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

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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

- NORSOK
- 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

Design

- IMO PSPC

“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

Compartment type	Structural member		t_{cc} or t_{cc}		
			Oil tankers	BC-A or BC-B ships with L ≥ 150 m	Other BC ships
Ballast water tank, bilge tank, drain storage tank, chain locker (1)	Face plate of PSM	Within 3m below top of tank (4)	2.0		
		Elsewhere	1.5		
	Other members (2) (3)	Within 3m below top of tank (4)	1.7		
		Elsewhere	1.2		
Cargo oil tank	Face plate of PSM	Within 3m below top of tank (4)	1.7	N/A	
		Elsewhere	1.4		
	Inner-bottom plating/bottom of tank		2.1		
	Other members	Within 3m below top of tank (4)	1.7		
		Elsewhere	1.0		
Dry bulk cargo hold (5)	Transverse bulkhead	Upper part (6)	N/A	2.4	1.0
		Lower stool: sloping plate, vertical plate and top plate (7)		5.2	2.8
		Other parts		3.0	1.5
	Sloped plating of hopper tank, inner bottom plating			3.7	2.4
	Other members	Upper part (6)		1.8	1.0
		Webs and flanges of the upper end brackets of side frames of single side bulk carriers			
		Webs and flanges of lower brackets of side frames of single side bulk carriers		2.2	1.2
		Other parts		2.0	1.2
Exposed to atmosphere	Weather deck plating		1.7		
	Other members		1.0		
Exposed to seawater	Shell plating between the minimum design ballast draught waterline and the scantling draught waterline		1.5		
	Shell plating elsewhere		1.0		
Fuel and lube oil tank			0.7		
Fresh water tank			0.7		
Void spaces (8)	Spaces not normally accessed, e.g. access only via bolted manhole openings, pipe tunnels, inner surface of stool space not common with a dry bulk cargo hold or ballast cargo hold, etc.		0.7		
Dry spaces	Internals of machinery spaces, pump room, store rooms, steering gear space, etc.		0.5		

CORROSION PROTECTION

1 GENERAL

1.1 Structures to be protected

1.1.1 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

Bulk carrier extract

2 CORROSION PROTECTION

2.1 General

2.1.1 Void double side skin spaces

Void double side 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 side skin spaces in the cargo area for ships having a freeboard length L_{LL} 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 coamings 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.

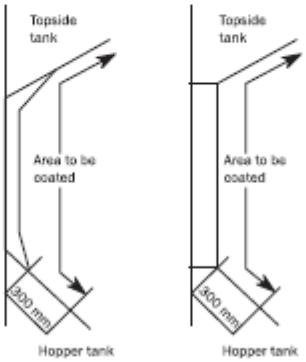
2.3.3 Side areas to be coated

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.

Figure 1 : Side areas to be coated



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
  - Who? What? When? Hold points!
- The generic paint scheme
  - See next slide
- Others e.g. Cathodic protection

Typical generic format

51	SPECIFICATION	S2009-04022-025M	PAGE 49

Painting scheme:

No	Painting scope	Type of paint applied	DFT (μm)
1.0	Outside		
1.1	Hull to deep load line	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy Sealer Tie-coat AF Tie-coat AF (60 days drydocking period)	150 150 50 (AF's DFT according to water primer)
1.2	Topside T/B	Anti-corrosive/Universal pure epoxy Anti-corrosive/Universal pure epoxy Polyurethane Finish RAL 1007 Polyurethane Finish RAL 1007	150 150 50 50 Σ 400
1.3	Exterior and main deckhouse: Inter deckhouse exterior		
2	Interior (Inside)		
2.1	Main deck, forecastle deck, bench coatings, bulwark inside, deck equipment etc.	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy Polyurethane Finish	150 150 50 Σ 350
2.2	Deck machinery, underneath	Maker's standard	
2.3	Foundation of deck machinery	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy	150 150 Σ 300
2.4	Hatch covers exposed surfaces	One shade Epoxy Polyurethane Finish Radiocrom	75 75 50 Σ 200
2.5	Hatch covers underneath	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy Epoxy	100 100 Σ 200
3	Deep tank		
3.1	Exposed surfaces of cofferdams, cleanings, wells, tunnel, inside etc.	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy Polyurethane Finish Polyurethane Finish	150 150 50 50 Σ 400
3.2	Exposed decks	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy Polyurethane Finish (brown)	100 100 50 Σ 150
4	Machinery space/engine room		
4.1	Uninsulated steel behind linings and insulation	Vinyl primer	50
4.2	Unused steel in way of accommodation, spaces etc.	Vinyl primer Vinyl finish	50 40 Σ 100
4.3	Decks (uninsulated)	Alkyd primer Alkyd finish	50 43 Σ 100
4.4	Gally, Oil stores, Sheathing in way of cold television rooms and engine room	No coating	
4.5	Gally, Oil stores, Sheathing in way of	BP Blaser or zinc primer Vinyl finish	10-15 40

51	SPECIFICATION	S2009-04022-025M	PAGE 50

No			
5	Cargo spaces etc.		
5.1	Cargo holds, passage ways, corner below lowerable deck etc.	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy Sing (Tank top radiocrom)	100 100 Σ 200
5.2	Decks in cargo holds, stern bunks in cargo holds etc.	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy	100 100 Σ 200
5.3	Void spaces, collisions, ventilation ducts, ventilation hatch etc.	Anti-abrasive/Universal pure epoxy	150
6	Engine room		
6.1	Engine room, below floor plates	Alkyd primer/Alkyd finish	100 100 Σ 200
6.2	Void spaces, cofferdams etc.	Anti-abrasive/Universal pure epoxy	150
6.3	Drain sumps etc.	Anti-abrasive/Universal pure epoxy Anti-abrasive/Universal pure epoxy	150 150 Σ 300
6.4	Steel or steel-backed linings and insulation	Alkyd primer	50
6.5	Unused steel in engine room, workshops, store spaces etc.	Alkyd primer Alkyd finish	50 40 Σ 100
6.6	Decks in engine room	Alkyd primer Alkyd finish	50 43 Σ 100
6.7	Gally, Oil stores, Sheathing	No coating	
6.8	Main engine, aux. engines, generator, pumps, rudder engine etc.	Builder's standard color should be to be applied upon any touch up subject to Owner's approval.	
6.9	Gallery, funnel casing, exhaust pipes etc.	Aluminium heat resistant Aluminium heat resistant	40 40 Σ 80
7	Tanks, void spaces etc.		
7.1	Water tanks: potable tank, air tank, sludge tanks, chain locker etc.	Anti-corrosive/Universal pure epoxy Red brown Anti-corrosive/Universal pure epoxy Light grey	100 100 Σ 200
7.2	Freshwater tanks	Potable (for potable water) Pure epoxy Pure epoxy Pure epoxy	100 100 100 Σ 300
7.3	Fuel oil tanks, Diesel oil tanks, Lub. Oil tanks	Fuel oil/Diesel oil Fuel oil/Diesel oil No coating, to be cleaned to bare plate	
7.4	Void, Trunks and cofferdams	Anti-abrasive/Universal pure epoxy	150

Typical paint company response

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Paint Specification & Specification

4.3 Deck (unsheathed) 无敷料的铁甲板

No.	Product	PCS	Color	DFT	Solids Content	Theory Spray Rate	Oil Loss Factor	Real Spray Rate	Area	Est. Volume	Standard Package	Number of Type
1		7105	brown	80	55%	7.80	2	3.50			20	2005
2		7238	grading	40	45%	12.25	2	6.13			20	2005
System Total:				120								

4.4 Galv. Or alum. Sheathing in way of cold provision rooms and engine room在冷藏室和机舱内镀锌或铝的表面—no paint

4.5 Galv. Or alum. Sheathing in way of accommodation在居住舱室内镀锌或铝的表面

No.	Product	PCS	Color	DFT	Solids Content	Theory Spray Rate	Oil Loss Factor	Real Spray Rate	Area	Est. Volume	Standard Package	Number of Type
1		7417	pistagreen	20	57%	20.50	2	10.25			20	8102
2		7238	white	40	45%	12.25	2	6.13			20	2005
System Total:				60								

5.0 Cargo spaces etc.货舱空间

5.1 Cargo holds except No.4， tanktop redbrown 货舱(除4号舱外) ———货舱底红棕色

No.	Product	PCS	Color	DFT	Solids Content	Theory Spray Rate	Oil Loss Factor	Real Spray Rate	Area	Est. Volume	Standard Package	Number of Type
1		7900	redbrown	125	72%	5.78	2	2.89			20	8102
2		7900	grey	125	72%	5.78	2	2.89			20	8102
3												
System Total:				250								

5.2 passage ways, stores below forecastle deck 主甲板下通道，舱壁、甲板下储藏室

No.	Product	PCS	Color	DFT	Solids Content	Theory Spray Rate	Oil Loss Factor	Real Spray Rate	Area	Est. Volume	Standard Package	Number of Type
1		7900	redbrown	125	72%	5.78	2	2.89			20	8102
2		7900	grey	125	72%	5.78	2	2.89			20	8102
3												
System Total:				250								

Owner wants - Predictable performance

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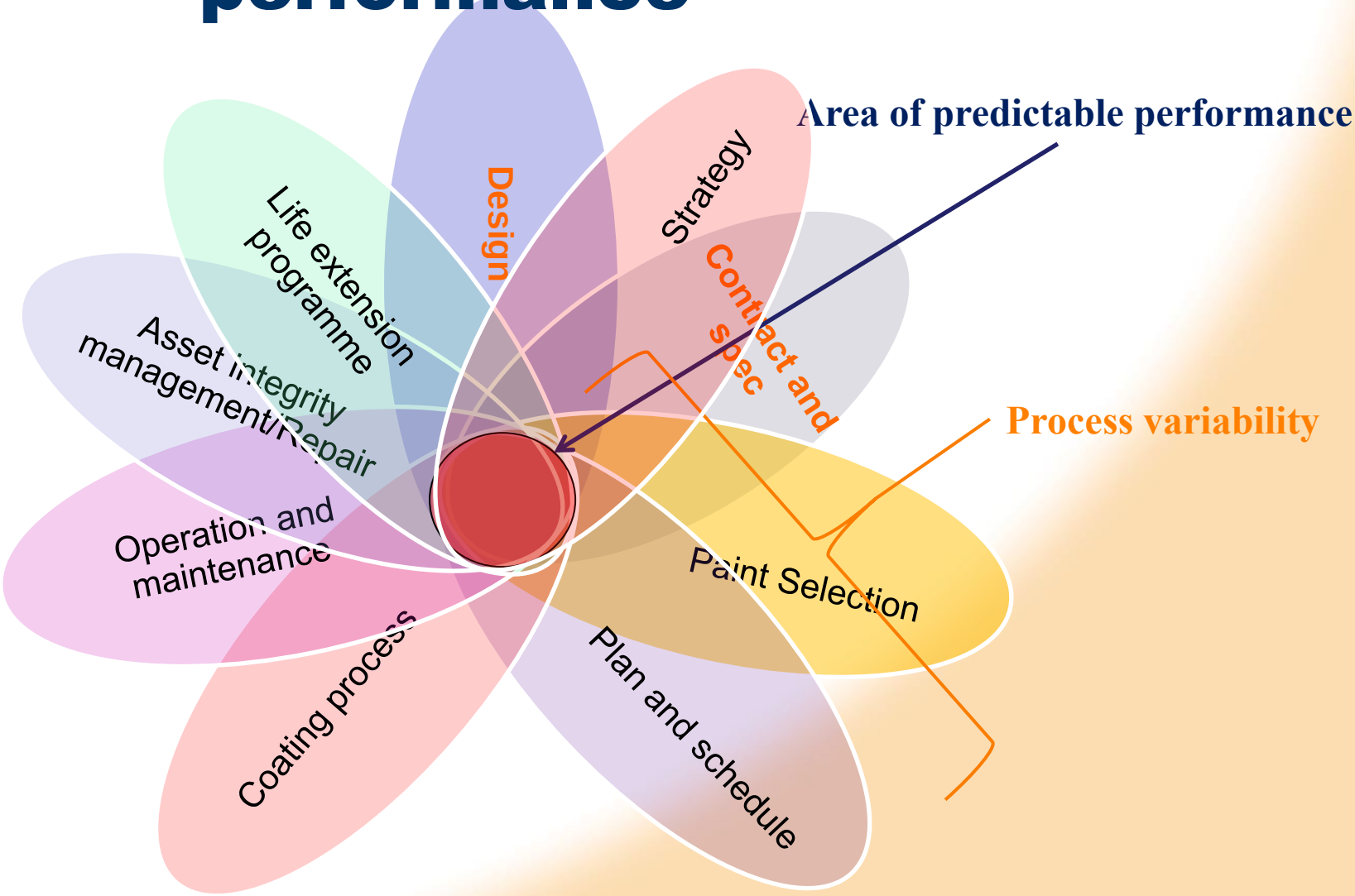

In effect all sources of failure

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 x 100 microns
    - Anti-abrasive pure epoxy x 100 microns
- Specification version 2 – memo to specification:
  - Cargo hold 1,2,3,5,6,7
    - 2 x125 microns
  - Cargo hold 4
    - 2 x 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!

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Technical Data sheet

5 pages

December 2010
Revision of February 2010

DESCRIPTION

two component high build polyamine cured epoxy primer/coating

PRINCIPAL CHARACTERISTICS

- surface tolerant primer/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 [redacted] Shade Card of [redacted]) - semigloss
Note: For Cargoholds grey (5177) and redbrown (6179) only - semigloss

BASIC DATA AT 20°C

(1 g/cm³ = 8.25 lb/US gal; 1 m²/l = 40.7 ft²/US gal)
(data for mixed product)

Mass density	1.4 g/cm³
Volume solids	72 ± 2%
VOC (supplied)	max. 263 g/kg (Directive 1999/13/EC, SED) max. 361 g/l (approx. 3.0 lb/gal)
Recommended dry film thickness	50 - 100 µm for brush/ roller 125 - 150 µm for airless spray
Theoretical spreading rate	5.8 m²/l for 125 µm, 4.8 m²/l for 150 µm
Touch dry after	2 hours
Overcoating interval	min. 6 hours * max. 6 months *
Curing time	7 days

(data for components)

Shelf life (cool and dry place)	at least 12 months * see additional data

RECOMMENDED SUBSTRATE CONDITIONS AND TEMPERATURES

- **for atmospheric exposure conditions:**
  - steel; blast cleaned to ISO-Sa2½ for excellent corrosion protection, blasting profile 40 - 70 µm
  - steel; blast cleaned to ISO-Sa2, blasting profile 40 - 70 µm or power tool cleaned to ISO-St2 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

December 2010

SYSTEM SPECIFICATION

2 x 125 µm dft [redacted]

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	none
Pot life	3 hours at 20°C * * see additional data

AIRLESS SPRAY

Recommended thinner	Thinner 91-92
Volume of thinner	0 - 5%, depending on required thickness and application conditions
Nozzle orifice	approx. 0.48 - 0.53 mm (= 0.019 - 0.021 in)
Nozzle pressure	15 MPa (= approx. 150 bar; 2130 p.s.i.)

AIR SPRAY

Recommended thinner	Thinner 91-92
Volume of thinner	5 - 10%, depending on required thickness and application conditions
Nozzle orifice	1.8 - 2 mm
Nozzle pressure	0.3 - 0.4 MPa (= approx. 3 - 4 bar; 43 - 57 p.s.i.)

BRUSH/ROLLER

Recommended thinner	Thinner 91-92
Volume of thinner	0 - 5%

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/l	7.2	5.8	4.8
dft in µm	100	125	150

max. dft when brushing: 100 µm

Technical Data sheet

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Overcoating table for [redacted] for dft up to 150 µm

	substrate temperature	5°C	10°C	20°C	30°C	40°C
with itself and various two pack epoxy coatings	minimum interval	16 hours	9 hours	6 hours	4 hours	3 hours
with polyurethanes	minimum interval	48 hours	30 hours	18 hours	9 hours	5 hours
with itself and various two pack epoxy coatings	maximum interval when not exposed to direct sunshine	12 months	9 months	6 months	3 months	1 month
	maximum interval when exposed to direct sunshine	1 month	1 month	21 days	14 days	7 days
with polyurethanes	maximum interval when exposed to direct sunshine	1 month	21 days	14 days	7 days	3 days

- surface should be dry and free from any contamination

Overcoating table for [redacted] for dft up to 150 µm

	substrate temperature	5°C	10°C	20°C	30°C	40°C
with various single pack coatings (such as alkyds and acrylics)	minimum interval	24 hours	24 hours	16 hours	8 hours	5 hours
	maximum interval	14 days	14 days	7 days	4 days	2 days

- after exceeding of the maximum interval, glossy finishes require a corresponding undercoat
- surface should be dry and free from any contamination
- best intercoat adhesion occurs when the subsequent coat is applied before the preceding coat is fully cured
- if this time is exceeded it may be necessary to roughen the surface

Curing table for [redacted] for dft up to 150 µm

substrate temperature	touch dry	dry to handle	full cure
5°C	12 hours	16 hours	25 days
10°C	6 hours	9 hours	15 days
20°C	2 hours	6 hours	7 days
30°C	1 hour	4 hours	4 days
40°C	1 hour	3 hours	2 days

- for cargo hold application: for full cure for hard angular cargoes, please contact your neare[redacted]atings sales office
- adequate ventilation to remove solvent must be maintained during application and curing (please refer to sheets 1433 and 1434)
- should [redacted]850 or the total coating system (2 x 125 µm) be applied in excess of the specified dry film thickness, then the time necessary to reach full cure will be increased

Pot life (at application viscosity)

15°C	4 hours
20°C	3 hours
30°C	2 hours
40°C	1 hour

Worldwide availability

Whilst it is always the aim o[redacted]atings 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 to product data sheets
Safety indications
Safety in confined spaces and health safety
Explosion hazard - toxic hazard
Safe working in confined spaces
Directives for ventilation practice

[redacted]

Technical Data sheet

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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 [redacted] products made by [redacted], 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.

[redacted] has no control over either the quality or condition of the substrate, or the many factors affecting the use and application of the product. [redacted] 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.

	PDS	7970
320396	grey	5177052200
320398	lederman	5179052200

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.

Explanation to data sheet

- 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.

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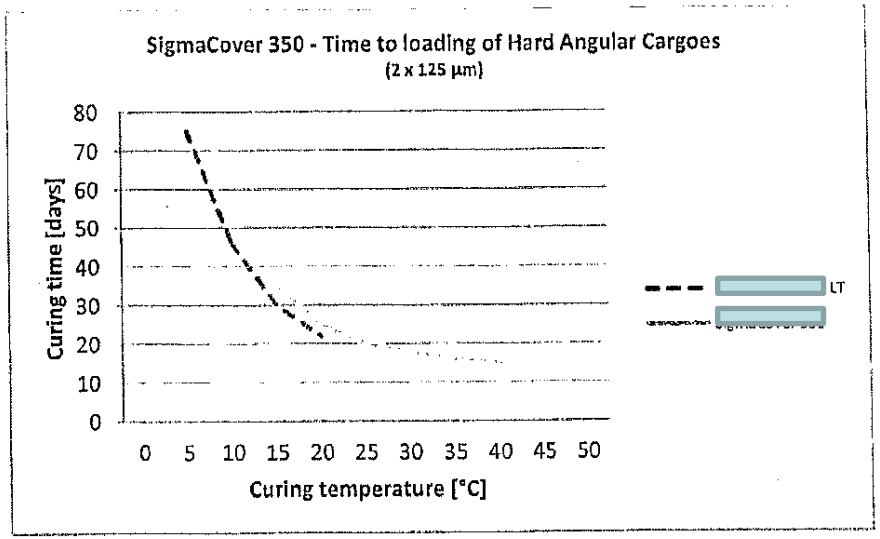
Please refer to your local office if you should have any questions on this important issue.

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 solvented 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



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 (R_Z) 40 - 70 µm steel with approved shop primer; sweep blasted to SPSS-Ss or power tool cleaned to SPSS - Pt3
paint system	[redacted] 125 µm [redacted] 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 15% of the total area. (see also information sheet 1411 for additional details)
notes	– if a recoatable epoxy system is required, [redacted] specified as topcoat at a dft of 125 µm replacing th[redacted] – The mechanical properties [redacted]6 are not the same as [redacted], therefore this should be taken in consideration with regard to transportation of hard angular cargoes. – at application temperatures below 5°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 WJ2/3 L or ISO Wa 2/2½ L followed by above specification - For wet cargo holds - VIS WJ2 L or ISO Wa 2½ L followed by appropriate primer as first coat - For more information see sheet [redacted]

Contract - guarantee

- *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"*

DFT

- 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

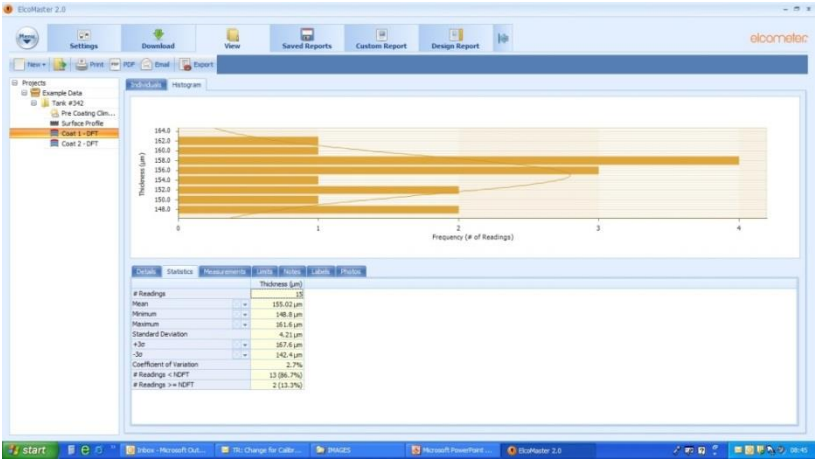
- Cargo hold 4 – 3 x 100 microns
  - Min in the range 80 to 90 microns
  - Max in the range 600 – 660 – 900 microns
- Other cargo holds – 2 x 125 microns
  - Min in the range 100 – 112.5 microns
  - Max in the range 500 – 550 - 750 microns

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?

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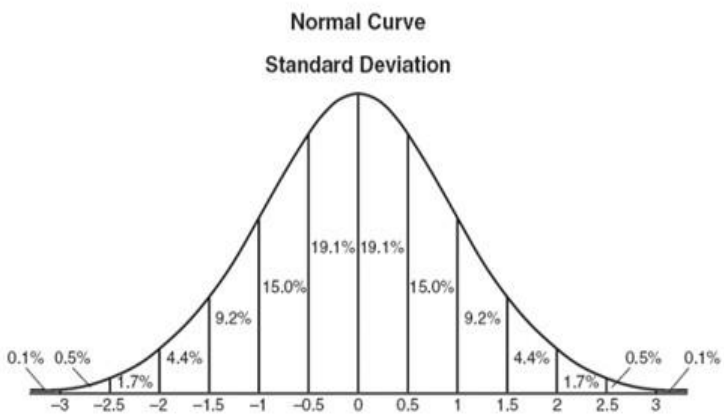
- **Example**



66.6% of readings within ± 1 σ 95.4% of readings within ± 2 σ
99.75% of readings within ± 3 σ
(σ = standard deviation)

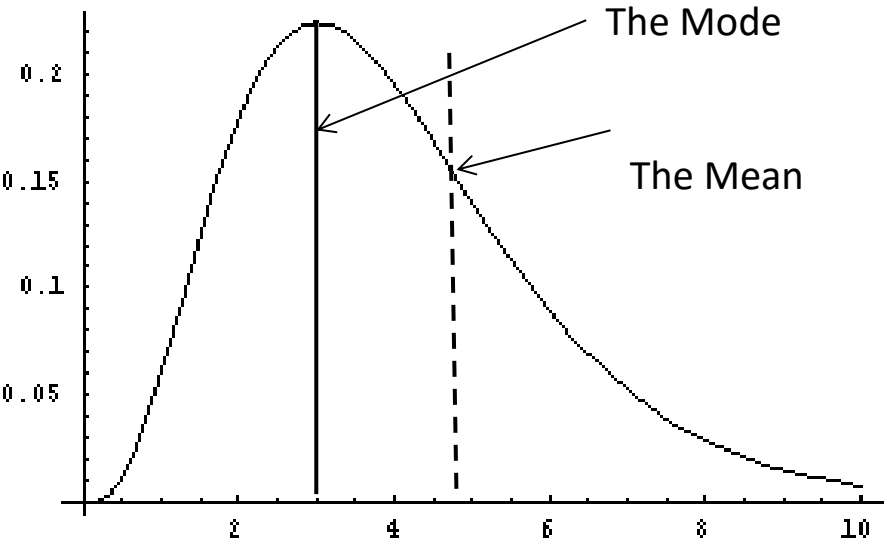
- Normal Distribution of readings
- 50% above mean & 50% below mean
- DTF Gauge Statistical Summary:

  Sample Size, n = 12

- Mean, Standard Deviation
- Maximum & Minimum Values, (Range)

What is Specified DFT?

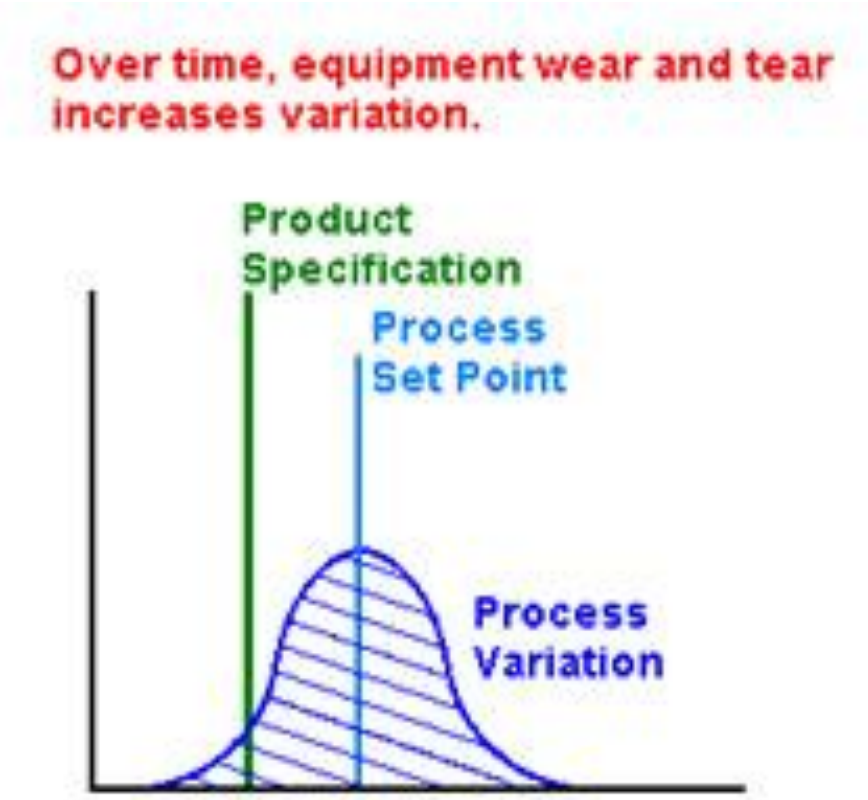
- **Example**



- 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

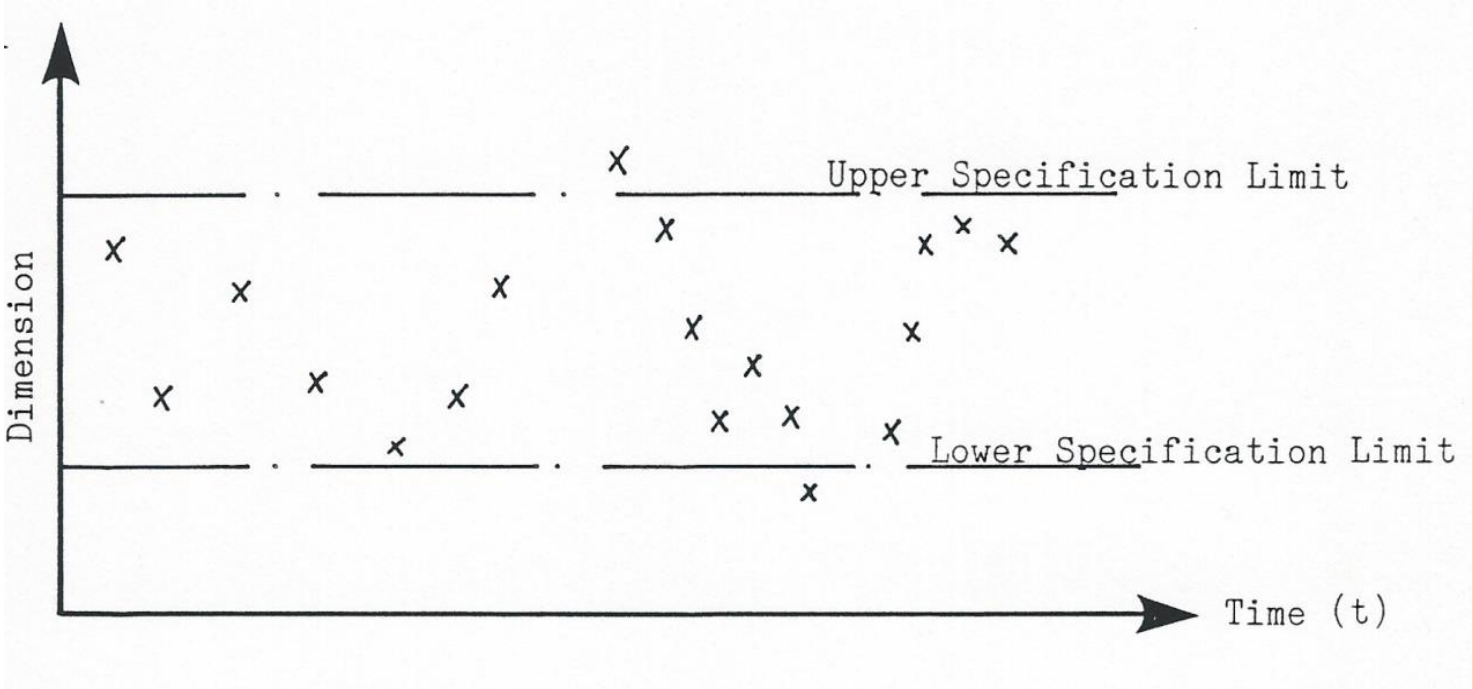
- Wrong or worn spray tips
- Wrong pressure
- Wrong stand-off distance

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

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- **Minimum & Maximum Values**

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

Source: Francis RA; Thickness of Marine Coatings: Measurement, standards and problems; RINA Conference on Marine Coatings, London April 2013

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 to 3 σ 250 – 1,048 µm

Impact on a Coating Scheme

- **Example**
- To achieve the required specification:
- Minimum DFT 225 µm
- Maximum DFT550 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?

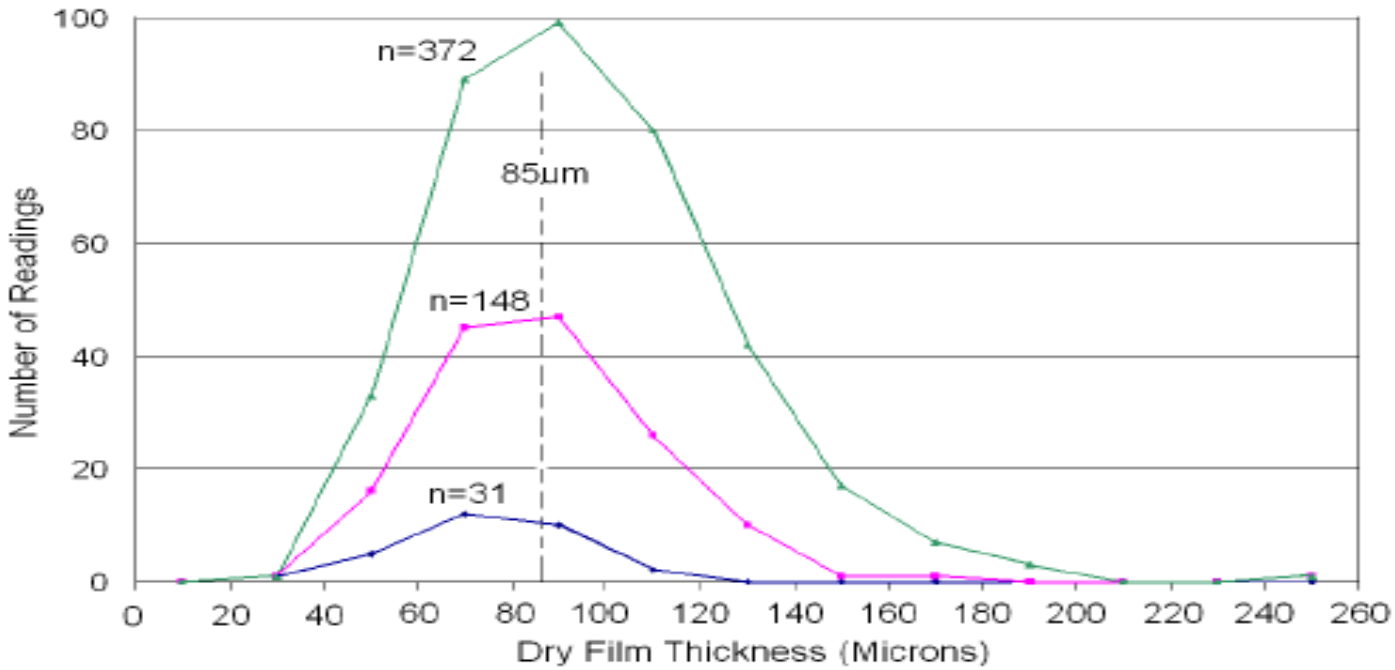
	SSPC PA-2	ISO 19840	PSPC
Spot Measurements – complex areas > 100 m²	5 for each 100 m²	10 for each 100 m²	1 for each m² (100 for a 100 m² area)
Spot measurements for 30,000 m²	1,500	3,000	30,000
No of Gauge Readings for 30,000 m²	4,500	3,000	30,000

- What limits?

Standard	No of Readings for spot reading	Minimum required average reading	Minimum Individual Reading Allowed	No of Readings Below Average Allowed
SSPC PA2	3	Specified DFT	0.8 x Specified DFT	Not stated
ISO 19840	1	Specified DFT	0.8 x Specified DFT	< 20% of readings
PSPC	Not stated	Not stated	0.9 x Specified DFT	< 10% of readings

Standards for Testing

- Effect of Number of Readings



Source: Francis RA; Thickness of Marine Coatings: Measurement, standards and problems; RINA Conference on Marine Coatings, London April 2013

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

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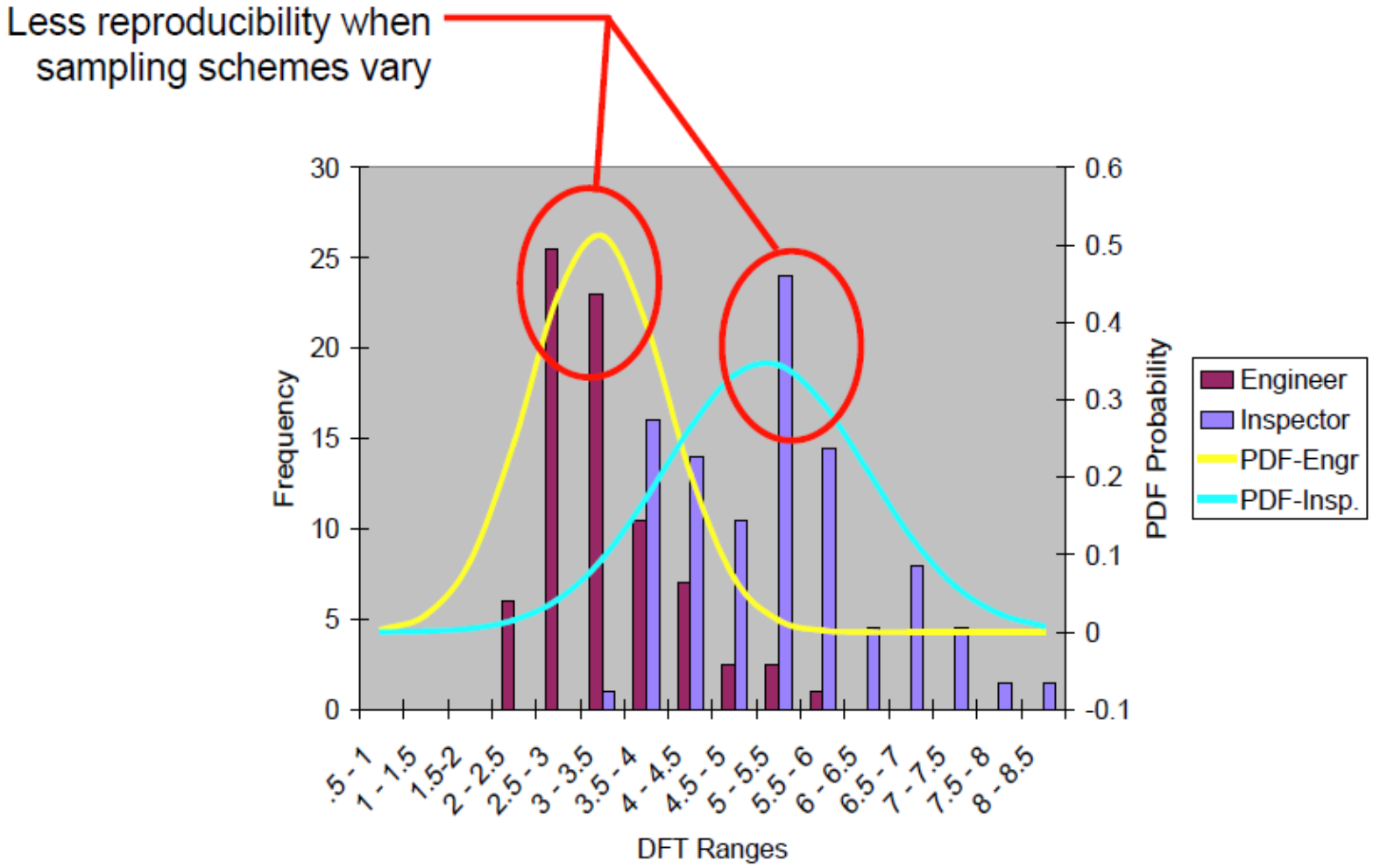
Disputes on DFT

Dispute Likelihood	Never	Infrequent	1 in 100	1 in 20	1 in 5	Half	Always
Degree of Flash Rusting	2%	16%	9%	27%	18%	20%	7%
Visual Surface Cleanliness	0%	31%	16%	16%	27%	11%	0%
Visual Surface Irregularities (weld splatter edge prep etc)	2%	39%	2%	30%	14%	11%	2%
UV Surface Cleanliness (oil grease etc)	5%	26%	21%	21%	23%	2%	2%
Surface Salts (Conductivity Measurement)	9%	33%	7%	21%	14%	14%	2%
Anchor Profile (Comparator)	7%	39%	7%	15%	20%	10%	2%
Dry Film Thickness (SSPC PA-2) – System	5%	41%	7%	20%	16%	11%	0%
Dry Film Thickness (SSPC PA-2) – Primer	5%	41%	7%	25%	11%	11%	0%
Dry Film Thickness (SSPC PA-2) – Intermediate Coats	5%	41%	9%	20%	14%	11%	0%
Surface Salts (Chloride Measurement)	11%	32%	7%	25%	16%	9%	0%
Dust (Tape Test)	7%	38%	19%	12%	10%	10%	5%
Dust (Visual)	7%	40%	14%	16%	9%	12%	2%
Visual Holiday Detection – Intermediate Coats	7%	43%	11%	16%	14%	9%	0%
Anchor Profile (Dial Depth Gauge)	7%	45%	7%	17%	17%	7%	0%
Visual Holiday Detection – Primer	9%	39%	16%	14%	14%	9%	0%
Visual Holiday Detection – System	7%	43%	14%	14%	16%	7%	0%
Recordkeeping (report to owner)	9%	38%	18%	16%	13%	7%	0%
Field check of coating properties (e.g. viscosity)	12%	35%	21%	16%	7%	7%	2%
Environmental Conditions Monitoring	9%	42%	13%	16%	18%	2%	0%
Environmental Conditions during coating application	14%	34%	18%	14%	18%	2%	0%
Environmental Conditions during cure	9%	43%	11%	18%	16%	2%	0%
Continuous Environmental Monitoring	9%	50%	11%	9%	13%	9%	0%
Anchor Profile (Testex Tape)	13%	47%	7%	13%	9%	9%	2%
Containment Integrity	7%	49%	9%	26%	5%	5%	0%
Electrical Holiday Detection	10%	52%	12%	12%	5%	7%	2%
Substrate Surface Temperature	7%	57%	11%	9%	11%	2%	2%
Laboratory QA of Coating Material	17%	43%	9%	13%	13%	4%	0%
Wet Film Thickness	7%	61%	14%	7%	2%	5%	5%

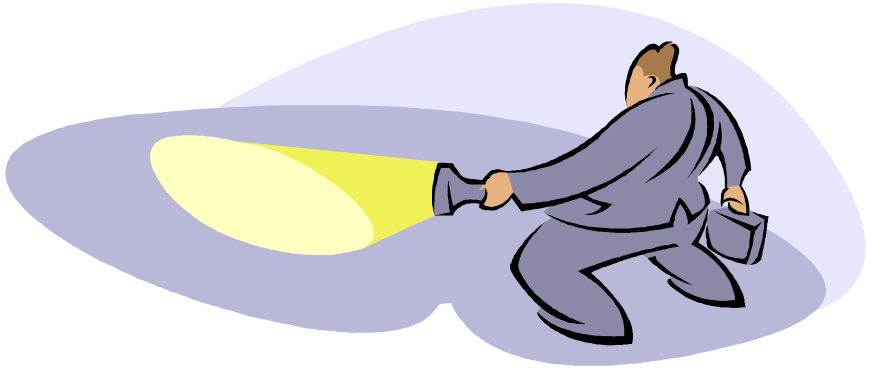
Errors in the field



And!

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

CONCLUSIONS



Conclusions

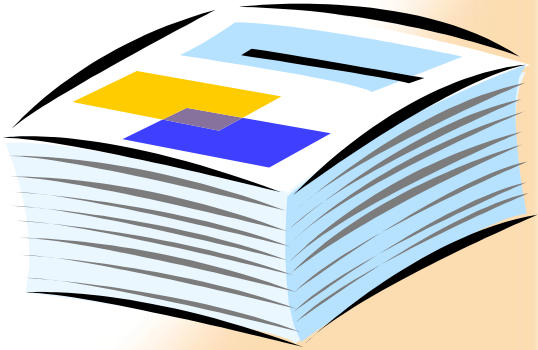
- **When a minimum DFT is specified, the Mean DFT increases due to the spread of thickness values inherent in the process**
  - This increase can result in the mean being above the recommended maximum.
  - The maximum may be exceeded
  - It is easier to add coating to build up the thickness than to remove coatingfrom 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

Safinah
a different approach to coatings