Ambiguities in Determining if 'Specified DFT' has been Achieved

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> **Takeaway:** *Despite the confusing roles that international coating standards and paint company guidelines and recommendations play in determining whether the "specified dry film thickness" has truly been achieved, the DFT plays a key part in the performance or failure of marine coatings.*

The Standards: How Many Readings?

One of the first problems that inspectors face in determining the achieved dry film thickness (DFT) of a coating application is: *how many readings should be taken to get a good overall view of the structure in question?*

Below, R. A. Francis shows how various standards require the readings to be taken, and their minimum DFT requirements. [1]

Standard: SSPC PA2
No. of readings for spot measurement: 3
Min. required average reading: Specified DFT
Min. individual readings allowed: 0.8 x Specified DFT
No. of readings below average allowed: Not stated

Standard: ICO 19840
No. of readings for spot measurement: 1
Min. required average reading: Specified DFT
Min. individual readings allowed: 0.8 x Specified DFT
No. of readings below average allowed: <20% of readings

Standard: PSPC
No. of readings for spot measurement: Not stated
Min. required average reading: Not stated
Min. individual readings allowed: 0.9 x Specified DFT
No. of readings below average allowed: <10% of readings

(*Number of reading and minimum values - R. A. Francis)*

Francis went on to demonstrate how the number of readings can influence overall measurement results. While the likely mean DFT readings for coating specified at 85 µm may be approximated by a relatively few readings, the minimum and maximum values (more so the maximum rather than the minimum) are influenced considerably by the number of readings.

Manufacturer Guidelines

Of course, the immediate reply is that there are technical data sheets (TDS) and manufacturer guidelines or recommendations. The most critical are the guidelines; however, in practice, the key document most often used in the field is the technical data sheet.

When comparing several different technical data sheets for ballast tank coatings from the major paint suppliers, a number of interesting observations can be made.

Although the TDS is often used in writing specifications, it is rarely provided to field personnel or referred to again unless a problem arises. In that case, the user will be referred to some statement in the TDS.

But a typical problem for cargo hold coatings is the time period before loading a first cargo of coal—information is rarely available in the TDS. Instead, this information is often found within the guidelines/recommendations document.

This raises the issue of the true purpose of the technical data sheet. Exactly what information should be included on them? For example, many anti-corrosive paints would be specified for non-cargo hold use and hence the time to load a first cargo of coal is not relevant to such specifications.

The net result would be some or all of the following:

- Increase in the number of technical data sheets required
- Increase the length of the data sheet
- Make a requirement of the specification to clearly identify some reference to a system guideline document in a prominent position (i.e. this data sheet should be read in conjunction with a marine coating systems guideline)

Inconsistent Terminology Use in Technical Data Sheets

The DFT provided on the data sheet generally takes into account a number of things, including:

- It is the DFT value at which the performance of the product is optimized. The paint supplier tests a range of thicknesses in an attempt to reflect practical conditions.
- The DFT allocated to a specific product for a specific use will also take into consideration what competitors offer for coatings for that use. If there is considerable deviation, then it could result in increased costs (higher DFT) or lowered costs (lower DFT).
- The minimum value at which the coating will coalesce if applied by airless spray.
- Other commercial or practical considerations.

Technical data sheets often give a DFT value or sometimes a range. Typical terminology used for the given DFT on major paint supplier data sheets are:

- Typical thickness
- Recommended dry film thickness
- Film thickness
- Indicated film thickness
- Recommended systems dry film thickness (with a minimum and maximum)

Characterizing the DFT Indicated

What is interesting is that none of these terms match the "nominal DFT" term as used in the IMO PSPC. For more general use, it is not unusual that the specification can deviate from the DFT as set out in the TDS.

For example, in cargo holds for bulk carriers, a typical system may be 2x150 µm DFT and the TDS may give a range for the DFT of 125–150 µm. While for the ballast hold of a bulk carrier, the specification itself may give 3x100 µm. Thus, a DFT is specified that would appear to be below the minimum value given on the TDS.

It is clear from the content of the TDS that the data sheets themselves are advisory and often they carry a legal disclaimer at the end indicating that the values given on them are based on laboratory testing that may be updated based on practical experiences.

What is not clear at all is the role of the DFT indicated:

- Is it a minimum, a nominal, an average or what?
- What does typical mean?

- If it is a recommended DFT, how will performance of the coating change if the application deviates from the recommended value?
- What does any range given mean?
- Is it a maximum/minimum, or simply some guideline values?

These ambiguities are not often resolved in the paint company guidelines for the use of TDS or application. This can leave the end users with difficulties in the event of a subsequent failure. (Learn more about DFT values in The Impact of Minimum & Maximum DFT Values on Coating Performance.)

Of course, one could argue that providing relatively vague data may suit the paint supplier as it makes subsequent claims in the event of a failure harder to assess.

Guidelines/Recommendations

On examining the recommendations sheets, most paint suppliers suggest that good practice would be that the maximum DFT should not be more than x2 that which is specified (per coat and for the whole scheme) with an allowance of up to x2.5 in limited areas (complex structural areas).

In absence of any recommendations from the paint suppliers, ISO standards refer to a value of x3 the specified DFT, while it is well known that for Korean yards, maximum DFT values are often specified as high as 2,000 µm for ballast tank coatings, which is about six times the PSPC nominal DFT and way above the recommended guidelines of x2 the specified DFT). While this may be convenient for the production capability of the yard, how does that affect the performance of the coating system when the nominal DFT is 320 µm?

In light of these issues, there would seem to be merit for the paint suppliers to carefully review the content and detail of both data sheets and their recommendation sheets to capture the current practical issues in particular with respect to DFT. (Best practices when applying the coatings is discussed in Increasing Coating Performance through Application Process Control.)

What is the Specified DFT?

When the paint specification only gives a value of 2x160 µm, what is this specified value? Is it the minimum, the mean, the mode or the maximum?

Most people would interpret this figure to be a “nominal” or an “average (mean)” value. In other words, it is not an exact number to be hit, and it is understood that there will be variation with a good practice limit set by the guidelines and recommendations. This is typically at x2 the specified DFT and a minimum set either by the physical ability of the paint film to coalesce or the adoption of a minimum rule such as the IMO 90:10 rule.

However, we have come across inspectors (shipyard, owners and paint companies) that often consider it as a minimum value.

The Chambers dictionary includes some of the following terms:

- Nominal: pertaining to, or of the nature of, only in name, so called, but not in reality.
- In an engineering sense, the term “nominal” is often used in association with a dimension and is normally accepted to mean: The nominal DFT may not match any DFT reading of the scheme applied. The nominal DFT may correspond to an aggregate over many readings.

This implies that a nominal dimension must be accompanied by a tolerance.

In shipbuilding, we can already see that the maximum recommended in paint-company guidelines is x2 the DFT; thus we have an upper limit on a nominal dimension. While for the minimum, a rule is normally applied such as the 80:20 rule or the 90:10. Let us consider, then, what this means for a specification of 2x160 µm:

- It has first to be assumed that the 160 µm is a nominal DFT.
- Perhaps it should be the mean or the mode.
- The mean would require that the average reading taken in a given sample (for sample sizes see: SSPC PA2, ISO19840, IMO PSPC) would be given by the arithmetic mean, while the mode is the value that occurs the most often of the set of readings taken.

For example, take the following set of numbers:

- 1,2 3,3,3,3,5,5,6,7,10,10
- Sample size n = 12
- Mean = 4.83
- Mode = 3.00

The Mean and the Mode

In a normal distribution, the mean is the value above which you would expect to find in the middle, with 50% of your DFT readings above, and the other 50% of them below. DFT gauge software assumes that you have a normal distribution when they provide a statistical summary that often includes:

- Average DFT
- Maximum
- Minimum
- Standard deviation
- Range

The average DFT is then simply the mean of the readings taken. The maximum is the highest reading taken. And, the minimum is the lowest reading taken, while the range is the difference between the maximum and the minimum.

Standard deviation is a measure of the spread of the curve. A low standard deviation would indicate a tight process that can perform accurately, and a low value for the range

(the difference between the maximum and the minimum values). A high standard deviation would indicate poorer control of the application resulting in a larger range.

For a normal distribution, the following approximate values are used (s = standard deviation):

- 66.6% of all values lie within the range ± 1 s
- 95.4% of all values lie within the range ± 2 s
- 99.75% of all values lie within the range ± 3 s

The mode can be below or above the mean, depending on the readings taken, and would generate a curve of a similar shape as the normal curve, but that would be "skewed" toward the ode value.

References

[1] Francis RA; Thickness of Marine Coatings: Measurement, standards and problems; RINA Conference on Marine Coatings, London April 2013.

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This article was co-written with John Fletcher.

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