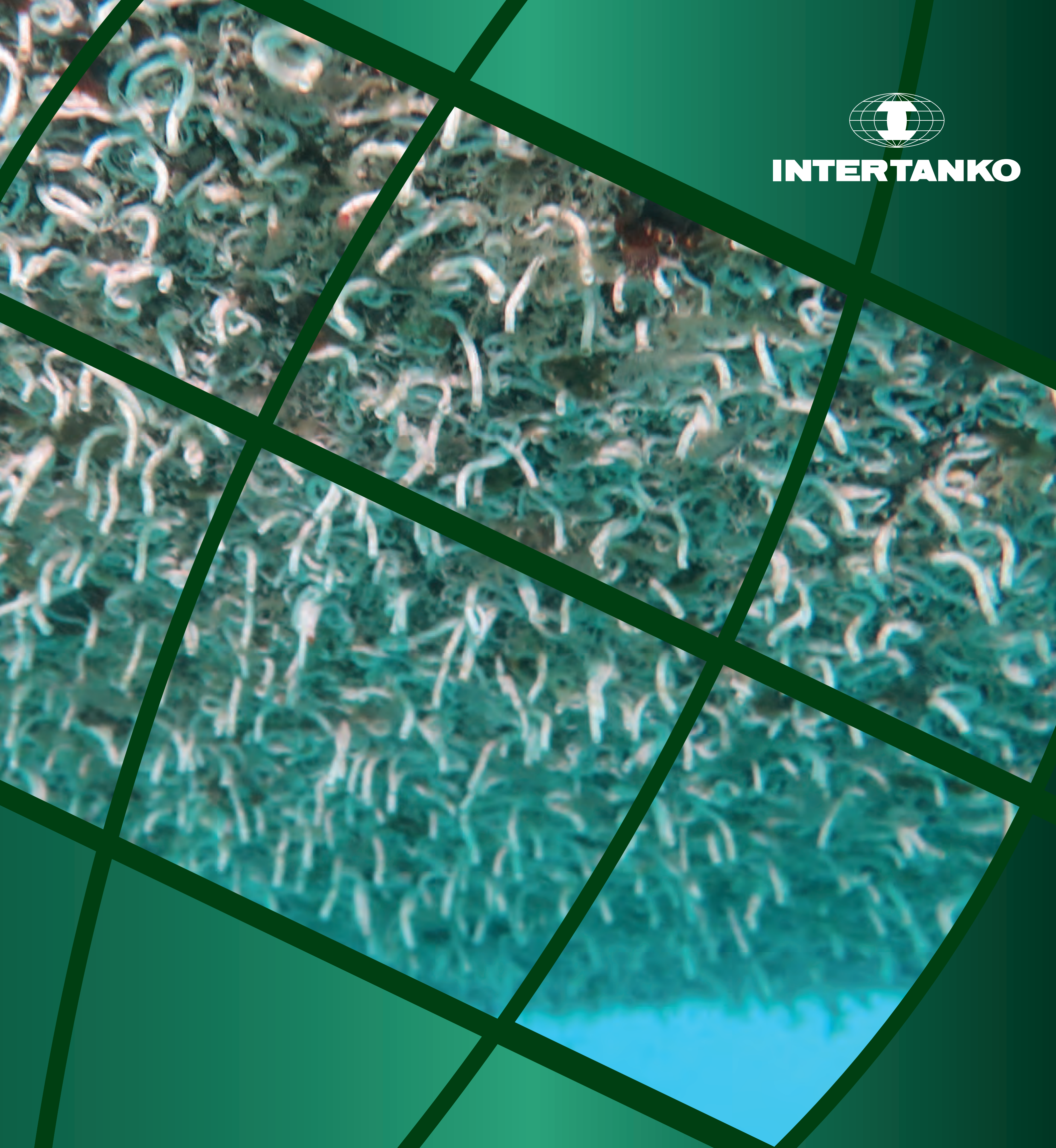

INTERTANKO

INTERTANKO GUIDE TO MODERN ANTIFOULING SYSTEMS AND BIOFOULING MANAGEMENT

TWENTY 16

INTERTANKO Guide to Modern Antifouling Systems and Biofouling Management

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Contents

Foreword iii

Introduction iiii

Acronyms and Abbreviations iiii

Background on Modern Antifouling Systems v

Part A: Coating Selection 6

1. Ship operational profile 6
2. Physical parameters of the coating 7

2.1 Binder Technology 7

2.2 Polishing rate 8

2.3 Polishing linearity 9

2.4 Leach layer 9

2.5 Cleaning resistance 10

Part B: Hull Management 12

1. Dry-docking 12
2. Performance monitoring 13
3. Hull Cleaning 15

Part C: Common Issues and Questions 17

1. Relative effectiveness of modern antifouling systems 17
2. Heavy fouling when idle for more than 10 days 18

Foreword

The development of this Guide is the culmination of work within INTERTANKO's Environmental Committee and in particular a series of discussions and exchanges between the Committee members and Mr. Johnny Eliasson. Mr. Eliasson has worked for over two decades on this issue for owners, class societies and charterers and is known throughout the industry as the leading expert on antifouling and hull management. The Guide brings together views, concerns and experiences together with practical solutions and ideas presented to and by Mr. Eliasson. INTERTANKO is extremely grateful for Mr. Eliasson's time in developing this Guide and for sharing his extensive knowledge and insight.

Introduction

An increased focus on hull performance for improved vessel efficiency as well as the need to minimise the transfer of invasive species on ships' hulls has seen the importance of antifouling coating selection elevated in many shipping companies. However, since the entry into force of the IMO's Antifouling Convention (AFS) in September 2008 and the subsequent banning of organotin-based antifouling systems, such as those containing tributyl-tin (TBT), there exists a wide diversity and consequential effectiveness of antifouling products. This has become increasingly relevant in recent years due to changes in the market, with vessel speeds now much lower, and an introduction of regional biofouling legislation. Both factors have also led, to a certain degree, to an increase in underwater hull cleaning.

INTERTANKO's Environmental Committee members first considered the problems in selecting suitable antifouling systems in 2013 and subsequently considered the need for modern coatings to address not only antifouling but changing vessel trading patterns, increased cleaning cycles and greater scrutiny for both hull efficiency and regulatory compliance.

This Guide provides advice on the current antifouling systems on the market and the operational challenges associated with performance measurement and hull management. In terms of hull management, one of the key areas of focus in this guide is the increasing need to undertake hull cleaning.

Acronyms and Abbreviations

AF	Antifouling
AFS	International Convention on the Control of Harmful Antifouling Systems on Ships
CDP	Controlled Depletion Polymer/Paint
Cu	Copper
FRC	Fouling Release Coating
Si	Silicon (Silyl-)
SPC	Self-polishing Copolymer
STC	Surface Treated Coating
TBT	Tributyl-tin
UWHC	Under Water Hull Cleaning
UWHG	Under Water Hull Grooming
UWHR	Under Water Hull Roughness
Zn	Zinc

Background on Modern Antifouling Systems

Since the entry into force of the AFS, there has been no single antifouling coating which can meet all the operational conditions for a particular vessel. The market has expanded with a wide selection of coating technologies which perform well in certain, limited vessel operating conditions. Ship owners must therefore optimise the specific antifouling paint, using the best technology at their disposal for each ship's specific operative profile. As a consequence of this extensive, and at times confusing, antifouling market in which to operate, the owner's selection of a suitable antifouling system becomes increasingly difficult. Further, the high cost of many systems coupled with the economic and high regulatory stakes means that getting the selection wrong will come with greater negative impacts for vessel owners.

It has been suggested that CDP and CDP Hybrids account for around 70% of the market today. But with the considerable number of products and technologies on the market and the constant changing of brand names, it may well be the case that many owners are not fully aware of what technology is being used on their ships. Binder and functional technologies are frequently renamed and mixed with other technologies in a confusing manner. For example, a CDP hybrid by one supplier is commonly referred to as a Cu-acrylate SPC as well as a Si-acrylate, even though as a CDP hybrid it is primarily Rosin-based and not primarily an acrylate system.

While noting the various operating and performance parameters discussed elsewhere in this guide, there is some degree of consensus that the leading antifouling technology at present appears to be the Silyl-acrylate systems. This technology initially suffered from some unexpected performance issues with inadequate hydrolysis rate at low seawater temperatures, although this issue has now been resolved.

The Silyl-acrylate resin used by most paint manufacturers is sourced from a single manufacturer. This may lead to an increase in cost. However, this may also ensure that the coatings made from the Silyl-acrylate resin have some degree of commonality that may allow for a more open market for the finished products. As volumes increase it is expected that more Silyl-acrylate resin manufacturers will enter the market.

A number of new generation coating systems are also entering the market and it is advised that owners keep abreast of developments through their coating suppliers. Some recent developments worth noting include the following:

- A hydrogel system produced by Hempel and Nippon Paint which is claimed to improve biocide delivery.
- A new polymer technology produced by International Paint promises a linear performance similar to that provided by TBT-SPC.
- Systems with reduced hull roughness from Jotun, Nippon Paint, Chugoku Marine Paints, and Kansai Paint Co.
- More resilient (to cleaning damage) acrylate coating from Jotun.

Note: the mention of coating manufacturing companies is by no way an endorsement of these brands or companies by INTERTANKO or its Members but are provided as examples of recent developments in the market, nor does this in any way suggest that paint companies not mentioned do not have equally good products.

Research and development by the coating industry is welcomed but significant claims for performance improvements must always be critically evaluated by the owner. Many manufacturers will claim fuel savings of 5-10%, however the baselines and the methods used for measuring performance are rarely disclosed.

Part A: Coating Selection

While it may be acknowledged that none of the current antifouling systems can match the effectiveness of the best TBT-based systems, it is also accepted that some of the TBT-free systems currently on the market are better than others in specific operative conditions. It can therefore be suggested that an optimisation of the antifouling selection based on the ship's true operational profile can greatly improve the expected overall performance, even if hull cleaning in the last year or two is still expected to remain common practice. The optimisation should also assist in reducing cleaning operation frequency and harshness.

The following provides a basic list of considerations for the selection of an antifouling system and is used as the structure for this guide:

1. Ship operational profile
2. Physical parameters of the coating

1. Ship operational profile

It is clear that an operator can never have a complete set of antifouling paint data for an ideal choice of product but a profile of the ship can nevertheless be established and provides a reasonable basis from which to make the selection, in cooperation with the paint manufacturers' antifouling expertise.

The owner should have a full and true understanding of the ship's operational (and commercial) activity, its dry-dock activity and an agreed method of monitoring performance.

All ships send position data at least every four hours to the company from which information may be extracted, analysed and stored by either the company or a third-party. This ship-specific data can then be used to identify the past operative profile of all ships in an owner's fleet.

Knowing the actual operative profile will enable a tightly optimised antifouling design while a more uncertain profile (spot, changing charter, etc.) will require a more conservative antifouling design to be considered. It should be noted that having an uncertain future operative profile will also put added pressure on the paint supplier to deliver the correct product that will perform as intended.

A ship with low activity, a slow actual speed (slow steaming), an uncertain operational profile and the risk of stagnant periods will require a faster polishing, higher thickness antifouling. This will generally come at a greater paint cost in the dry dock. On the other hand, a ship with high activity, a more 'normal' speed and a predictable operational profile will require a slower polishing, lower thickness antifouling system which may come at a lower cost. To receive a non-optimal antifouling paint for a vessel's operational profile will lead to early fouling, higher fuels cost, increased CO_2 emissions and a higher risk for the spread of invasive aquatic species.

Some of the high end and relatively new technologies are not recommended for activities less than 50%. In this respect it is important to demand that the paint supplier knows and considers the past and expected actual operational profile of the vessel before recommending an antifouling product. Furthermore, if a detailed and thorough actual operational profile can be developed by the owner then this can form the basis of a firm technical specification for the antifouling system. With this information the owner is placed in a stronger position to request bids from the coating suppliers on suitable products.

Different parts of the ship also have different operational profiles. For example, boottop areas are often above water at intervals long enough to kill off fouling species, while sea chests have a different water flow compared to the ship sides. The lower side bottom is often constantly immersed but exposed to light during the daytime while the flat bottom is always immersed and in permanent darkness. These differences should be considered and the antifouling paint selection matched accordingly. It is advisable to request from the manufacturer a performance-based optimisation of antifouling for the niche areas and boottop as well as the side- and flat-bottoms as different areas can have different operational profiles and require different polishing rates.

Working with the manufacturer is a key factor in the optimisation process and the tough questions need to be answered by the manufacturers. For example, have the manufacturers truly taken into account the performance of the system being recommended? The paint manufacturer should be asked to recommend an antifouling system which performs for the time required and not just at the lowest cost. Manufacturers claimed savings in percentage terms should come qualified with the baseline from which the savings were ascertained. Any experience-based data provided should come with an explanation of how the data was compiled.

For a biocide-free system the predicted performance will only be based upon a clean hull. As such, once a slime layer (micro-fouling) has formed, usually a few months after dry docking, the performance will only be as good as the hull with slime on it.

2. Physical parameters of the coating

The most important physical parameters of antifouling coatings are:

2.1 Binder Technology
2.2 Polishing rate
2.3 Polishing linearity
2.4 Leach layer
2.5 Cleaning resistance

All the above parameters are generally difficult to obtain specific information and data on directly from the coating suppliers. INTERTANKO has established a webpage on its website for Members to exchange and share experience on hull coatings and where many of the above four considerations are considered (http://www.intertanko.com/Topics/Environment/Antifouling-paints/).

2.1 Binder Technology

Using the primary binder as the ranking tool the following listing can be suggested:

- Hydrolysis-based acrylate technology (Cu-, Zn-, Silyl-acrylates)
- Rosin-based technology (CDP and CDP hybrids)
- Hard surface coatings ("Surface Treated Coatings" – STC)
- Silicone and modified silicones (FRC)

It could be argued that the common division for antifouling into biocide-based and biocide-free systems may be misleading. For example, many FRC silicones contain both an organotin catalyst and either silicone or fluorpolymer oils (as a vital fouling retarding component). There is also a current trend to incorporate biocides into FRCs, specifically for slime control, and more recently also for barnacle control.

Based on the present state of technology a general ranking can be provided for the risk of fouling growth, with the most effective option first:

- Silyl-acrylate
- Cu-acrylate
- Zn-acrylate
- Controlled Depletion Polymer (CDP) hybrids
- CDP
- Surface Treated Coating (STC)

FRC silicone systems are not included in this list because their performance is heavily dependent on vessel activity. Biocide-containing Foul Release Coatings (FRC) that are claimed to resist stagnant conditions for longer periods have been introduced, but their long-term performance has yet to be proven.

There are Silyl- and Cu-acrylates available that can resist fouling relatively well under all operational profiles, even in stagnant conditions. While having other advantages, STCs do not resist fouling at all, and must be regularly cleaned.

2.2 Polishing rate

Manufacturers should provide polishing rate data but this data will need to be normalised for comparisons, as the polishing rate is influenced by a number of variables such as speed, activity, water temperature and polymer formulation.

Paint companies will quote the required thickness and type of paint based on the operational profile of the vessel provided by the Operator. The competition for the dry docking paint supply is tough, and there is a risk that the competing paint suppliers will recommend less paint than optimally needed just to get the sale. It is hard for the operator to check these thickness values when they do not have access to the base facts.

Table 1 below shows normalised polish rates based on 100% activity, 25^{o}C seawater and a 15knot worldwide trading speed based on information from six paint suppliers. That there is a difference is clear, which also highlights the need for careful optimisation, and the asking of tough questions.

Maker	Product	SB mic/month	FB mic/month
X	a	4.7	3.1
	b	9.4	6.2
	c	4.7	3.1
	d	5.3	3.5
Y	a	6.0	4.0
	b	8.0	5.0
	c	15.0	10.0
	d	5.0	3.0
	e	8.0	5.0
	f	15.0	10.0
Z	a	4.0	2.6
	b	6.0	4.0
	c	8.0	5.3

Maker	Product	SB mic/month	FB mic/month
D	a	2.9	1.9
	b	4.0	2.7
	c	3.5	2.3
	d	12.0	7.9
	e	6.5	4.3
E	a	3.8	2.3
	b	4.0	2.5
	c	4.0	2.5
	d	8.0	5.0
	e	16.0	12.0
F	a	5.8	3.7

Table 1: Normalised polish rate comparison between six manufacturers

A fast polishing antifouling needs to be applied in a thicker layer to perform at equal speed and activity. Increasing the thickness will invariably increase cost. From this also follows that if a paint maker bids on price only a slower polishing antifouling paint might look more attractive, but might not perform as intended.

2.3 Polishing linearity

Some technologies, including Silyl-acrylates, have been found to show some seawater temperature dependency. Newer products however have been claimed to be less seawater temperature dependent but have not yet been proven over the longer term. One such technology is a new polymer which does not depend on hydrolysis, as most current antifouling coatings today, but instead uses advanced dissolution.

2.4 Leach layer

The leach layer (LL) remains an important parameter for determining coating performance on any given vessel. Hydrolysis based AF technology has a less thick LL while the likes of CDP has a deep/thick LL. For the new polymers entering the market, the LL is not yet known but is allegedly equal to hydrolysis based.

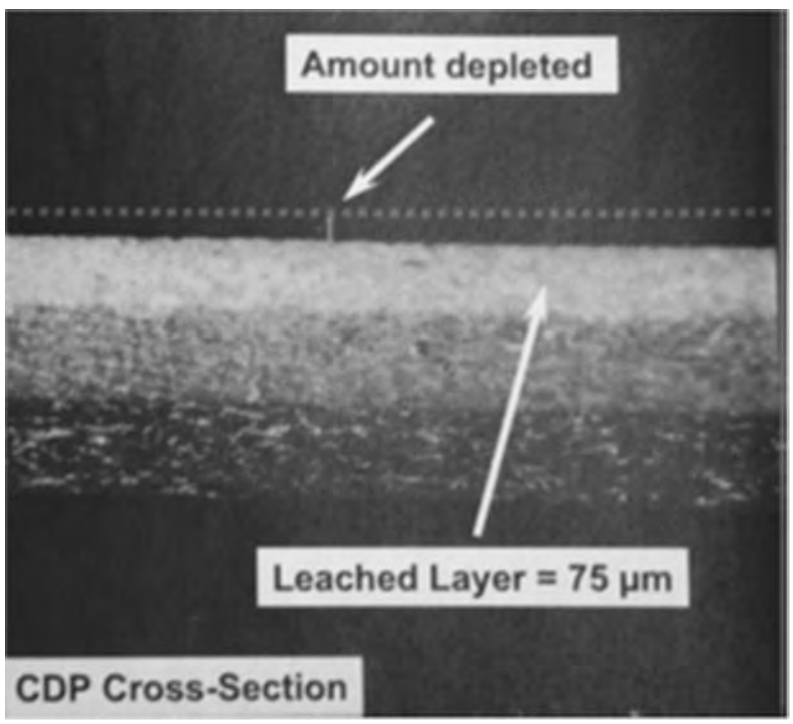

Figure 1: CDP Cross-section showing leach layer thickness

The LLs affect the film integrity (e.g. cracking and detachment) meaning the better the technology the better the expected result, and it can influence drag and fuel usage.

Table 2 demonstrates the impact of the selection of antifouling type on fuel performance. Leach layer contributes, among other factors, to the observed differences seen in the table:

Technology	Initial Fuel Penalty FP	Performance Loss Over 5 years	Average Loss During 5 Years Excl. Initial FP	Comparative Average Loss Excl. Initial FP	Comparative Average Loss Including Initial Loss
Latest linear polishing technology	0 (baseline)	3.56	1.76	0 (baseline)	0 (baseline)
Si-Acrylate	1	4.25	1.625	-0.135	0.845
Cu-Acrylate	2	6.05	2.025	0.265	2.245
CDP	2.5	7.38	2.44	0.68	3.16
CDP including expected fouling	2.5	11.39	4.445	2.685	5.165

Table 2: Impact of the selection of antifouling type on fuel performance

Table 2 highlights the importance of selecting the optimal technology as well as the importance of the correct polishing rate as already covered previously. The cost of better paint (say latest technology versus CDP) can be high; easily adding $100,000 to the dry docking budget of a VLCC. However, 2.245% less fuel usage over the first year (100T/day, cost $500/T, 75% activity = 273 running days) can equate to a reduction in cost terms of as much as $345,000 with a payback time for the added antifouling cost of 3 ½ months.

2.5 Cleaning resistance

As previously noted, under water hull cleaning (UWHC) is an inevitable part of modern hull management so the coating's relative strength to 'reasonable' cleaning can be ranked as follows, with the most resilient first:

- STC
- Silyl-, Cu-, Zn-acrylates
- CDP hybrids
- CDP
- Silicone

2.5.1 Cleaning STC

STC can basically be cleaned as often as desired with little or no expected damage, even when heavily fouled by macro-fouling such as large barnacles. The other coatings are all affected to some degree by UWHC.

2.5.2 Cleaning Acrylates

In terms of cleaning acrylate systems, Silyl-, Cu- and Zn-acrylates all have firm films with shallow leach layers and clean reasonably well. As with most coatings, these are best cleaned at the "micro-fouling" stage when a smoothing, rather than damaging, result is expected. Barnacles and other hard "macro-fouling", once formed, can break up in the cleaning process and form abrasive protrusions that can cause damage and loss of paint. Further damage may also be caused when attempting to remove the macro-fouling remnants owing to the need to use rough brushes (containing steel wire) during the cleaning.

2.5.3 Cleaning CDP and CDP Hybrids

As mentioned above, cleaning is best undertaken at the "micro-fouling" stage and the cleaning of CDP and CDP hybrids are no exception to this rule. CDP hybrids have a deeper leach layer, see section 2.4, i.e. they have a greater thickness of "expired" paint remnants over the intact paint layer, and therefore lose more paint when cleaned at the "micro-fouling" stage. The coating is also weakened (softened) by water absorption and may be damaged more easily compared to the acrylates.

The thicker the leach layer, and the softer the paint type, the more they are expected to leach copper as well as paint fragments when cleaned, and to lose paint thickness. Cleaning at the "macro-fouling" stage will invariably lead to coating damage also to the acrylate types, as well as the silicone types.

2.5.4 Cleaning Silicones

Silicone coatings can be frail and easily damaged, more so than other hull coating types. As such, only specialised cleaning is recommended and always at the "micro-fouling" stage. Once "macro-fouling" such as barnacles settle and grow to a larger size there is a high risk of coating damage when the barnacles are removed.

Silicone coatings' performance also depends on the presence of silicone or fluoropolymer oil at the coating surface, which can leach out from the bulk paint body after each cleaning. This means there is a limit to the amount of cleaning operations that can be done over time and as the silicone oil reservoir is depleted. This can be seen as the primary reason for the manufacturer's requirement of a full refresher coat after five years in service.

Part B: Hull Management

1. Dry-docking

Dry-dockings activities can be divided into four main parts:

1. Pre-docking
2. Docking
3. Result validation
4. Continuous monitoring.

1.1 Pre-docking activities

- Condition data acquisition
- Operative profile definition
- Spec writing
- Paint supplier bidding or contribution

Diver surveys, so called lazy-S swimming, while undertaking scheduled propeller polishing will provide fouling and under water paint condition data. When visiting the ship, use the launch to take a turn around the ship at anchorage to gain an idea of the hull's condition. This, and studying the ships UWHC records, gives a good idea about the performance of the system applied in the last dry dock.

Using the GPS data collected from the ship since the last dry dock, such as distance per year, time at anchorage, frequency of residence times and time in high fouling areas will establish the true operative condition. Assuming the ship will have a similar trading pattern in the next docking period the past can be used to optimise the antifouling system design.

Knowing the factors above, a detailed hull coating specification can be produced that aims at achieving the intended performance for the next inter docking period; which should be:

1) free from macro-fouling,
2) micro-fouling showing after only (x) years (suggested 3), and;
3) the hull only requiring (y) UWHG events (suggested 2).

The selected paint supplier, if there is a contract in place, or the bidding paint supplier contenders can use the above to design optimised system offers.

1.2 Docking

- In-docking fouling data logging, and hull fresh water washing
- In-docking under water hull roughness (UWHR) measuring
- Action in dry dock
- Out-docking UWHR measuring.

When the ship is on the blocks and the dry dock is safely available, carefully inspect the hull for the degree and type of fouling present. Check the conductivity of the fresh water used for hull high pressure water jet cleaning, and check the residual soluble salt contamination after washing (ISO 8502-9) – suggested maximum limit 50 µg/m^2.

The UWHR shall be a measure representing the roughness of the hull, and not the intact paint. This means that representative measuring values are to be taken from intact paint, blistered paint as well as rusty areas and parts, with these values averaged out. The hull should be divided into 10 vertical zones, with each zone divided into three levels on each side and on each side of the flat bottom. This will result in 120 measuring areas. The measuring areas should be averaged out for port side, starboard side, flat bottom and for the whole hull. The hull should be inspected on the blocks in great detail and affected areas agreed between owner and yard.

The coating specification should be finalised using the real condition of the ship when it is dry on the blocks, and action taken accordingly.

ISO 8501-1-1988 may be a useful reference and describes different degrees of blasting:
- Sa 2 ½ gives and clean surface, good long-term performance, and a smooth surface after painting;
- Sa 2 provides a good smoothness but less longer term performance; and,
- Sa 1 provides a rough surface, increased hull roughness and fuel losses.

Some ship yards perform hydro or slurry blasting with highly variable results.

Once the painting is completed the UWHR should again be measured.

1.3 Result validation

- Calculating theoretical in-docking condition fuel penalty
- Calculating theoretical out-docking condition fuel penalty
- Calculating the difference = the expected benefit
- Measuring performance after ship is back in service validating the theoretical calculations

1.4 Continuous monitoring

- Propeller polishing with a "lazy-S swim around" for fouling condition monitoring
- Under water hull grooming (UWHG), or under water hull cleaning (UWHC) carried out as needed
- Performance monitoring (see below)

All ships should have their propeller polished at intervals. This is to remove the calcareous deposits formed by the impact on the propeller by the anodes, or impressed current, used to protect the hull from galvanic corrosion attack. During these events the divers should be asked to swim from fwd to aft in an S-shape reporting on the condition of the hull, including the degree of fouling seen.

2. Performance monitoring

As a consequence of increases in fuel cost, increased focus on the spread of invasive aquatic species, and imperfect antifouling solution often in use it has become increasingly important to implement an effective monitoring programme for the vessel's hull. Visual observations are not easy and many owners are using various techniques to check the state of the antifouling system and general biofouling. This can range from the use of waterproof video cameras extended from the deck to below the waterline by the crew, to requesting divers performing propeller polishing (an increasingly frequent routine these days) to include an additional 'lazy s-swim' to provide a spot check of the fouling condition on the hull and in niche areas. The more frequent propeller polishing may also allow for inspections of antifouling test patches, the use of which is highly encouraged.

The introduction of the International Standards Organization's standard ISO 19030 for the Measurement of changes in hull and propeller performance may become a useful universal tool to assist owners in monitoring and measuring performance changes. This can be used when changing coatings and to assess the performance of the current coating against observed fouling. Combined with regular propeller polishing, the hull fouling may become the main variable.

The decision to clean then may relate to the visual observation of fouling or the measured changes in performance. In regards to the latter, Dr. M. Schultz has produced a straightforward assessment of the impact of increasing fouling on the performance and of the vessel based on required power. Dr. M. Schultz's illustration can be useful when we know the ship's true activity (%) profile. See Figure 2 below.

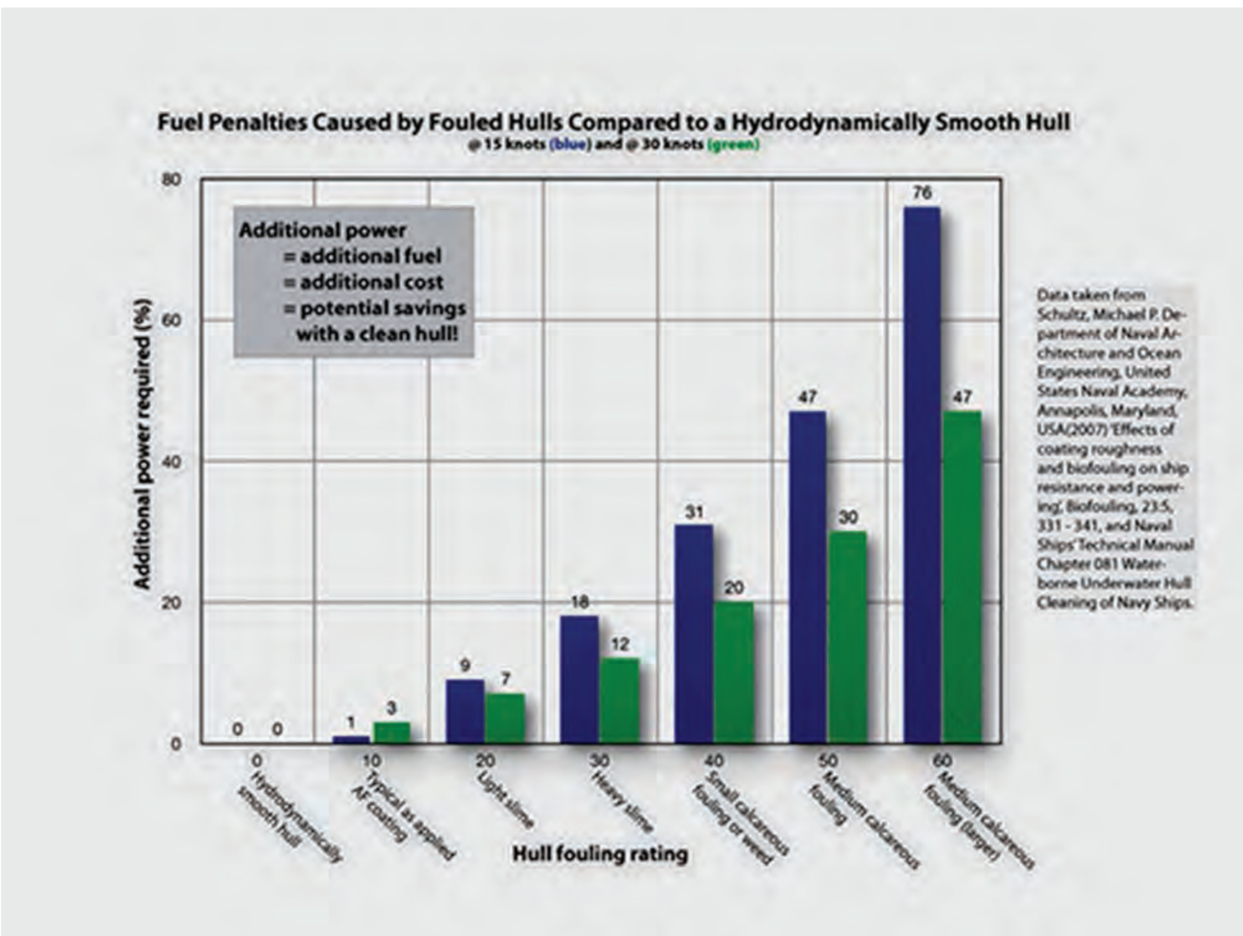

Figure 2: Fuel Penalties Caused by Fouled Hulls Compared to a Hydrodynamically Smooth Hull (Dr. M. Schultz)

Although generalised in nature and noting that the actual values vary between ships, the values presented by Dr. Schultz are sufficiently accurate for most ships to be relevant.

3. Hull Cleaning

Hull cleaning general comes down to two methods; UWHG and UWHC. At present the methods, techniques and options for hull cleaning are not standardised with a diversity available depending on the service provider. Equipment can vary from damaging steel brushes to soft nylon ones and to no touch technology such as water jets.

However, while there remains some degree of uncertainty in cleaning techniques and methods there is a move to standardise terminology and as such define more clearly the cleaning requirements.

More frequently the term 'grooming' (UWHG) is being used in the industry. This focuses exclusively on the removal of micro-fouling and is a quick and relatively easy technique that done correctly should not damage the coating.

Cleaning of the macro-fouling (UWHC) on the other hand is slow, more difficult and will invariably damage the coating. Importantly from an environmental perspective, cleaning macro-fouling may also present a greater risk of invasive species dispersal as the organisms that would otherwise remain on the hull are being actively removed, necessitating the securing of a new substrate for the organism in the local environment.

Table 3 below demonstrates the significant effect on performance of slime:

Fouling Type	Increase in Resistance	Source
Slime	5%	Conn *et al.* (1953)
	8 – 14%	Watanabe *et al.* (1969)
	18%	Lewkowisz & Das (1986)
	10 – 20%	Loeb *et al.* (1984)
	25%	Lewthwaite *et al.* (1985)
	8 – 18%	Bohlander (1991)
Shell & Weed	85% (extreme case)	Kempf (1937)

Table 3: Reported effect of fouling on hull's frictional resistance (Townsin, 2003 and Schultz and Swain, 1999, source, Advances in Marine Antifouling Coatings and Technologies; Edited by Claire Hellio and Diego Yebra)

The scatter in the "slime" values comes from the fact that slime is not defined by any standard and there are many contributing species that affect performance differently. However, the most important parameter is thought to be the thickness and density of the slime (micro-fouling) layer.

From Table 3 it follows that from a hull performance view point it is more economical, and poses less risk of damaging the coating, to maintain the hull while in the micro-fouling stage; in other words utilising UWHG – grooming. This also helps prevent the spread of aquatic invasive species.

Considering that hull fouling is not typically uniform, and that more than one type of fouling is present, it is important that the hull grooming/cleaning company is aware of the ship's expectations, before the job starts. With 99% slime (micro-fouling) and 1% hard barnacles it can be argued that UWHG treating softly the 99% of the surface area, while killing the barnacles but leaving the barnacle "cement" pads intact is the best choice compared with UWHC using rough, hard, abrasive discs to assure removal of all barnacle remnants, while also damaging 99% of the surface.

There should be a conversation between the operator and the hull treatment diving company about the optimal solution and choice of brushes (or other tools).

Marine biologists around the world have mapped the fouling organisms in great detail in their local environment and have presented their data in scientific papers. What is clear from this research is that fouling organisms spawn at different periods of time, during different seasons and in different areas. Using this vast bank of knowledge it should be possible to develop a fouling risk assessment tool for all major ports and anchorage positions, to help the operators manage the fouling risk better.

While a ship may not be able to choose the location where it will anchor for a given length of time, having this data can help the operator develop counter measures, or at least be aware of the potential for fouling.

Part C: Common Issues and Questions

1. Relative effectiveness of modern antifouling systems

Issue: Technologies available today seem to vary widely from conventional coatings that have very limited resistance to idle time (~10 days) to more advanced types of Silyl-acrylate-based coatings and to the highest standard (albeit not commonly used) biocide-free silicon-based coatings.

Comment:

Different technologies have different residence time limits. In brief, CDP and CDP Hybrids are not well suited for stagnant conditions as they need the "used" paint to be worn off by the friction of water of a moving ship (= drag). Experience with Zn-acrylates is limited but are not expected to have a great success in idle conditions either. The Cu- and Silyl-acrylate family have fast polishing types that pose less risk for limited stagnant conditions, however, they will polish fast when the ship moves at higher speed. STC will quickly foul up, but can be cleaned. Silicone systems will foul and will need cleaning but they have a limit, which differs by product, to the amount of cleaning events possible.

Issue: Normally deterioration starts in year 3 and deteriorates further in years 4 and 5.

Comment:

All ships today enter dry-dock with a slime line. The TBT biocide in TBT-SPC was effective against fouling of all types from micro- to macro-fouling. Copper is not considered effective against slime, which is why many TBT-Free AF paints depend on booster biocides to manage slime. Today most ships have some hard fouling as well which has meant the return of hull 'scraping' in the dry dock.

The selection of antifouling products for most ships today is not optimal and years 4 and 5 will present a key challenge. The reason for this is that the booster biocides in the coating are released by diffusion. The diffusion rate is driven by, (1) the concentration gradient, (2) temperature and (3) paint thickness. So the booster biocide concentration at the paint surface is greater early in the paint life and reduces over time, until in the last months the biocide is often exhausted. New technologies promise a more even booster biocide release rate (hydro gel), but these have not been proven on a large scale.

Issue: Since modern coatings are not fully tested, having only been applied in the last 18 – 24 months, then the results may show to be good. The real information is in the coatings when they reach years 4 and 5.

Comment:

This is true, most AF coatings should perform well for 18 months so not much is learned yet from the new paints recently applied. Laboratory tests, and comparison tests with known systems, can only give so much data. Real life tests are therefore extremely important. The use of test patches are therefore vital and owners and the industry in general are strongly encouraged to support manufacturers in using them. The manufacturers generally have extensive in-house knowledge which goes well beyond their marketing and sales and which owners are encouraged to enquire about and use as much as possible.

2. Heavy fouling when idle for more than 10 days

Issue: The idle time of the vessel is the highest fouling contributing factor.

Comment:

Idle time, location, season and type of antifouling technology/type are the most important parameters. There are high polishing Silyl- and Cu-acrylate antifouling paints that can sustain idle conditions in most locations beyond 30 days. All locations will not pose the same risk for fouling and different seasons in the same location can have very different risk profiles. All these variables make it hard for the operator to manage the fouling risk during anchorage periods.

By knowing the frequency and length of residence periods an optimal antifouling choice can be made. By knowing the seasonal fouling risk profile of the intended anchorage location and the coatings designed tolerance to residence periods, the fouling risk can be assessed and counter measures, where needed, designed.

Issue: Effects of water temperature and pollution?

Comment:

Clearly, water temperature is important both on the effect of the coating and the fouling intensity. In terms of water quality, fresh water visits can inhibit seawater fouling but more importantly are the local blooming seasons for certain fouling organisms. For example, tube worms are known to bloom during certain periods of the year off Singapore. There are extensive scientific studies available that map fouling risks by location.

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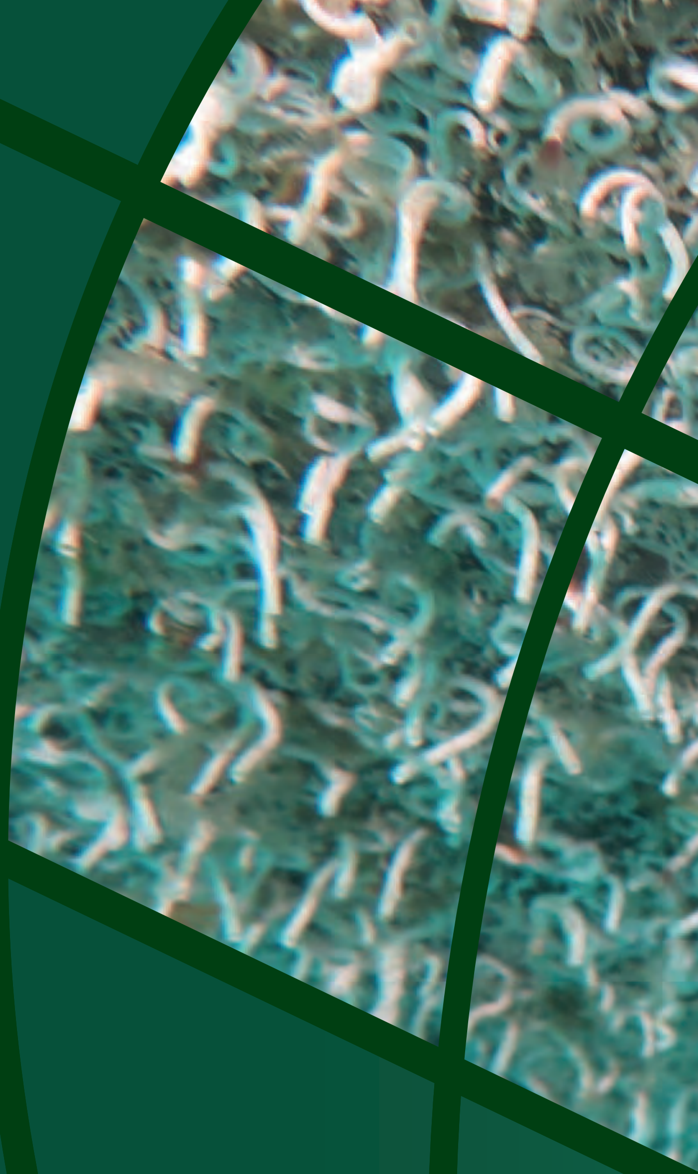

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