The challenges of designing and complying with paint specifications (Ships)

Raouf Kattan C.Eng FRINA
Safinah Ltd
www.safinah.co.uk
The Mystery of coatings

Tell asset owners there is an invisible being in the sky who created the universe, and the vast majority will believe you.

*Now try telling them their coatings will perform….*
Focus

DFT – easy to understand but fraught with issues.
The need for coatings

- NORSO
- IMO/Flag requirement for ballast tanks
- IMO/Flag requirement for crude oil tanks
- Class requirements for coatings, type approval, extent of coatings (cargo holds/tanks) or when acting as RO, advisory documents/guides
- Cargo carriage requirement
- Owner need for asset protection and operational life (costs).
- Etc.
Corrosion allowances

Class for ships
- Allocate corrosion allowances in CSR
- Identify the need for smooth rounded edges to avoid stress concentrations

For offshore
- Guidelines with some coating basics
“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 configurations permits easy access for tools and to facilitate cleaning, draining and drying of the space to be coated”.
## CSR requirements

### CORROSION PROTECTION

<table>
<thead>
<tr>
<th>Compartment type</th>
<th>Structural member</th>
<th>Oil tankers</th>
<th>BOA or BO-B ships with L ≥ 150 m</th>
<th>Other BC ships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballast water tank, bilge tank, drain storage tank, chain locker</td>
<td>Face plate of PSM</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elsewhere</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other members (a)</td>
<td>1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elsewhere</td>
<td>1.2</td>
<td></td>
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<tr>
<td>Cargo oil tank</td>
<td>Face plate of PSM</td>
<td>1.7</td>
<td></td>
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<tr>
<td></td>
<td>Elsewhere</td>
<td>1.4</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Inner-bottom plating/bottom of tank</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other members</td>
<td>1.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elsewhere</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry bulk cargo hold (a)</td>
<td>Transverse bulkhead</td>
<td>Upper part (a)</td>
<td>2.4</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Lower stow side plate, vertical plate and top plate (a)</td>
<td></td>
<td>6.2</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Other parts</td>
<td>3.0</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sloped plating of hopper tank, inner bottom plating</td>
<td>Upper part (a)</td>
<td>3.7</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Web and flanges of the upper end brackets of single frames of single side bulk carriers</td>
<td></td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Webs and flanges of side brackets of single carriers</td>
<td></td>
<td>2.2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Other parts</td>
<td></td>
<td>2.0</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Exposed to atmosphere</td>
<td>Weather deck plating</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other members</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exposed to seawater</td>
<td>Shell plating between the minimum design ballast draught waterline and the scantling draught waterline</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shell plating elsewhere</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fuel and lube oil tank</td>
<td></td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fresh water tank</td>
<td></td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Void spaces (a)</td>
<td>Spaces not normally accessed, e.g. access only via bolted manhole openings, pipe tunnels, inner surface of steel space not common with a dry bulk cargo hold or ballast cargo hold, etc.</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dry spaces</td>
<td>Internals of machinery spaces, pump room, store rooms, steering gear space, etc.</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

### 1 GENERAL

#### 1.1 Structures to be protected

Dedicated seawater ballast tanks

All dedicated seawater ballast tanks are to have an efficient corrosion prevention system.

#### 1.1.2 Cargo oil tanks

Cargo oil tanks are to be protected in compliance with the requirements specified in Pt 2, Ch 2, Sec 2, [1].

#### 1.1.3 Bulk carriers

Void double side skin spaces and cargo holds of bulk carriers are to be protected in compliance with the requirements specified respectively in Pt 2, Ch 1, Sec 2, [2.2] and Pt 2, Ch 1, Sec 2, [2.3].

#### 1.1.4 Narrow spaces

Narrow spaces are generally to be filled by an efficient protective product, particularly at the ends of the ship where inspections and maintenance are not easily practicable due to their inaccessibility.

### 2 SACRIFICIAL ANODES

#### 2.1 Attachment of anodes to the hull
2 CORROSION PROTECTION

2.1 General

2.1.1 Void double side skin spaces
Void double skin spaces are to have a corrosion protective system fitted in accordance with [2.2].

2.1.2 Cargo holds and ballast holds
Cargo holds and ballast holds are to have a corrosion protective system fitted in accordance with [2.3].

2.2 Protection of void double side skin spaces

2.2.1
Void double skin spaces in the cargo area for ships having a freeboard length \( L_{\text{free}} \) of not less than 150 m are to have an efficient corrosion prevention system, such as hard protective coatings or equivalent.

2.3 Protection of cargo hold spaces

2.3.1 Coating
It is the responsibility of the builder and of the owner to choose coatings suitable for the intended cargoes, in particular for the compatibility with the cargo.

2.3.2 Application
All internal and external surfaces of hatch covers and hatch covers, and all internal surfaces of cargo holds (side and transverse bulkheads), excluding the inner bottom area and part of the hopper tank sloping plate and lower stool sloping plate, are to have an efficient protective coating, of an epoxy type or equivalent, applied in accordance with the manufacturer’s recommendation.

The side and transverse bulkhead areas to be coated are specified in [2.3.3] and [2.3.4] respectively.

2.3.3 Side areas to be coated
The areas to be coated are the internal surfaces of:
- The inner side plating.
- The internal surfaces of the topside tank sloping plates.
- The internal surfaces of the hopper tank sloping plates for a distance of 300 mm below the frame end bracket for holds of single side skin construction, or below the hopper tank upper end for holds of double side skin construction.

These areas are shown in Figure 1.

2.3.4 Transverse bulkhead areas to be coated
The areas of transverse bulkheads to be coated are all the areas located above an horizontal level located at a distance of 300 mm below the frame end bracket for holds of single side skin construction or below the hopper tank upper end for holds of double side skin construction.
Life of the ship without coatings

- Work undertaken through Newcastle Univ under a Design for coatings project, indicated that if uniform corrosion is applied in line with Class assumptions under CSR then a vessel would continue to comply with class rules for no more than 5-10 years.

- To get 10+ years of vessel life then coatings are essential
Coating costs

Typically 10-15% of new build costs (including labour costs)

- Paint is often less than 1% of total costs of the vessel
- Re-work in the form of touch up can account for 20-30% of the total coating man hours
Poorly understood

- The Engineer end user of coatings does not really understand what coatings can/cannot do and what factors are relevant.
- Corrosion Engineers do not always understand coatings.
- Compromise by adopting a generic coating specification
  - Salesman, Tech support, Price, Reputation of company (when did they last mess up!).
Standards - Subjective

Challenges – example

- IMO PSPC inspection requirements
  - Visual surface cleaning standards – subjective
  - Visual mechanical prep standards – subjective
  - Visual cleanliness in between coats – Subjective
  - Weld defects and steel defects significance – Subjective
  - Dust levels – subjective
  - % area of problems - subjective
Visual checks and access

Visual assessment

- At new build access to all parts of the vessel is generally excellent (design permitting)
- In service and in D.Dock access is very restricted to make any adequate visual assessment
Standards – can be vague

- ISO8501-3 – “Parties should preferably agree”
- Class/IMO PSPC – “Good”, “Fair”, “Poor” – Subjective
- Sampling methods (DFT) – cumbersome, how many readings are enough?
- Multiple standards with variations e.g.
  - Mechanical prep: ISO8501- pts 1 and 3, NACE SP0178, SSPC SP3, SSPC SP11.
Generic specification

- Usually produced by builder in first instances
  - Minimise thicknesses
  - Minimise number of coats
  - Minimise overall costs
- Asset owner may influence based on commercial issues/experience, contracts and or paint company pressure
- Paint company refines
- Provided in a standard format
- Do not differ much
Paint specification

- **General**
  - Colours
  - Paint maker recommendations
  - Non-mild steel surfaces
  - Outfit items
  - Non-specified items

- **Surface preparation**
  - Structural steel above 6mm thick
  - Secondary surface preparation
  - Cleaning before over-coating.

- **Application**
  - Application, mixing, alterations, paint maker standard specification
  - Stripe coats
  - Cosmetics
  - Repair to damages
  - Leak test issues
Paint specification

✦ Film Thickness
  – DFT readings after each coat
  – Min DFT (usually apply a rule say 90/10, 80/20 or 85/15).

✦ Inspection

✦ The generic paint scheme
  – See next slide

✦ Others e.g. Cathodic protection
Typical generic format
Typical paint company response

### Paint Specification & Specification

#### 4.3 Deck (unsheathed) 无衬里甲板

<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Color</th>
<th>Gloss</th>
<th>Particles</th>
<th>Theory</th>
<th>Dry Film</th>
<th>Fall Factor</th>
<th>Spray Rate</th>
<th>Actual Paint</th>
<th>Standard Paint</th>
<th>Efficacy</th>
<th>Expenditure</th>
<th>Paint No.</th>
<th>Paint Package</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>7035</td>
<td>brown</td>
<td>80</td>
<td>55%</td>
<td>7.30</td>
<td>2</td>
<td>2.90</td>
<td>30</td>
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<td>100%</td>
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<td>30</td>
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<tr>
<td>2</td>
<td>7208</td>
<td>peeling</td>
<td>40</td>
<td>45%</td>
<td>9.25</td>
<td>2</td>
<td>6.13</td>
<td>30</td>
<td>2005</td>
<td>2005</td>
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<td>100%</td>
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<td></td>
</tr>
</tbody>
</table>

#### 4.4 Galv. Or alum. Sheathing in way of cold provision rooms and engine room在冷冻室和机舱内铺设铁板的表面—无油漆

#### 4.5 Galv. Or alum. Sheathing in way of accommodation在居住舱室铺设铁板的表面

<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Color</th>
<th>Gloss</th>
<th>Particles</th>
<th>Theory</th>
<th>Dry Film</th>
<th>Fall Factor</th>
<th>Spray Rate</th>
<th>Actual Paint</th>
<th>Standard Paint</th>
<th>Efficacy</th>
<th>Expenditure</th>
<th>Paint No.</th>
<th>Paint Package</th>
</tr>
</thead>
<tbody>
<tr>
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<td>pealgreen</td>
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<td>51%</td>
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<td>8182</td>
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<td>26</td>
<td>26</td>
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<tr>
<td>2</td>
<td>7236</td>
<td>white</td>
<td>40</td>
<td>45%</td>
<td>11.25</td>
<td>2</td>
<td>6.13</td>
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<td>2005</td>
<td>2005</td>
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<td>100%</td>
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</tr>
</tbody>
</table>

#### 5.0 Cargo spaces etc. 货舱空间

#### 5.1 Cargo holds except No.4，bunktop redbrown 货舱(除4号舱外) —— 舱板或红棕色

<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Color</th>
<th>Gloss</th>
<th>Particles</th>
<th>Theory</th>
<th>Dry Film</th>
<th>Fall Factor</th>
<th>Spray Rate</th>
<th>Actual Paint</th>
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<th>Efficacy</th>
<th>Expenditure</th>
<th>Paint No.</th>
<th>Paint Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7370</td>
<td>redbrown</td>
<td>125</td>
<td>72%</td>
<td>576</td>
<td>2</td>
<td>2.88</td>
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<tr>
<td>2</td>
<td>7976</td>
<td>grey</td>
<td>125</td>
<td>72%</td>
<td>576</td>
<td>2</td>
<td>2.88</td>
<td>26</td>
<td>8182</td>
<td>8182</td>
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<td></td>
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</tr>
</tbody>
</table>

#### 5.2 Passage ways, xthems below forecastle deck 主甲板下通道，舱底、甲板下通道

<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Color</th>
<th>Gloss</th>
<th>Particles</th>
<th>Theory</th>
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<td>26</td>
</tr>
<tr>
<td>2</td>
<td>7976</td>
<td>grey</td>
<td>125</td>
<td>72%</td>
<td>576</td>
<td>2</td>
<td>2.88</td>
<td>26</td>
<td>8182</td>
<td>8182</td>
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<tr>
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<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Owner wants - Predictable performance

In effect all sources of failure
Failure of the generic spec

- What can product do or not do?
- What are critical functions
  - E.g. Winter/Summer build or operation
- How it meets shipyard requirements?
- How does it meet owner requirements?
- Final decision then based on Paint company and price..
- Need for a functional or engineered specification
Paint marketing – cargo holds

- Pure epoxy or modified epoxy
- Abrasion resistant
- Surface tolerant
- Flexible
- Workable
- Easy clean
- Self healing
Ultimately Price

Given the paucity of engineering data and understanding the final selection of products to meet the specification is then often based on price.

Paint companies do offer

- Track record
- Testimonials
- Many brochures
- Many claims made about the products
Cargo hold example

Specification version 1:
- Cargo holds 1,2,3,4,5,6,7
  - Anti-abrasive pure epoxy $\times$ 100 microns
  - Anti-abrasive pure epoxy $\times$ 100 microns

Specification version 2 – memo to specification:
- Cargo hold 1,2,3,5,6,7
  - 2 $\times$ 125 microns
- Cargo hold 4
  - 2 $\times$ 150 microns
Final agreed – paint company

- Cargo holds 1,2,3,5,6,7
  - 2 x 125 microns
- Cargo hold 4
  - 3 x 100 microns

- Product ABC in alternate colours red and grey
Scale

Painting is a manual process

- 80 microns is about the thickness of a sheet of photocopier paper!
Technical Data sheet

SYSTEM SPECIFICATION

- 2 x 125 µm thick

INSTRUCTIONS FOR USE

- Mixing ratio by volume: base to hardener 80:20
- The temperature of the mixed base and hardener should preferably be above 15°C, otherwise extra solvent may be required to obtain application viscosity
- Too much solvent results in reduced sag resistance
- Thinner should be added after mixing the components

- Induction time
- Pot life
- 3 hours at 20°C *
- "* see additional data

AIRLESS SPRAY

- Recommended thinner
- Volume of thinner
- Nozzle orifice: 0.8 - 2 mm
- Nozzle pressure: 15 MPa (= approx. 150 bar; 2130 psi)

- AIR SPRAY

- Thinner: 91-82
- Volume of thinner: 5 - 10% depending on required thickness and application conditions
- Nozzle pressure: 0.3 - 0.4 MPa (= approx. 3 - 4 bar; 43 - 57 psi)

- BRUSH/Roller

- Thinner: 91-82
- Volume of thinner

- CLEANING SOLVENT

- Thinner: 90-53

SAFETY PRECAUTIONS

- For paint and recommended thinners see safety sheets 1430, 1431 and relevant material safety data sheets
- This is a solvent borne paint and care should be taken to avoid inhalation of spray mist or vapour as well as contact between the wet paint and exposed skin or eyes

ADDITIONAL DATA

- Film thickness and spreading rate
  - "theoretical spreading rate m²/lit 7.2 5.8 4.8
  - "dft in µm 100 125 150
  - max. dft when brushing: 100 µm

DESCRIPTION

- Two component high build polyamine cured epoxy primer/coating

PRINCIPAL CHARACTERISTICS

- Surface tolerant priming coating for topsides, decks, superstructures and cargo holds
- Good impact and abrasion resistance
- Fast curing
- Smooth film, easy to clean
- compatible with various aged coatings
- Excellent corrosion resistance
- Resistant to splash and spillage of a wide range of chemicals

COLOURS AND GLOSS

- Various colours (in line with the shade card of...)

BASIC DATA AT 20°C

- Mass density: 1.4 g/cm³
- Solids: 72 ± 2%
- VOC (supplied): max. 283 g/kg (Directive 1999/13/EC, EEC)
- Recommended dry film thickness: 50 - 100 µm for brush/roller
- Theoretical spreading rate: 5.6 m²/lit for 125 µm, 4.8 m²/lit for 150 µm
- Touch dry after: 2 hours
- Overcoating interval: min. 6 hours, max. 6 months
- Curing time: 7 days
- Shelf life (cool and dry place): at least 12 months

RECOMMENDED SUBSTRATE CONDITIONS AND TEMPERATURES

- For atmospheric exposure conditions:
  - Steel: blast cleaned to ISO-8501-2 for excellent corrosion protection, blasting profile 40 - 70 µm
  - Steel: blast cleaned to ISO-8501-2 for good corrosion protection, existing sound epoxy coating systems and most sound alkyd coating systems; sufficiently roughened, dry and free from any contamination
- Substrate temperature should be above 5°C and at least 3°C above dew point
Technical Data Sheet

## Overcoating Table for Epoxy Coatings

<table>
<thead>
<tr>
<th>Substrate Temperature</th>
<th>5°C</th>
<th>10°C</th>
<th>20°C</th>
<th>30°C</th>
<th>40°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum interval</td>
<td>16 hours</td>
<td>9 hours</td>
<td>6 hours</td>
<td>4 hours</td>
<td>3 hours</td>
</tr>
<tr>
<td>Maximum interval</td>
<td>48 hours</td>
<td>30 hours</td>
<td>18 hours</td>
<td>9 hours</td>
<td>5 hours</td>
</tr>
</tbody>
</table>

Note: For maximum interval when not exposed to direct sunshine, multiply by 2.

## Cure Table for Polyurethanes

<table>
<thead>
<tr>
<th>Substrate Temperature</th>
<th>Touch Dry</th>
<th>Dry to Handle</th>
<th>Full Cure</th>
</tr>
</thead>
<tbody>
<tr>
<td>5°C</td>
<td>12 hours</td>
<td>16 hours</td>
<td>25 days</td>
</tr>
<tr>
<td>10°C</td>
<td>8 hours</td>
<td>9 hours</td>
<td>15 days</td>
</tr>
<tr>
<td>20°C</td>
<td>2 hours</td>
<td>6 hours</td>
<td>7 days</td>
</tr>
<tr>
<td>30°C</td>
<td>1 hour</td>
<td>4 hours</td>
<td>4 days</td>
</tr>
<tr>
<td>40°C</td>
<td>1 hour</td>
<td>3 hours</td>
<td>2 days</td>
</tr>
</tbody>
</table>

- For cargo hold application, for full cure for hard angular cargoes, please contact your nearest sales office.
- Adequate ventilation to remove solvent must be maintained during application and curing (please refer to sheets 1433 and 1434).
- Should temperature of the total coating system (2 x 125 µm) be applied in excess of the specified dry film thickness, the time necessary to reach full cure will be increased.

## Worldwide Availability

- What is always the aim of the sales office to supply the same product on a worldwide basis, slight modification of the product is sometimes necessary to comply with local or national rules/circumstances. Under these circumstances an alternative product data sheet is used.

## References

- Explanation of product data sheets
- Safety indications
- Safety in confined spaces and health safety
- Explosive hazard - Toxic hazard
- Safe working in confined spaces
- Directives for ventilation practice
LIMITATION OF LIABILITY

The information in this data sheet is based upon laboratory tests we believe to be accurate and is intended for guidance only. All recommendations or suggestions relating to the use of the [blank] products made by [blank], whether in technical documentation or in response to a specific enquiry, or otherwise, are based on data which to the best of our knowledge are reliable. The products and information are designed for users having the requisite knowledge and industrial skills and it is the end-user’s responsibility to determine the suitability of the product for its intended use.

[blank] has no control over either the quality or condition of the substrate, or the many factors affecting the use and application of the product. [blank] does therefore not accept any liability arising from loss, injury or damage resulting from such use or the contents of this data sheet (unless there are written agreements stating otherwise).

The data contained herein are liable to modification as a result of practical experience and continuous product development.

This data sheet replaces and annuls all previous issues and it is therefore the user’s responsibility to ensure that this sheet is current prior to using the product.

The English text of this document shall prevail over any translation thereof.

<table>
<thead>
<tr>
<th>POS</th>
<th>7970</th>
</tr>
</thead>
<tbody>
<tr>
<td>225296</td>
<td>grey</td>
</tr>
<tr>
<td>225296</td>
<td>medium</td>
</tr>
</tbody>
</table>
Max DFT

No specific mention of Max dft on specification (WBT – PSPC requires it)
– Refer to guide notes/system sheets or ISO standards
  • ISO 12944 standard – x3 specified value
  • Guide notes – Good practice x2 up to x2.2 for 10% of area.
Recommended dft - The dry film thickness for a paint system indicated in our system sheets is the recommended dft for the specific exposure conditions and based on airless spray application.

Dft specifications referred to herein are valid for the coatings and coating systems in this manual unless mentioned otherwise in the respective product and system sheets.
Minimum dft for application The minimum dft of a paint system (also a one coat system) should follow the 90/10 rule (e.g. 90% of the recommended dft is acceptable for up to 10% of the readings only), whilst for individual coats the minimum dft should not be lower than 80% of the recommended dft, and must form a closed film.

Maximum dft for application - General Application of a paint at thicknesses in excess of the dft recommended on the product data sheet may result in performance problems. Such problems include solvent retention and a reduction in cohesive strength in association with certain types of topcoat. In a coating system, the dft of a primer is of the utmost importance. In general, xxxx would restrict the dft of any primer to 1.5 times that specified on the product data sheet. For a coating system, including the individual coats (except the primer), the maximum dft is 2 times the recommended dft, whereas for the critical areas of a painted structure, 10% of the readings can be between 2 and 2.2 times the recommended dft. Critical areas are e.g. weld seams, edges, bolts, corners, nuts and areas of difficult access.

For coating specifications requiring coating thicknesses which exceed the recommended dfts as mentioned in the product and system sheets, the maximum dft allowed should be established per project prior to startup.

Over-application and its consequences is a complex subject and is dependent on the generic type of system, recommended dft and number of coats, as well as the intended exposure.
Please refer to your local office if you should have any questions on this important issue.

The life time of any protective coating system is also determined by the dry film thickness applied to critical areas. The dft of all of these critical areas should be closely monitored and controlled by the application of stripe coats with the same material as the consecutive coat of the system (or as recommended otherwise by xxx).

Please note that if a solvated coating has been applied over the specified dft then the minimum overcoating time must be increased to ensure that sufficient time is given for solvent evaporation.

Care must also be taken to avoid over-application on critical areas during the progress of the job. Overapplication does not lead to enhanced performance life time of the coating system. Maximum dft for application - Linings For linings for severe exposure conditions or reinforced solvent free systems, the dft of the primer and the subsequent coatings can be more critical. Dft limitations are detailed in the respective system / product data sheets.
Cargo hold systems

SigmaCover 350 - Time to loading of Hard Angular Cargoes
(2 x 125 μm)

Curing time [days]

Curing temperature [°C]

SPECIFICATION 3

General purpose epoxy coating system for new building and maintenance and wide range of surface pretreatments. Good impact and abrasion resistance and suitable for carriage of a wide range of cargoes. Also resistant against hard angular cargoes for normal service life expectations.

pretreatment

Steel; blast cleaned to ISO - Sa 2½, blasting profile (Rz) 40 - 70 μm steel with approved shop primer, sweep blasted to SSPS-Sa or power tool cleaned to SSPS - Pi3

paint system

125 μm

125 μm

dry film thickness (dft)

For the minimum and maximum applied dry film thickness principles of good coating practice are valid.

The minimum dft of the paint system should follow the 85/15 rule (e.g. 85% of the recommended dft is acceptable for up to 15% of the readings only).

For optimum performance, in relation to typical properties like curing and time to first cargo, the dry film thickness of the applied coating system should not be in excess of 2 times the recommended value. This is valid for each individual coat and for the paint system. On areas for which there are application constraints the applied dry film thickness may be up to 2.2 times the recommended value, however these areas should typically not exceed 16% of the total area.

(see also information sheet 1411 for additional details)

notes

- If a recoatable epoxy system is required, should be specified as topcoat at a dft of 125 μm replacing the

- The mechanical properties G are not the same as therefore this should be taken in consideration with regard to transportation of hard angular cargoes.

- At application temperatures below 6°C, the specified products can be replaced by the LT versions

maintenance

should preferably be carried out according to this specification

pretreatment

When hydrojetting will be used, the following standards are recommended:

- For dry cargo holds - VIS WU2/3 L or ISO Wa 2/2½ L followed by above specification

- For wet cargo holds - VIS WU2 L or ISO Wa 2½ L followed by appropriate primer as first coat

- For more information see sheet
Coating on surface areas which, because of their physical shape, characteristics or configuration, present special difficulties in effecting specified preparation and coating such as limited to, ladders, platforms, heating coils, rivets, contact surfaces between profiles and all small area equipment and attachments having a surface area of less than 10 square meters per item”
Specification seems to be OK in the range 100-150 microns per coat

Maximum in the range of x2 – 2.2 – 3 depending on source

Minimum can be in the range 80-90% of specified value
Cargo Holds

Cargo hold 4 – 3 x 100 microns
- Min in the range 80 to 90 microns
- Max in the range 600 – 660 – 900 microns

Other cargo holds – 2 x 125 microns
- Min in the range 100 – 112.5 microns
- Max in the range 500 – 550 - 750 microns
Compliance
What is Specified DFT?

- Interpretation
  - The Minimum?
  - The Mean (Average)?
  - The Mode (Most common value)?
  - The median?
  - The Maximum?
  - The Nominal? (Tolerance?)
What is Specified DFT?

Example

• Consider a Set of Values:
  • 1, 2, 3, 3, 3, 3, 5, 5, 6, 7, 10, 10
  • Sample Size \( n = 12 \)
  • Mean = 4.83
  • Mode = 3.00
What is Specified DFT?

Example

- Normal Distribution of readings
- 50% above mean & 50% below mean
- DTF Gauge Statistical Summary:
  - Sample Size, \( n = 12 \)
  - Mean, Standard Deviation
  - Maximum & Minimum Values, (Range)

66.6% of readings within \( \pm 1 \sigma \)
95.4% of readings within \( \pm 2 \sigma \)
99.75% of readings within \( \pm 3 \sigma \)

(\( \sigma \) = standard deviation)
What is Specified DFT?

**Example**

- Skewed Distribution of readings
- Typical of Dry Film Thickness values when the coating is sprayed
- Mean and Mode have significantly different values
Process Stability & Control

Variability

Assignable causes
- Wrong or worn spray tips
- Wrong pressure
- Wrong stand-off distance

Random variation
- Size of atomised particles
- Operator’s physical attributes
- Gusts of wind/Temperature
- Air pressure
Process Stability & Control

- Variability

- Simple Control Chart
Impact on a Coating Scheme – small area one coat

- Minimum & Maximum Values
  - Nominal DFT 85 µm
  - Range 240 µm
  - Minimum 20 µm
  - Maximum 260 µm

Impact on a Coating Scheme

- **Safinah Study** — Cargo holds
- Specified Scheme DFT: 250 µm
- Mean thickness: 649 µm
- Standard Deviation (σ): 133 µm
- Process Capability: 250 – 1,048 µm to 3 σ
Impact on a Coating Scheme

- Example
  - To achieve the required specification:
  - Minimum DFT 225 µm
  - Maximum DFT 550 µm
  - Mean DFT 387.5 µm
  - The standard deviation would have to be 54 µm or 40% of what is being achieved (according to Safinah data)

*Ignore measurement errors*
How to assess compliance? – DFT example

How many readings?

<table>
<thead>
<tr>
<th></th>
<th>SSPC PA-2</th>
<th>ISO 19840</th>
<th>PSPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot Measurements –</td>
<td>5 for each 100 m²</td>
<td>10 for each 100 m²</td>
<td>1 for each m² (100 for</td>
</tr>
<tr>
<td>complex areas &gt; 100 m²</td>
<td></td>
<td></td>
<td>a 100 m² area)</td>
</tr>
<tr>
<td>Spot measurements for</td>
<td>1,500</td>
<td>3,000</td>
<td>30,000</td>
</tr>
<tr>
<td>30,000 m²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of Gauge Readings</td>
<td>4,500</td>
<td>3,000</td>
<td>30,000</td>
</tr>
<tr>
<td>for 30,000 m²</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What limits?

<table>
<thead>
<tr>
<th>Standard</th>
<th>No of Readings for spot reading</th>
<th>Minimum required average reading</th>
<th>Minimum Individual Reading Allowed</th>
<th>No of Readings Below Average Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSPC PA2</td>
<td>3</td>
<td>Specified DFT</td>
<td>0.8 x Specified DFT</td>
<td>Not stated</td>
</tr>
<tr>
<td>ISO 19840</td>
<td>1</td>
<td>Specified DFT</td>
<td>0.8 x Specified DFT</td>
<td>&lt; 20% of readings</td>
</tr>
<tr>
<td>PSPC</td>
<td>Not stated</td>
<td>Not stated</td>
<td>0.9 x Specified DFT</td>
<td>&lt; 10% of readings</td>
</tr>
</tbody>
</table>
Standards for Testing

- Effect of Number of Readings

Impact on a Coating Scheme

Example

- The issue of high thickness is made worse if low areas are touched up with airless spray.
- An area with 200 μm thickness will have an additional coat of 125 μm added bringing the total to 325 μm.
- A brush coat may add just 80 μm – still above the target of 250 μm.
## Disputes on DFT

<table>
<thead>
<tr>
<th>Dispute Likelihood</th>
<th>Never</th>
<th>Infrequent</th>
<th>1 in 100</th>
<th>1 in 20</th>
<th>1 in 5</th>
<th>Half</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of Flash Rusting</td>
<td>2%</td>
<td>16%</td>
<td>9%</td>
<td>27%</td>
<td>18%</td>
<td>20%</td>
<td>7%</td>
</tr>
<tr>
<td>Visual Surface Cleanliness</td>
<td>0%</td>
<td>31%</td>
<td>16%</td>
<td>16%</td>
<td>27%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Visual Surface Irregularities (weld splatter edge prep etc)</td>
<td>2%</td>
<td>39%</td>
<td>2%</td>
<td>30%</td>
<td>14%</td>
<td>11%</td>
<td>2%</td>
</tr>
<tr>
<td>UV Surface Cleanliness (oil grease etc)</td>
<td>5%</td>
<td>26%</td>
<td>21%</td>
<td>21%</td>
<td>23%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Surface Salts (Conductivity Measurement)</td>
<td>9%</td>
<td>33%</td>
<td>7%</td>
<td>21%</td>
<td>14%</td>
<td>14%</td>
<td>2%</td>
</tr>
<tr>
<td>Anchor Profile (Comparator)</td>
<td>7%</td>
<td>39%</td>
<td>7%</td>
<td>15%</td>
<td>20%</td>
<td>10%</td>
<td>2%</td>
</tr>
<tr>
<td>Dry Film Thickness (SSPC PA-2) – System</td>
<td>5%</td>
<td>41%</td>
<td>7%</td>
<td>20%</td>
<td>16%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Dry Film Thickness (SSPC PA-2) – Primer</td>
<td>5%</td>
<td>41%</td>
<td>7%</td>
<td>25%</td>
<td>11%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Dry Film Thickness (SSPC PA-2) – Intermediate Coats</td>
<td>5%</td>
<td>41%</td>
<td>9%</td>
<td>20%</td>
<td>14%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>Surface Salts (Chloride Measurement)</td>
<td>11%</td>
<td>39%</td>
<td>7%</td>
<td>25%</td>
<td>16%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Dust (Tape Test)</td>
<td>7%</td>
<td>38%</td>
<td>19%</td>
<td>12%</td>
<td>10%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Dust (Visual)</td>
<td>7%</td>
<td>40%</td>
<td>14%</td>
<td>16%</td>
<td>9%</td>
<td>12%</td>
<td>2%</td>
</tr>
<tr>
<td>Visual Holiday Detection – Intermediate Coats</td>
<td>7%</td>
<td>43%</td>
<td>11%</td>
<td>16%</td>
<td>14%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Anchor Profile (Dial Depth Gauge)</td>
<td>7%</td>
<td>45%</td>
<td>7%</td>
<td>17%</td>
<td>17%</td>
<td>7%</td>
<td>0%</td>
</tr>
<tr>
<td>Visual Holiday Detection – Primer</td>
<td>9%</td>
<td>39%</td>
<td>16%</td>
<td>14%</td>
<td>14%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Visual Holiday Detection – System</td>
<td>7%</td>
<td>43%</td>
<td>14%</td>
<td>14%</td>
<td>16%</td>
<td>7%</td>
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</tr>
<tr>
<td>Recordkeeping (report to owner)</td>
<td>9%</td>
<td>38%</td>
<td>18%</td>
<td>16%</td>
<td>13%</td>
<td>7%</td>
<td>0%</td>
</tr>
<tr>
<td>Field check of coating properties (e.g. viscosity)</td>
<td>12%</td>
<td>35%</td>
<td>21%</td>
<td>16%</td>
<td>7%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Environmental Conditions Monitoring</td>
<td>9%</td>
<td>42%</td>
<td>13%</td>
<td>16%</td>
<td>18%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Environmental Conditions during coating application</td>
<td>14%</td>
<td>34%</td>
<td>18%</td>
<td>14%</td>
<td>18%</td>
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</tr>
<tr>
<td>Environmental Conditions during cure</td>
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<td>43%</td>
<td>11%</td>
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<td>Continuous Environmental Monitoring</td>
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<td>50%</td>
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<td>13%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>Anchor Profile (Testex Tape)</td>
<td>13%</td>
<td>47%</td>
<td>7%</td>
<td>13%</td>
<td>9%</td>
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<td>2%</td>
</tr>
<tr>
<td>Containment Integrity</td>
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<td>49%</td>
<td>9%</td>
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<tr>
<td>Electrical Holiday Detection</td>
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<td>52%</td>
<td>12%</td>
<td>12%</td>
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<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Substrate Surface Temperature</td>
<td>7%</td>
<td>57%</td>
<td>11%</td>
<td>9%</td>
<td>11%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Laboratory QA of Coating Material</td>
<td>17%</td>
<td>43%</td>
<td>9%</td>
<td>13%</td>
<td>13%</td>
<td>4%</td>
<td>0%</td>
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<tr>
<td>Wet Film Thickness</td>
<td>7%</td>
<td>61%</td>
<td>14%</td>
<td>7%</td>
<td>2%</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>
Errors in the field

Less reproducibility when sampling schemes vary
And!

- What about a request for a cosmetic coat?
- Or a request to grind back and re-apply?
CONCLUSIONS
Conclusions

• When a minimum DFT is specified, the Mean DFT increases due to the spread of thickness values inherent in the process
  – This increase can result in the mean being above the recommended maximum.
  – The maximum may be exceeded
  – It is easier to add coating to build up the thickness than to remove coating from areas that are too thick
Conclusions

• An improvement to the coating application technique is needed to reduce the spread of thickness values (standard deviation) to make these specifications work
  – The number of coats
  – The complexity of the structural design
  – The skill of the applicator
  – The condition of the equipment
Conclusions

• Technical Data Sheets
  – Need specific DFT values
  – Preferable to state a range from minimum to maximum for each coat
  – Need tested high limits
  – Need to co-ordinate all documentation to be consistent
  – Need to ensure all documents are available/referred to
Conclusions

• Dry Film Thickness Gauges
  – Statistics calculated assuming a normal distribution
  – DFT readings for paint processes tend to be skewed
  – Need better standards for coating work and many existing ones need a good review to eliminate ambiguities/inconsistencies
  – If readings not grouped then more readings are needed to generate a normal distribution
Conclusions

• Current assessment methods for coatings are inadequate.
  – High subjectivity element
  – Inadequate access in service
  – Problems even with simple objective elements
    • DFT values in TDS can be misleading
  – Coating process variability is high
  – Min/Max limits do not reflect process capability
  – Need a functional approach
Any questions?

Acknowledgment
Thanks to the Team at Safinah for their invaluable data