacky or excessively soft. Tacky coating films may cause unwanted adhesion of the magnet of a Type 1 gage. Unusually soft films may be denting by the pressure of the probe of a Type 1 or a Type 2 gage. Soft or tacky films can sometimes be measured satisfactorily with Type 2 gages by putting a shim on the film, measuring total thickness of coating plus shim, and subtracting shim thickness.
7.6.1 Ordinary dirt and grease can be removed from a probe by wiping with a soft cloth. Magnetic particles adhering to the probe can be removed using an adhesive backed tape. Any adhesive residue left on the probe must then be removed.

7.7 ALLOY STEEL SUBSTRATES: Differences among most mild low-carbon steels and high strength low alloy (HSLA) steels will not significantly affect magnetic gage readings. For higher alloy steels, the gage response should be checked. Regardless of the alloy type, the gage should be adjusted to the same steel over which the coating has been applied.

7.8 CURVATURE OF STEEL SURFACE: Magnetic gage readings may be affected by surface curvature. If the curvature is appreciable, valid measurements may still be obtained by adjusting the gage on a similarly curved surface.

7.9 PROXIMITY TO EDGES: Magnetic gages are sensitive to geometrical discontinuities of the steel, such as holes, corners or edges. The sensitivity to edge effects and discontinuities varies from gage to gage. Measurements closer than 2.5 cm (1 inch) from the discontinuity may not be valid unless the gage is adjusted specifically for that location.

7.10 PROXIMITY TO OTHER MASS OF STEEL: The older two-pole gages with permanent magnets are sensitive to the presence of another mass of steel close to the body of the gage. This effect may extend as much as 8 cm (3 inches) from an inside angle.

7.11 TILT OF PROBE: All of the magnets or probes must be held perpendicular to the coated surface to produce valid measurements.

7.12 OTHER MAGNETIC FIELDS: Strong magnetic fields, such as those from welding equipment or nearby power lines, may interfere with operation of the gages. Residual magnetism in the steel substrate may also affect gage readings. With fixed probe two-pole gages in such cases, it is recommended that the readings before and after reversing the pole positions be averaged. Other gages may require demagnetization of the steel.

7.13 EXTREMES OF TEMPERATURE: Most of the magnetic gages operate satisfactorily at 4°C and 49°C (40°F and 120°F). Some gages function well at much higher temperatures. However, if such temperature extremes are met in the field, the gage might well be checked with at least one reference standard after both the standard and the gage are brought to the same ambient temperature. Most electronic gages compensate for temperature differences among the gage, the probe, and the surface.

7.14 VIBRATION: The accuracy of the Type 1 (pull-off) gages is affected by traffic, machinery, concussions, etc. When these gages are set up for verification of calibration or measurement of coating films, there should be no apparent vibration.

7.15 COATING THICKNESS STANDARDS: Coating thickness standards consisting of coated steel plates with assigned thickness values traceable to national standards are available from several sources, including most manufacturers of coating thickness gages. Shims of known thicknesses are also available from most of these same sources.

7.16 VARIATION IN THICKNESS - 80% of MINIMUM/120% of MAXIMUM: In any measurement there is a certain level of uncertainty. Two inspectors using the same gage will not necessarily record the exact same number for a given spot measurement using the same 4 cm (1.6 inch) diameter circle. To allow for this natural fluctuation, an individual spot measurement is permitted to be below the specified minimum thickness as long as other spots in the 10 m² (100 ft²) area are high enough to make the average thickness meet or exceed the specified minimum thickness. Similar reasoning applies to maximum thickness. The 80% of specified minimum and 120% of specified maximum allow for the accuracy of the gage and reference standards and for variations in the substrate.

7.17 CORRECTING LOW OR HIGH THICKNESS: The contracting parties should agree upon the method of correcting film thicknesses that are above the maximum or below the minimum specification. This method may be specified in the procurement documents, may follow manufacturer's instructions, or may be a compromise reached after the non-conforming area is discovered.

7.18 TYPE 1 PEN GAGES: Instances may arise where a pen-type pull-off gage is the only practical method for measuring DFT. Although these gages do not normally meet the 5% accuracy requirement, they may be used if the contracting parties agree.

APPENDIX 1 - Numerical Example of Average Thickness Measurement

Appendix 1 does not form a mandatory part of this standard.

The following numerical example is presented as an illustration of Section 4. Metric values are calculated equivalents from U.S. Customary measurements. (Reference Journal of Protective Coatings and Linings, Vol. 4, No 5, May 1987.)

Suppose this structure is 30 m² (300 ft²) in area. Mentally divide the surface into three equal parts, each being about 10 m² (100 ft²).

- Part A - 10 m² (100 ft²)
- Part B - 10 m² (100 ft²)
- Part C - 10 m² (100 ft²)
First, measure the coating thickness on Part A. This involves at least 15 readings of the thickness gage (see Figure A1). Assume the specification calls for 64 μm (2.5 mils) minimum thickness. The coating thickness for area A is then the average of the five spot measurements made on area A, namely 66 μm, (2.6 mils).

<table>
<thead>
<tr>
<th>Spot</th>
<th>Thickness (μm)</th>
<th>Mil Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>76</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>53</td>
<td>2.1</td>
</tr>
<tr>
<td>4</td>
<td>76</td>
<td>3.0</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>2.3</td>
</tr>
<tr>
<td>Average</td>
<td>66 μm</td>
<td>2.6 mils</td>
</tr>
</tbody>
</table>

Considering the U.S. Customary Measurements: The average, 2.6 mils, exceeds the specified minimum of 2.5 mils and thus satisfies the specification. Next, determine if the lowest spot measurement, 53 μm, is within 80% of the specified minimum thickness. Eighty percent of 64 μm is 51 μm (0.80 x 64 = 51). Although 53 μm is below the specified minimum, it is still within 80% of it so the specification is satisfied. There are individual gage readings of 38 μm (1.5 mils) at spot 5 and 46 μm (1.8 mils) at spot 3, both of which are clearly less than 51 μm. This is allowed because only the average of the three readings (i.e., the spot measurement) must be greater than or equal to 51 μm.

Since the structure used in this example is about 30 m² (300 ft²), the procedure used to measure the film thickness of part A must be applied to both part B and part C. The measured thickness of part B must exceed the 64 μm (2.5 mils) specified minimum, as must the thickness of part C.

To monitor the thickness of this entire 30 m² (300 ft²) structure, at least 45 individual gage readings must be taken, from which 15 spot measurements are calculated. The five spot measurements from each 10 m² (100 ft²) part of the structure are used to calculate the thickness of that part.

**APPENDIX 2 - Examples of the Adjustment of Type 2 Gages Using Shims**

Appendix 2 does not form a mandatory part of this standard.

This example describes a method of adjustment to improve the effectiveness of a Type 2 (electronic) gage on a
blast cleaned or otherwise roughened surface. Blast cleaning is used throughout this example, but these methods are applicable to other types of surface preparation. A less uniform surface, such as partially rusted hand tool cleaned steel, may require more gage readings to achieve a satisfactory level of statistical significance. Since gage operation differs among manufacturers, follow the manufacturer's instructions for adjustment of a particular gage.

A Type 2 gage needs to be adjusted to account for the profile of the substrate in order to read the coating thickness directly.

A portion of the substrate, after blast cleaning but prior to coating, can be used to adjust the gage. Alternatively, an uncoated test panel, blasted at the time the structure was blast cleaned and having a profile representative of the structure can be used to adjust the gage provided the test panel is of material with similar magnetic properties and geometry as the substrate to be measured. If this is not available then a correction value can be applied to a smooth surface adjustment as described below.

Three adjustment techniques can be used depending on the capability and features of the gage to be used for the inspection. Note that due to the statistical variation produced by a roughened surface, individual readings taken using these three methods may not perfectly agree.

The first two examples describe adjustment and verification to one or more shims. When shims are used, resultant gage measurements are less accurate and must be recalculated. For example, the accuracy of a properly calibrated gage is probably ±2%. The thickness of a shim might be accurate to within ±3%. The combined tolerance of the gage and the shim will be ±4% as given by the sum of squares formula:

$$\sqrt{2^2 + 3^2} = 3.6056 \approx 4$$

For the gage to be in agreement with the shim, the average thickness measured by the gage must be within ±4% of the shim's thickness. If the average thickness measured on a 250 µm (10 mil) shim is between 240 µm (9.6 mils) and 260 µm (10.4 mils), the gage is properly adjusted. The minimum 240 is 250 minus 4% of 250 (9.6 is 10 minus 4% of 10); the maximum of 260 is 250 plus 4% of 250 (10.4 is 10 plus 4% of 10). [4% of 250 is 10; 4% of 10 is 0.4.]

A2.1 SINGLE POINT CALIBRATION ADJUSTMENT: This example uses a single shim value at or close to the thickness to be measured. The thickness range over which this adjustment achieves the required accuracy will vary with gage design.

Assuming that the coating thickness to be measured is 100 µm (4.0 mil), then a shim of approximately 100 µm (4.0 mil) should be used to adjust the gage. The shim is placed on an area of the substrate that has been blast cleaned to the required standards, or on a blasted test coupon with a similar surface profile.

The average of 10 readings on the shim is sufficient to allow for the statistical variation in the blast profile.

A2.2 TWO POINT CALIBRATION ADJUSTMENT: This example uses two shim values, one above and one below the expected film thickness to be measured. It should be noted that not all film thickness gages can be adjusted in this manner.

Assuming that the coating thickness to be measured is 100 µm (4.0 mil), then shims of 250 µm (10.0 mil) and 50 µm (2.0 mil) are appropriate for setting the upper and lower values on the scale of the gage.

As protective coatings are normally applied to blast cleaned metal surfaces, a statistical approach is required to obtain a typical value for the adjustment. Ten readings on a shim are sufficient to establish a reliable average value for that shim on the roughened surface. Following the manufacturer's instructions, the gage is adjusted so that the actual shim thickness is then used to set the gage.

This procedure should be repeated for both the upper and lower shim values. The average of 10 readings on an intermediate shim, approximately 100 µm (4.0 mil), thick in the case described above, will confirm that the gage has been adjusted correctly. It is acceptable for the average reading to be within ±4% of the shim thickness.

This method ensures that the gage reads the thickness of the coating over the peaks of the profile.

A2.3 SMOOTH SURFACE CALIBRATION ADJUSTMENT: If access to the bare blast cleaned substrate is not available because the coating already covers it, a smooth surface can be used to adjust the gage. Adjust the gage on a smooth surface according to the manufacturer's instructions.

Readings taken on the blast-cleaned substrate will be higher than the true value by an amount dependent on the surface profile and the gage probe design. For most applications a correction value of 25 µm (1.0 mil) is generally applicable. Note that this value is not related to the actual surface profile measurement. This correction value must be subtracted from each gage reading to correct for the effect of the profile. The resulting corrected reading represents the thickness of the coating over the peaks.

For fine profiles the correction value may be as low as 10 µm (0.4 mil) but for coarse profiles it could be as high as 40 µm (1.6 mil). Table A2 gives approximate correction values to be used when a blast cleaned surface is not available to adjust the gage.

The use of coated standards to adjust gages means that a correction value must be applied to readings as the coated standards make use of smooth substrate surfaces.

APPENDIX 3 - Methods for Measuring Dry Film Thickness on Steel Beams (Girders)

Appendix 3 is not a mandatory part of this standard, but it provides two sample protocols for measuring DFT on beams and girders.
A3.1 A problem for the painter in coating steel beams or girders is providing the same uniform thickness over high and low vertical surfaces as over horizontal surfaces. On a beam, there are proportionately more edges that tend to have low dry film thickness (DFT) and inside corners that tend to have high DFT compared to the center of the flat surfaces. Each painter usually develops a pattern of work for a specific task. Hence, the DFT on the underside of the top flange, for example, may be consistently on the high side or the low side of the target DFT. This type of error is easy to detect and correct. Random errors pose a more difficult problem. Gross errors where the paint is obviously too thin or too thick must be corrected and are beyond the scope of this standard.

The number of spot measurements in these protocols may far exceed the "5 spot measurement per 10 ft (100 ft)" required in the standard. The full DFT determination, described in Section 3.2, provides a very thorough inspection of the beam. The sample DFT determination, described in Section 3.4, allows for fewer spot measurements. The user does not have to require a full DFT determination for every beam in the structure. For example, the requirement may be for a full DFT determination on one beam out of ten, or a sample DFT determination on one beam out of five, or a combination of full and sample DFT determinations.

A beam has twelve different surfaces as shown in Figure A3. Any one of these surfaces may have a DFT outside the specified range, and hence, shall be measured. If the thickness of the flange is less than 25 mm (1 inch), the contracting parties may choose not to measure the DFT on the toe, i.e., surfaces 2, 6, 8, and 12 of Figure A3. As an informal initial survey, the inspector may want to check for uniformity of DFT across each surface. Is the DFT of the flange near the fillet the same as near the toe? Is the DFT uniform across the web? The inspector must be sure to use a gage that is not susceptible to edge effects. Follow the gage manufacturer's instructions when measuring the edges.

### Table A2

<table>
<thead>
<tr>
<th>ISO 8503 Profile Grade</th>
<th>Correction Value (µm)</th>
<th>Correlation Value (mil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>10</td>
<td>0.4</td>
</tr>
<tr>
<td>Medium</td>
<td>25</td>
<td>1.0</td>
</tr>
<tr>
<td>Coarse</td>
<td>40</td>
<td>1.6</td>
</tr>
</tbody>
</table>

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1 International Organization for Standardization (ISO), Case Postale 56, Geneva CH-1211, Switzerland. ISO standards may be obtained through the American National Standards Institute (ANSI), 1818 L Street NW, Suite 600 Washington DC 20036. Standards may also be downloaded from http://www.iso.org. The standard from which this data originates is under development and has not formally been adopted as of June 1, 2004.

2 On rolled beams, measurement of surfaces 2, 6, 8, and 12 may not be practical.

A3.2 FULL DFT DETERMINATION OF A BEAM: Divide the beam or girder into five equal sections along its length. Identify the 12 surfaces of the beam as shown in Figure A3 for each section. For all beams where the height of the beam is 91 cm (36 inches) or more, divide the web in half along the length of the beam. For the full DFT determination, each half of the web is considered a separate surface. Take one spot measurement (as defined in Section 3.1.2) on surface 1 in each of the five sections. The location of the surface 1 measurement within a section is arbitrarily chosen by the inspector in each of the five sections. The average of these five spot measurements is the DFT of surface 1. Repeat for the other 11 surfaces (7 surfaces if the toe is not measured; 14 surfaces for tall beams). The data can be reported in a format shown in Table A3.1.

A3.3 No single spot measurement can be less than 80% of the specified minimum DFT. No single spot measurement can be more than 120% of the specified maximum DFT. The average value for each surface must conform to the specified DFT. (There will be only eight average values if the DFT of the toe is not measured; there may be as many as 14 average values for tall beams.)

A3.4 SAMPLE DFT DETERMINATION OF A BEAM: In lieu of a full DFT determination of each beam, the job specification may require only a sample DFT determination for selected beams less than 18 m (60 ft) long. For a sample DFT determination, the web of tall beams is not split.

A3.4.1 Beams less than 6 m (20 ft): For beams less than 8 m (20 ft), take two spot measurements, randomly distributed, on each of the 12 surfaces (8 surfaces if the toe is not measured) of the beam as defined in Figure A3. Each spot measurement must conform to the specified DFT.

A3.4.2 Beams between 6 m (20 ft) and 18 m (60 ft): For beams between 6 m (20 ft) and 18 m (60 ft), take three spot measurements, randomly distributed, on each of the 12 surfaces (8 surfaces if the toe is not measured) of the beam as defined in Figure A3. Each spot measurement must conform to the specified DFT.

A3.5 NON-CONFORMANCE: If any spot measurement falls outside the specified range, additional measurements may be made to define the non-conforming area.

A3.6 RESTRICTED ACCESS: If the beam is situated such that one or more of the surfaces are not accessible, take measurements on each accessible surface in accordance with Section A3.2 or Section A3.4, as specified.
FIGURE A.3
THE SURFACES OF A STEEL BEAM

Less than 91 cm (36 inches) in height
12 surfaces

Top Flange

91 cm (36 inches) in height or greater
14 surfaces

Top Flange

Toe

Web

Fillet

Bottom Flange

TABLE A3
DATASHEET FOR RECORDING SPOT MEASUREMENTS AND AVERAGE DFT VALUES
FOR THE 12 SURFACES OF A BEAM OR GIRDER

<table>
<thead>
<tr>
<th>Surface*</th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
<th>Section 4</th>
<th>Section 5</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10t*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* t = top half of web (for tall beams)
b = bottom half of web (for tall beams)
A3.7 ATTACHMENTS: Stiffeners and other attachments to a beam shall be arbitrarily measured at a frequency specified in the job specification.

APPENDIX 4 - Methods for Measuring Dry Film Thickness for a Laydown of Beams, Structural Steel, and Miscellaneous Parts After Shop Coating

Appendix 4 is not a mandatory part of this standard, but it provides two sample protocols for measuring DFT for a laydown.

A4.1 GENERAL: A "laydown" is a group of steel members laid down to be painted in one shift by one painter. For inspection of a laydown, first make a visual survey to detect areas with obvious defects, such as poor coverage, and correct as necessary. As an informal initial survey, the inspector may want to check for uniformity of DFT across each surface.

A4.2 FULL DFT DETERMINATION

A4.2.1 Beam (Girder): Follow the procedure described in Section A3.2.

A4.2.2 Miscellaneous Part: Take one spot measurement (as defined in Section 4.1.2) on each surface of the part. If the part has fewer than five surfaces, take multiple spot measurements on the larger surfaces to bring the total to five. If the total area of the part is over 10 m² (100 ft²), take 5 spot measurements randomly distributed over the part for each 10 m² (100 ft²) or fraction thereof.

A4.3 No single spot measurement can be less than 80% of the specified minimum DFT. No single spot measurement can be more than 120% of the specified maximum DFT. The average value of the spot measurements on each surface must conform to the specified DFT. If there is only a single spot measurement on a surface, it must conform to the specified DFT.

A4.4 SAMPLE DFT DETERMINATION: In lieu of a full DFT determination of each painted piece as described in Section A4.2, the job specification may require only a sample DFT determination for selected pieces.

A4.4.1 Beams less than 6 m (20 ft): Follow the procedure described in Section A3.4.1.

A4.4.2 Beams between 6 m (20 ft) and 18 m (60 ft): Follow the procedure described in Section A3.4.2.

A4.4.3 Miscellaneous parts: For a miscellaneous part, take three spot measurements, randomly distributed on the part. Each spot measurement must conform to the specified DFT.

A4.5 NON-COMFORMANCE: If any spot measurement falls outside the specified range, additional measurements may be made to define the non-conforming area.

A4.6: RESTRICTED ACCESS: If a beam or miscellaneous part is situated such that one or more of the surfaces are not accessible, take measurements on each accessible surface in accordance with Section A4.2 or Section A4.4, as specified.

A4.7 NUMBER OF BEAMS OR PARTS TO MEASURE: In a laydown, the number of beams or parts to receive a full DFT determination and the number to have a sample DFT determination can be specified. For example, do a full DFT determination on a piece painted near the beginning of the shift, near the middle of the shift, and near the end of the shift in accordance with Section A4.2; and perform a sample DFT determination on every third piece in accordance with Section A4.4.

A4.8 ATTACHMENTS: Stiffeners and other attachments to a beam shall be arbitrarily measured at a frequency specified in the job specification.

TABLE A3.1

<table>
<thead>
<tr>
<th>LENGTH OF BEAM</th>
<th>NUMBER OF SPOT MEASUREMENTS PER SURFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL DFT DETERMINATION</td>
<td>SAMPLE DFT DETERMINATION</td>
</tr>
<tr>
<td>less than 6 m (20 ft)</td>
<td>5</td>
</tr>
<tr>
<td>from 6 to 18 m (20 to 60 ft)</td>
<td>5</td>
</tr>
<tr>
<td>over 18 m (50 ft)</td>
<td>5</td>
</tr>
</tbody>
</table>

1 For tall beams (91 cm [36 inches]) or more, the top half and bottom half of the web are treated as separate surfaces in a full DFT determination.
APPENDIX 5 - Method for Measuring Dry Film Thickness on Coated Steel Test Panels

Appendix 5 is not a mandatory part of this standard, but it provides a sample protocol for measuring DFT on coated steel test panels.

A5.1 Panel Size: The test panel shall have a minimum area of 116 cm² (18 in²) and a maximum area of 930 cm² (144 in²); e.g., minimum 7.5 x 15 cm (3 x 6 inch) and maximum 30 x 30 cm (12 x 12 inch).

A5.2 Procedure: Use a Type 2 electronic gage. Take two gage readings from the top third, the middle third, and the bottom third of the test panel. Readings shall be taken at least 12 mm (one-half inch) from any edge and 25 mm (one inch) from any other gage reading. Discard any unusually high or low gage reading that cannot be repeated consistently. The DFT of the test panel is the average of the six acceptable gage readings.

A5.3 Minimum Thickness: The average of the acceptable gage readings shall be no less than the specified minimum thickness. No single gage reading shall be less than 80% of the specified minimum.

A5.4 Maximum Thickness: The average of the acceptable gage readings shall be no more than the specified maximum thickness. No single gage reading shall be more than 120% of the specified maximum.

A5.5 Rejection: If a gage reading is less than 80% of the specified minimum DFT or exceeds 120% of the specified maximum DFT, additional measurements may be made to reevaluate the DFT on the area of the test panel near the low or high gage reading. If the additional measurements indicate the DFT in the disputed area of the panel to be below the minimum or above the maximum allowable DFT, the panel shall be rejected.

APPENDIX 6 - Method for Measuring Dry Film Thickness of Thin Coatings on Coated Steel Test Panels that Had Been Abrasive Blast Cleaned

Appendix 6 is not a mandatory part of this standard, but it provides a sample protocol for measuring DFT of thin coatings on coated steel test panels that had been abrasive blast cleaned.

A6.1 A coating is defined as thin if the dry film thickness (DFT) is on the order of 25 micrometers (1 mil) or less. Because the DFT is the same order as the statistical fluctuations of a DFT gage on bare blast cleaned steel, many gage readings must be taken to get a meaningful average.

A6.2 Panel Size: The test panel shall have a minimum area of 116 cm² (18 in²) and a maximum area of 930 cm² (144 in²); e.g., minimum 7.5 x 15 cm (3 x 6 inch) and maximum 30 x 30 cm (12 x 12 inch).

A6.3 Procedure: Use a properly adjusted Type 2 electronic gage. Take ten gage readings randomly distributed in the top third of the panel. Compute the mean (average) and standard deviation of these ten readings. Similarly, take ten readings from the middle third and ten readings from the bottom third of the test panel and compute their means and standard deviations. Readings shall be taken at least 12 mm (one-half inch) from any edge and 25 mm (one inch) from any other gage reading. Discard any unusually high or low gage reading, i.e., a reading that is more than three standard deviations from the mean. The DFT of the test panel is the average of the three means.

A6.4 Minimum Thickness: The average of the means shall be no less than the specified minimum thickness. No single mean shall be less than 80% of the specified minimum.

A6.5 Maximum Thickness: The average of the means shall be no more than the specified maximum thickness. No single mean shall be more than 120% of the specified maximum.