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Feasibility Study for New Eco-labels According to DIN EN ISO 14024 for Select Product Groups

Sub-project 3: Biocide-free Antifouling (AF) Products

Umwelt Bundes Amt
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Feasibility Study for New Eco-labels According to DIN EN ISO 14024 for Select Product Groups

Sub-project 3: Biocide-free Antifouling (AF) Products

by

Dr. rer. nat. B. Watermann, BSc. L. Weaver & K. Hass

LimnoMar, Laboratory for Freshwater/Marine Research and Comparative Pathology, Hamburg

On behalf of the Federal Environmental Agency

Publisher: Federal Environmental Agency (Umweltbundesamt)
Postfach 33 00 22
14191 Berlin
Tel.: +49/30/8903-0
Telex: 183 756
Telefax: +49/30/8903 2285
Internet: http://www.umweltbundesamt.de

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16. Abstract

This feasibility study aimed to examine whether appropriate and valuable certification criteria for biocide-free antifouling systems can be set out. The study focused on the review of suitable tests of fouling resistance and the exclusion of dangerous compounds, thus guiding the consumer (ship owners of pleasure boats, shipping companies, authorities, Navy) towards effective and environmentally friendly products. Growing concern on adverse effects in humans and wildlife of antifouling biocides actually in use, and on the background of the EU Biocidal Products Directive, instigated multiple research and development activities for more environmental friendly- and biocide-free antifouling products. The actual research and development activities on biocide-free antifouling systems are shortly reviewed. A couple of biocide-free antifouling products are available on the market. The existing procedures, as outlined in the TNsG of the BPD are reviewed and screened for their applicability on biocide-free antifouling products. It is recommended to create an eco label for biocide-free antifouling systems. The creation of this eco label may facilitate the entry to the market of basically new technologies.

17. Keywords

maritime industry, underwater coatings, antifouling coatings, biocides, biocide-free antifouling products, efficacy criteria, dangerous substances, EU-Biocidal Products Directive, eco label

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16. Zusammenfassung

In der vorliegenden Machbarkeitsstudie sollte geprüft werden, ob geeignete und umsetzbare Prüfkriterien für biozidfreie Antifoulingprodukte aufgestellt werden können. Hierbei standen vor allem mögliche Wirksamkeitsnachweise und der Ausschluss gefährlicher Inhaltsstoffe im Vordergrund. So könnte für die Verbraucher (Sportbootbesitzer, Reeder, Behörden, Marine) eine Kauforientierung hinsichtlich eines umweltfreundlichen, aber auch wirksamen Produkts gegeben werden.

Die zunehmende Besorgnis über die humantoxischen und ökotoxischen Eigenschaften der in Gebrauch befindlichen Biozide hat vor dem Hintergrund der EU-Biozid Richtlinie zu intensiven Forschungsanstrengungen zur Entwicklung von umweltfreundlicheren und biozidfreien Alternativprodukten. geführt. Die aktuellen Forschungs- und Entwicklungsrichtungen werden im Bericht zusammengefasst dargestellt. Aktuell ist schon eine Reihe von biozidfreien Produkten sowohl für den Berufsschifffahrts- als auch für den Sportbootbereich auf dem Markt. Die in den TNsG der EU-BRL beschriebenen Wirksamkeitsnachweise für Antifouling-Produkte werden zusammengefasst dargestellt und geprüft, welche auf biozidfreie Produkte anwendbar sind. Es wird ein positives Votum für die Schaffung eines Umweltzeichens für biozidfreie Antifouling-Systeme abgegeben.

17. Schlagwörter

Schifffahrt, Unterwasseranstriche, Antifouling, Biozide, Biozidfreie Antifouling-Produkte, Wirksamkeitskriterien, gefährliche Inhaltsstoffe, EU-Biozid Richtlinie, Umweltzeichenl

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Foreword

With this report, the Federal Environmental Agency (Umweltbundesamt – UBA) is publishing the results of a preliminary study on the award of an eco-label to biocide-free antifouling products.

Award of the Blue Angel eco-label is a market-oriented instrument designed to provide an incentive for enhanced development and sale of new, more environmentally friendly technologies and products. In respect of anti-fouling products, the aim is, in particular, to reduce releases of harmful substances to water bodies.
In addition, the Blue Angel eco-label is intended to provide consumers and industrial users with a simple guide to less polluting antifouling products.

In order to achieve these goals, the study contractor and the Federal Environmental Agency present, as the result of the study, a range of criteria which extensively exclude the use of harmful substances and can be used to demonstrate the efficacy of biocide-free antifouling products and systems.

The exclusion of harmful substances was based on the premise that Blue Angel products should not require labelling under Germany's Ordinance on Hazardous Substances, particularly not bear the dead-fish label, the symbol for "dangerous for the environment". Strict standards were also applied in formulating the efficacy criteria, since fitness for use is one of the key conditions for environmentally friendly products.

With this publication, the Federal Environmental Agency would like to initiate a debate on the proposals formulated.

Before a Blue Angel eco-label for biocide-free antifouling products can be adopted by the independent Environmental Label Jury, there will be a formal consultation process. The results of this consultation of experts will be presented to the Environmental Label Jury. The Jury's decision is open.

We are looking forward to a vivid discussion. You are invited to send your comments and proposals to the Federal Environmental Agency, Section IV 1.6, Seecktstr. 6-10, 13581 Berlin.

Content

Abstract

This feasibility study aimed to examine whether appropriate and valuable certification criteria could be proposed for use in the control of biocide-free antifouling systems. The study focussed on both the review of suitable methods of testing fouling resistance as well as the exclusion of dangerous compounds, the objective being a market focussed more towards effective and environmentally friendly products. The market for antifouling systems consists of both private and commercial ship owners as well as governmental authorities and Navies.

After the adoption of the IMO Antifouling Convention, the international market for antifouling products has been dominated by products containing copper as the primary biocide combined with a multitude of active organic ingredients acting as co-biocides. Both the growing concerns about the adverse effects of current antifouling biocides on humans and wildlife, and the advent of the EU Biocidal Products Directive, have instigated multiple research and development activities directed towards more environmentally friendly and biocide-free antifouling products. Research and development activities for biocide-free antifouling systems are briefly reviewed in the following pages with the inclusion of some biocide-free antifouling products available on the market at the present time. Products used for commercial shipping are usually marketed by large international companies offering biocidal products with a selection of biocide-free products. Products used in amateur and private boating are marketed by large, international and small/medium-sized enterprises offering biocidal and biocide-free products. A small number of manufacturers are producing exclusively biocide-free antifouling systems for the German market and worldwide.

Technical Notes for Guidance have been developed to aid the implementation of the EU-BPD. These guidelines were reviewed and screened for their applicability on biocide-free antifouling products, and existing eco-labels served as guidance with regards to the exclusion of dangerous compounds. In addition, the chemical compositions of products available on the international and German market were investigated in an effort to generate realistic and product-directed criteria.

The proposal to create an eco label for biocide-free antifouling products has not been met with general approval by the paint industry in total. The European and the German Paint Maker Association have expressed multiple objections, while in contrast, some smaller enterprises openly support the creation of such an eco label.

Despite minor difficulties associated with the definition of efficacy limits on fouling resistance rates and the question of how many products will meet the criteria for the exclusion of dangerous compounds, the creation of an eco label for biocide-free antifouling systems is still in progress. Continuing discussions between enterprises has led to an increasing interest in the criteria outlined thus far, as they may serve as guidance for the design of new products. Furthermore the creation of an eco label may facilitate the entry of new technologies to the market.

1 Introduction

The antifouling coatings industry at present exists in a state of rapid change, and like most industrial arenas of late, much of this change is being brought about by increasing concern over worldwide environmental issues. International awareness of the environmental consequences of leaching of biocides contained in antifouling coatings is ever-increasing and has resulted in many new laws and regulations designed to protect the marine environment being brought into force.
To date, the most prominent of these has been the IMO's global ban on the use of organotin compounds, but this convention can only be looked at as the first major step, with more focus now being directed at the detrimental effects of other harmful biocides. The convention will allow the ban of other harmful biocides when detrimental effects on the marine environment are evident and scientifically sound. The push towards development of non-toxic alternatives to biocide containing antifouling coatings creates a complex issue which necessitates a balance between commercial and environmental interests.
Presently there is much energy being directed at finding novel means of foul control through investigations of natural substances and new types of materials. Sessile marine organisms have been observed to control their surface fouling through biological processes and many investigations are now underway to try to identify some of these intrinsic defence mechanisms and whether they can be used for commercial means. Compounds released by organisms which act as adhesion inhibitors are the focus of several research projects. Mechanical cleaning can provide a cost effective alternative with high initial outlay balanced against low running costs and often very effective results. Silicone foul-release coatings are at present the most common alternative to be found on the market. These coatings rely on their unusual surface properties to deter the colonisation of marine organisms and also inhibit their attachment, making them unable to withstand higher than average cruising speeds. In addition, an increasing number of biocide-free eroding paints can be found on the global market.

Although biocide-free antifouling coatings have been in use for some time and the market is set to grow, there is still very little regulation concerning their use or assurance of efficacy. Through the introduction of an eco label award for biocide free antifouling products, Germany is taking a significant step in the development of guidelines and incentives for the marketing and use of environmentally friendly antifouling products, rather than simply controlling the use of biocidal compounds. Germany was the first country to introduce a national eco-labelling program with the "Blue Angel" program being initiated in 1977. The "Blue Angel" is a seal-of-approval program aimed at being a "market oriented instrument of environmental policy" by giving guidance to the consumer in purchasing environmentally sound products whilst driving manufacturers to develop products that meet this need. In early 2003 the Blue Angel was awarded for the environmental management of ships and the environmental commitment of shipping lines, including aspects of emissions, waste management, propulsion tube cooling etc. and choice of antifouling paints.

In this feasibility study basic criteria to be used in the development of an ecolabel for biocide-free antifouling products are proposed. The aim of this project is the formulation of clear and comprehensive criteria for the evaluation of efficacy of

biocide-free antifouling systems whereby the future release of dangerous substances into the aquatic environment will be prevented.

This study will give an overview on:

- The market of biocidal and biocide-free antifouling systems including their environmental impact.
- The status of research and development of biocide-free antifouling technologies
- Key German and foreign companies selling biocidal antifouling coatings as well as biocide-free products
- Existing regulations on the efficacy of antifouling products
- Development of efficacy criteria and criteria for the exclusion of dangerous ingredients

In this feasibility study existing international methodologies for efficacy testing and regulation of conventional antifouling paints have been brought together and reviewed to outline the most suitable criteria to be employed in the approval process of products to receive the eco label “Blue Angel for biocide-free antifouling paints”.
It is hoped that this eco-label will act as an incentive for manufacturers to continue production of biocide free antifouling paints and inspire others to bring new ones onto the market. It will also serve as a quality label for the consumer in ensuring the purchase of an effective and environmentally friendly product.

2 Market of antifouling paints with regard to types of biocidal and biocide-free products

On the international market for antifouling systems many products sold in large quantities for commercial use, and to a lesser extent some amateur products, are chemically identical but distributed under different brand names. There are approx. 10 international paint manufacturers currently existing. On the German market – as in several European countries – there are some small and medium sized companies producing and marketing antifouling systems for amateur use locally. In parallel, an increasing number of companies are using the internet to bring their amateur use products to the global market. This complex market structure complicates the search for valid data on market structure and share.

To give a short introduction into the different types of antifouling paints in use, a brief characterisation of antifouling paints, sorted by active ingredients and leaching mechanism, is given below. According to their chemical backbone and leaching mechanism (whether biocides are released through or from the surface of the coating) antifouling paints differ remarkably regarding their environmental impact. A key factor affecting the performance and life of a biocidal antifouling paint is its characteristic leaching process. The biocide must be released continuously at a rate sufficient to maintain toxic or inhibitory concentrations at the surface, where fouling organisms interact with the coating. An effective coating will repel, kill or impair the microscopic larvae and spores of multicellular sessile organisms before they attach to the paint surface and develop into larger adult organisms (algae, barnacles etc.) which produce more effective adhesives.
The life of a biocidal antifouling is therefore limited by the content and leaching mechanism of the biocide. All types of biocidal antifouling paints must be classified

according to their active ingredients and the chemical backbone controlling biocide release rate.

2.1 Eroding biocide containing antifouling paints

These paints are subdivided into two main categories:

- "Conventional" or free association paints which is indicative of a lack of chemical binding between the paint matrix and the biocide(s)
- Self-polishing coatings (SPCs) in which at least a part of the main biocide is chemically bound to the paint matrix

2.1.1 Free association paints (conventional AFS, ablative AFS, controlled depletion polymers, CDPs)

In these paints the biocide is physically dispersed and subsequently released from the paint matrix. When the paint surface is immersed, seawater penetrates the paint film and interacts with the biocide, thus dissolving it and allowing its migration to the paint surface via diffusion.

The soluble matrix consists of a binder mixture of gum rosin and plasticizers or synthetic polymers in which biocides are dispersed. Rosin is slightly soluble in seawater and for this reason is suitable for use in antifouling paints, however it requires addition of film forming material to give it mechanical strength and film forming properties. A careful balance between rosin and film forming components is needed to arrive at a durable coating with a suitable leaching rate. As the binder dissolves fresh biocide is continuously released, however the rate of binder dissolution is a critical aspect for efficacy of this type of antifouling paint. Soluble matrix paints typically take on an exponential leaching rate of biocide where if binder dissolution is too slow, the coating will not provide sufficient biocidal protection; if too fast, the biocide reservoir will be too rapidly exhausted, limiting the effective life of the coating. To improve the dissolution process modern soluble matrix paints contain limed rosin, phenolic varnishes or chlorinated rubber in addition to the natural rosin, however, even with these additives, the effective life of the paint is generally short, approximately 12 to 18 months.
In eroding/ablative or controlled depletion polymer (CDP) paints, the most advanced types of soluble matrix paints, a dissolution/erosion process exists which facilitates biocide delivery while increasing film integrity. Seawater-soluble binders and polymeric ingredients are incorporated to physically control the dissolution rate. In theory the paint matrix and the biocides are washed or 'polished' away fully over time when in contact with seawater, however, because of impurities and accumulation of various inert molecules, in practice there is usually a development of a leached layer. This leached layer reduces the effectiveness of the paint by inhibiting biocide release and for this reason CDP's are usually limited to a life span of 36 months.

The market share of these paints is closely related to the restricted life-time of 18 and 36 months. For commercial vessels it is only used for ships with dry-dock intervals of 18 or 36 months. Thus these paints can be found on coastal operating ships, feeders, some container ships and tankers. In general, they are cheaper than copper-based SPCs and are currently preferred by shipping companies when a performance of 60 months is not needed and for trading profiles with low to medium fouling pressure.

2.1.2 Self-polishing coatings (SPCs)

For decades SPC-technology with copolymer-bound TBT was the leading antifouling type. Roughly, 70 - 80% of the world fleet of deep-sea going ships were coated with TBT-SPC's. Ten years ago Japanese paint companies succeeded in replacing TBT with copper or zinc, and created the first TBT-free self-polishing paints. Now, the self-polishing technology using chemically bound copper or zinc as primary biocides is available in a variety of products.
As in TBT-SPC's, TBT-free-SPC's are based on a copolymer binder. The copolymer hydrolyzes in seawater at a constant linear rate thus releasing the biocides. The binder then becomes water soluble as soon as enough of the copolymer has been hydrolyzed.
Biocide-based copolymers have a unique mechanism to prevent antifouling. Because the biocide is chemically bonded to the polymer backbone, a controlled and slow chemical reaction with the seawater at the paint surface occurs and guarantees a constant but very low release rate.
In the majority of products, copper is covalently bonded to the matrix. A lot of paint manufacturers are using other biocides bonded to the matrix, but in general they are not effective enough (e.g. Zn) or are ineffective like silicon compounds. The latter are bonded to the acrylate copolymers to achieve a controlled release of biocides. The copper acrylate copolymers, zinc acrylate and silyl polymer systems can be considered as self-polishing copolymer systems.
This holds true for recently developed zinc carboxylate salt binder technology as well as polymer systems with exclusively organic booster biocides.
In general it has to be taken into account that in each SPC additional biocides are freely dispersed, because only 10-20% of e.g. copper can be bonded to the polymer backbone. This percentage is not high enough to achieve a sufficient antifouling efficacy. Strictly no pure self-polishing antifouling paints exist and the products on the market are usually a mixture of SPC and free association paints.
Hybrid technology: It is claimed this new development in antifouling has the CDP features of surface tolerance and attractive volume solids, together with the SPC features of polishing rate control, biocide release control and a reduced leached layer size. The addition of a hydrolysable polymer, such as copper acrylate, to rosin to form this new type of antifouling has been further enhanced by the use of pyrithione boosting biocides. The coating is effective for up to 36 months in service for the vertical sides of the hull and 60 months for the flat bottom, while its high volume solids content means efficient control of solvent emissions.
This system uses a binder that is composed of synthetic rosin resinates and different polymer co-binder systems. The synthetic rosin resinates, obtained through a hydrogenation and distillation process, eliminate impurities and double bonds. This new synthetic compound has all the benefits of natural rosin, but none of the weaknesses. It has also been reacted into zinc carboxylate binder, which during immersion in seawater undergoes a chemical ion-exchange process to form a more soluble sodium carboxylate binder.
In some paints the binder technology is used with the addition of micro-fibres. The incorporation of micro-fibres into antifouling paints provides mechanical reinforcement to the paint film and allows greater amounts of functional binder to be added to achieve full variation in the polishing rate. TBT-free SPC's can achieve life times of up to 60 months.

Since the announcement of the IMO Antifouling Convention a steadily increasing percentage of TBT-free SPC applications have been recorded. Even if these coatings are more expensive than conventional antifouling paints, they are optimal for 60 month dry-dock intervals if a reliability of 90% is expected when trading in waters with high fouling pressure. The latter aspect is indicated by the fact that even tankers are now shifting from conventional paints to SPCs.

2.2 Non-eroding biocide antifouling paints with insoluble matrix (long-life antifouling-, contact leaching paints)

These paints are known as diffusion or insoluble matrix coatings, based on insoluble resins, such as chlorinated rubber, acrylic compounds or vinyl. As only the biocides are released, the paint film is left behind as a porous skeleton and as the depth of porous layer increases, the rate of biocide-release is reduced. Eventually no more biocides can be released, antifouling performance drops dramatically and the layer becomes clogged with fouling organisms. Effective life is up to 24 months and a relatively porous layer remains. This left-over porous film provides a very weak substrate for any new coatings and a sealer-coat is normally required. Because some of the active coatings in the film are not released, both resources and money are wasted.
The market share of this type of antifouling paint is steadily decreasing due to the disadvantages described above. They can be found on the market for coastal operating ships and for pleasure boats.

2.3 Antifouling biocides

2.3.1 Biocides of free association paints

The most common biocide used in conventional antifouling paints is copper, either as a metal or a compound. To improve the efficacy of copper most antifouling paint formulations contain additional booster biocides. Biocides most commonly used in conventional antifouling paints are listed in Table 1.
It has to be taken into account that some biocides (inorganic metal compounds and the metal moieties of organometallic compounds, e.g. zinc in zinc pyrithione) are not degradable due to their chemical nature and most of the organic biocides in use have a low degradation potential (e.g. Diuron). For some biocides in use no risk data are available. In general all of the biocides listed in table 1 are classified as “dangerous for the environment” and assigned the corresponding symbol “N” according to Directive 67/548/EEC.
Legislative restrictions for some of the co-biocides exist not only for their use on pleasure boats, but also on deep-sea going vessels due to their persistence and ecotoxicity.

In conclusion, free association paints don’t have a constant leaching rate. At the beginning of the life of the paint the biocide leaching rate is well above the level needed to achieve an antifouling effect whereas towards the end it declines to a level below the critical leaching rate. In general, they create a higher input of biocides in the marine environment than self-polishing coatings (SPCs).

Table 1. Main biocides and cobiocides used in antifouling paints

Biocide by chemical name (IUPAC)	**Common names or trade names**	**Persistence Category (aquatic)**	**Bioaccumulation Category**
Copper (II) ions	Copper metal and copper compounds	Not biodegradable, but chelatable and/ or immobilizable[1]	BCF/seawater: 75 – 27,000/algae 10,000 – 20,000/macrophytes 7,000 – 10,000/ crustacea[1]
Zinc-2-pyridinethiol-N-oxide	Zinc pyrithione	Rapid primary degradation[1]	Considering the log P_{OW} of 0.97, a bioaccumulation potential lower than that of the other biocides can be expected[1]
Tetramethylthiuram disulphide	Thiram	II[2]	Log $P_{OW=}$ 1.73[2] No indication of a bioaccumulation potential
Zinc ethylenebis-(dithiocarbamate)	Zineb	n.a.	II[2]
Manganese ethylenebis-(dithiocarbamate)	Maneb	II[2] not readily biodegradable	Log $P_{OW=}$ 1.75[2] No indication of a bioaccumulation potential
Manganese ethylenebis-(dithiocarbamate) (polymeric) Complex with zinc salt	Mancozeb	II[3]	Log $P_{OW =}$1.34[3] No indication of a bioaccumulation potential
4,5-Dichloro-2-n-octyl-4-isothiazolin-3-on	Sea-Nine 211	III[2]	III[2]
3-(3,4-Dichlorophenyl)-1,1-dimethyl urea	Diuron, Preventol A6	III-IV[3]	III[2]
N-Dichlorofluoromethylthio-N',N'-dimethyl-N-phenyl-sulfamide	Dichlofluanid, Preventol A4	IV[3]	I[3]
N-Dichlorofluoromethylthio-N',N'-dimethyl-N-p-tolylsulfamide	Tolylfluanid, Preventol A5	III[3]	II[3]
Tetrachloroisophthalonitrile	Chlorothalonil	III[3]	III[3]
N²-tert-butyl-N[4]-cyclopropyl-6-methylthio-1,3,5-triazine-2,4-diamine (2-Methylthio-4-tert-butylamino-6-cyclopropylamino-s-triazine)	Irgarol 1051	Not readily biodegradable[2]	III[2]

Overall persistence categories, resulting from the combination of the criteria: (a) primary degradation, (b) mineralization, and (c) bound residues

I low persistence
II moderate persistence
III high persistence
IV not biodegradable

Bioaccumulation

Overall assessment, derived from the combined criteria (a) bioconcentration factor BCF, and (b) elimination (or depuration, expressed as half-life clearance time CT50)

I no concern
II indication of risk potential
III cause for concern
IV high risk (recommendation for risk reduction) n.a. = data not available

[1] MEPC 43/INF.19 (1999) Harmful effects of the use of anti-fouling paints for ships submitted by Germany, IMO, 4pp.

[2] Bruckmann, U. (1995) Bewertung des biologischen Abbaus, der mikrobiellen Hemmung und der Bioakkumulation von ausgewählten Antifoulingwirkstoffen, 18 pp. (unpublished)

[3] Communication of UBA (unpublished) 2003.

2.3.2. Biocides used in self-polishing coatings

One important difference of TBT-free SPC's to conventional paints is the restricted number of biocides and cobiocides in use. In most formulations available at the market, exclusively the following biocides are incorporated:

- Copper and copper compounds
- Zinc pyrithione
- 4,5-Dichloro-2-n-octyl-4-isothiazolin-3-one.

Regarding the environmental behaviour of these compounds please see table 1.

2.3.3 Antifouling paints containing biogenic biocides or enzymes

Antifouling products containing biogenic or natural biocides are very rare and are only found on the market for small scale recreational boat applications. Most disappeared after one or two years due to claims of inefficacy or adverse health effects encountered during the process of application. Examples of these are extracts of the Neem-tree, eucalyptus oil, horse-radish extracts and piperine as well as Capsain (extracts of pepper and chilli) and a multitude of other natural compounds.
Currently there are none of these products on the German market, and the previous market share of existing products was negligible.
Another type of antifouling paint uses enzymes to inhibit the curing and hardening of adhesives produced by fouling organisms. To date there is only one product on the Danish market to be used on pleasure boats. Products suitable for commercial vessels are in the developmental process.

2.4 Biocide-free antifouling paints and techniques

To avoid any leaching of biocides into the sea, several paint companies have developed antifouling coatings that contain no active ingredients. Their action is through inhibition of attachment of fouling organisms by specially designed surfaces.
Paints that do not contain any active ingredients and do not involve any biocidal action are subjected to different registration or approval procedures depending on national regulations. In most countries no registration is necessary, but manufacturers have be aware of related regulations on Volatile Organic Compounds (VOC) as well as regulations and administrative provisions relating the classification, packaging and labelling of dangerous substances.

2.4.1 Non-eroding coatings

2.4.1.1 Non-stick coatings (silicone-, Teflon-based paints)

The chemical backbone of silicones used as non-stick coatings is mostly polydimethylsiloxane (PDMS). For most fouling organisms silicones have an unattractive low surface energy. It is this free surface energy, in combination with hydrophobicity, flexibility (elastic modulus) and surface microroughness of the

material, that determines whether an organism attaches or not. Only limited prevention of fouling is achieved, but the adhesion between the fouling and the coating is weak, therefore, fouling can be easily removed, by hand or through movement of the ship if sufficient speed (5 – 10 knots) is achieved. In theory, the life-span is unlimited, with the exception of substances which have an additional antifouling effect through the exudation of oils such as silicone or paraffin. Exudation of silicone oils is a critical factor as degradability of PDMS silicones is close to zero. Silicones must not be used on ships trading in ice and must not be used on vertical parts of the hull exposed to heavy mechanical impact.
The percentage market share of non-stick coatings cannot be easily measured as the number of commercial fleets using silicone coatings are steadily increasing compared to cruisers, high-speed ferries and patrol boats, whereas the number of vehicle carriers or container ships painted with silicones is still below 50 units. Due to a performance of over 60 months silicones have an increasing market share among fast military vessels. Only the occasional pleasure boat can be found painted with silicones but Teflon-based antifoulings are used in freshwater areas and areas where biocide-containing antifouling paints are banned.

2.4.1.2 Fibre coatings

This type of coating consists of short fibres applied in a dense pattern (200 - 500 fibres/mm^2) which deters settlement of fouling organisms. First, an epoxy is applied and serves as glue for the fixation of fibres. The fibres are then electro-statically charged and sprayed into the wet epoxy so they remain perpendicularly oriented in the adhesive. Special devices are used for the charging of fibres. When the coating is submerged, it is assumed that the fibres are moved by currents, thus providing a spiny surface which is permanently in motion.
Market shares for this type of coating cannot be given as only singular ships are fully coated.

2.4.2 Eroding coatings (self-polishing and ablative systems)

Paints using this technology perform in much the same way as TBT or tin-free self-polishing antifouling systems. The self-polishing characteristics result from a controlled hydrolytic mechanism. In some non-toxic self-polishing coatings the copolymer bound biocide is substituted by a non-toxic compound but the basic process of hydrolysis is identical. In addition to true self-polishing systems based on methacrylate copolymers, other coatings are based on soluble epoxy or natural rosin. These systems have to be classified as biocide-free conventional paints with eroding or ablative matrix. As the chemical backbone of the coatings is mostly unknown and covered by patents, data on degradability or bioaccumulation are not available. For methyl-methacrylates extensively used in TBT- and TBT-free SPCs no degradation data are published, and it is expected that they are degradable in marine waters as no measurable concentrations in sediments are recorded up to now.

Self-polishing and ablative paints have a very low market share in coastal operating ships and some freshwater operating ferries. In recreational boating the market is markedly increased where biocides are banned. In some Scandinavian countries and parts of Germany biocide containing paints are either banned or restricted in all

freshwater areas (Germany: Lake Ratzeburg). An interesting situation occurred in the Netherlands where copper was banned for the use on pleasure boats in 1999. According to paint manufacturers, the market share of biocide-free ablative coatings increased despite the fact that in the first year the ban was not enforced. Unfortunately, the legislative situation in the Netherlands is confused which may lead to a decrease of the use of biocide-free antifouling paints. In general it can be stated that elevated percentages of biocide-free coatings could only be observed where biocides had been banned.

2.4.3 Fouling control by physical installations

Few companies developed a lifting-system to facilitate out of water cleaning of pleasure boats. The company “Boot Dock” developed a system in which two tubular floats (the size of which depends on the length, width and weight of the boat) are interconnected with a traverse. The Floats are lifted in the water by filling up with air, consequently lifting the boat out of the water. The boat is simply guided into the dock between the padded bars which can be specifically adapted to the dimensions of the boat. The dock is controlled by a console mounted at the entrance to the dock with simple dials for raising and lowering the boat. This is not a cleaning system, but rather allows easy access to the hull and avoidance of long periods of inactivity in water. The company claims that around 100 mooring places are equipped with this system in Germany and in South Europe.
A comparable system produced by “Hydro-Hoist” is available at the German market.

2.4.4 Electrical systems

Just recently the German company Jobeck presented a fouling protection system based on direct galvanic current, suitable for pleasure boats with wooden or plastic hulls. An anode is fixed along the waterline and a cathode along the keel. The company claims effective fouling protection in fresh and salt water.

2.5 State of the market for biocidal and biocide-free antifouling system including their environmental impact

There is a multitude of paint companies present on the German market for antifouling products. Larger international companies are producing products for commercial use (avp), amateur use (ava), fouling problems in cooling stations of power plants or industrial installations (inu) as well as for aquaculture (aqa). The smaller companies are trading almost exclusively on the market for pleasure boats.
While some companies use distributors to retail their product in foreign markets, sale and distribution to commercial vessels is usually performed by the paint companies themselves. Sale of product for use in recreational boating is mostly handled by distributors. As can be seen in table 1 of the annex, the majority of paint companies offer biocidal products and their use is clearly foremost on recreational and commercial vessels, however, there is still a large variety of companies active in the production and sale of biocide-free antifouling products.
Large companies usually offer several biocidal products along with one or two biocide-free ones. Small/medium sized enterprises are producing some biocidal and/or biocide-free products but those which are exclusively producing biocide-free

products will benefit most by the creation of an eco label. There are no published data on company sales or market share in Germany.

The most important factor when choosing an antifouling product is its efficacy. Antifouling coatings on commercial vessels are renewed every 12, 24, 36 or 60 months and contracts between the shipping company and the paint company incorporate entitlement to compensation in the case of inefficacy. Owners of recreational vessels, who renew their antifouling paint every one to three years, do not have the same kind of conditional assurance and there is a strong need for them to have some kind of indication of the efficacy of an antifouling product. This is especially applicable to biocide-free products when paint companies must prove even their biocidal products effective. Yacht magazines have been running comparisons on antifouling paints to provide a little orientation, but at present there is no neutral and standardized testing of biocide-free products.

At this point no valid data exists concerning the market share of biocide-free antifouling products. What can be ascertained through personal communication with several paint manufacturers is that the market share of biocide-free products in Germany is under 1% for professional and amateur use
This implies that over 99% of antifouling products in use are biocidal products releasing moderate to highly persistent biocides into the marine environment (Thiram, Maneb, Mancozeb, Diuron, Tolylfluanid, Chlorothalonil) with bioaccumulation potential (Irgarol, Chlorothalonil, Diuron, Sea-Nine). (Table 1).

3 Review of current research and development activities on antifouling techniques

Environmental concerns about the long-term effects of leachable antifouling biocides have led to increased interest in the development of environmental friendly alternatives. Research activities are centered on biodegradable toxic compounds, non-toxic adhesion inhibitors, electro-chemical systems and cleaning devices.

3.1 Natural products

All organisms, benthic and pelagic, must maintain a foul-free surface for their survival. This rationale is largely reflected in the types of organisms that have been investigated for the elucidation of their antifouling mechanisms. Predominantly, the antifouling strategies of sessile organisms have been the subject of several research projects[4,5,6,7]. The usual approach adopted has been to extract the tissues using solvents and subsequently employ bioassays to assess the antifouling potential of the extracts. The first groups of organisms to be investigated were corals and sponges which were known to maintain a foul-free surface. Tunicates, bryozoa and thallophyta were also thoroughly screened. Red algae extracts have been found to contain halogenated furanones which show biocidal activity comparable to, and sometimes better than that observed with commercial biocides. In more recent investigations crustacea (lobster and shore crabs), echinoderms (sea stars and sea urchins), and the egg-cases of dog-fish were investigated to elucidate their antifouling mechanism as these organisms do not secrete toxic substances to the surface. It was thought that a passive physico-chemical defence system may exist in the egg-cases of dog-fish and in the shell of the shore crab. Egg cases appear remarkably clean, with little or no evidence of macrofouling, even after several months in seawater. Thomason et al. developed the hypothesis that the incorporation of tanning chemicals into the case during its formation by the nidamental gland prevents macrofouling[8]. Other research groups concentrated on the microtexture of egg cases, sea urchin spines and the skin of sea mammals.
In general the search for natural compounds is greatly encouraged by the finding that the effect of biogenic antifouling compounds is more based on a repellent mode of action than on a strong toxicity. Thus, research activities are shifting from the detection of toxic molecules to those with little or no toxicity and properties which inhibit microbes and eukaryotic organisms to attach to man-made structures. The search for adhesion inhibitors includes the isolation of active compounds as well as

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[4] Peters, N., H. Sönnichsen, H.-D. Berger, K. Langner & B. Watermann, 1994: Natürliche Biozide und biozidfreie Mittel zur Bewuchshemmung, ihre Effektivität und Anwendung auf Schiffen im marinen Bereich.. Texte UBA, Berlin, (55) 94, 229 pp.
[5] Steinberg, P.D., R. de Nys & S. Kjelleberg (1998): Chemical inhibition of epibiota by Australian seaweeds. Biofouling 12(1-3), 227-244.
[6] Clare, A.S. (1996): Marine natural product antifoulants: Status and potential. Biofouling, 9(3), 211-229.
[7] Willemsen, P. R. & G. M. Ferrari (1996): Possibilities and impossibilities of alternative anti- fouling techniques. In: DGSM, The Hague & ORTEPA, The Hague (eds.), Proc. International one day symposium on antifouling paints for ocean going vessels, The Hague, 60-67.
[8] Thomason, J.C., J. Davenport & A. Rogerson, 1994: Antifouling performance of the embryo and egg case of the dogfish Scyliorhinus canicula. J. mar.biol. Ass. U.K., 74, 823-836.

surface properties which inhibit the curing or hardening of the adhesive of fouling organisms[9].

3.2 Non-stick coatings

In the last decade several investigations have dealt with non-stick coatings that are mainly based upon silicones and fluoropolymers. About 40 patents have been registered but only a few products are effective and available on the market. The adhesion of settling organisms is remarkably lowered on these coatings. Normally this effect is due to a combination of hydrophobicity, low surface free energy and microroughness. The silicones are composed mostly of polydimethylsiloxanes (PDMS) which may have incorporated exuding silicone oils, paraffin, petroleum wax or fatty acids. The most effective non-stick coatings possess a self-cleaning mechanism, by which the loosely attached organisms are easily removed by turbulence experienced when the vessel is underway, therefore peeling itself off. On the other hand non-stick coatings have their own drawbacks: High price, difficult application, mechanical frailty and persistence. The latter aspect is important with respect to silicone peeling off into the sea and the exudation of silicone oils[10].
To date, the commercial use of some silicone coatings is expanding from fast naval vessels, patrol boats and fast ferries to cruisers, vehicle carriers and even container ships. Nevertheless the basic mode of action of silicone-based polymers is poorly understood and several research projects are investigating the non-stick properties of silicone polymers. These compounds serve as model substances to develop non-stick surfaces based on natural or degradable polymers.

3.3 Electrical devices

For years various ways of using electric currents for the purposes of antifouling have been investigated. Only a select few can presented here however.

The Marine Growth Prevention System by Electrolysis Technology (MAGPET) was developed by Mitsubishi using a conductive type of coating. An electrical current is conducted through the hull causing chloride ions to be transformed into hypochlorite through electrolysis. Hypochlorite is highly toxic to fouling organisms. The advantage of this system over other antifouling systems is to activate the system only when necessary, i.e. in harbours or in service at low speed. In total, the energy demand is said to be very low ranging in roughly 0.2 W/m^2.
A drawback to this system is that even though hypochlorite decomposes rapidly in water, halogenated by-products are created by the electrolytic action. The creation of halogenated by-products has been documented in both drinking water treatments and chlorinated cooling systems.

Another direction to use electrical currents is based on the principle that the pH-value is discontinuously changed on a specific prepared surface.

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[9] Callow, M. 2003: Some new insights into marine biofouling. World Super Yacht, 1, 34-39.
[10] Watermann, B. , H.-D. Berger, H. Sönnichsen & P. Willemsen, 1997: Performance and effectiveness of non-stick coatings in seawater. Biofouling, 11,(2), 101-118.

Driven by a periodical electrical drive the conductive outer coating induces changes in the pH-value at the surface for several hours thus preventing the attachment of fouling organisms. Successful laboratory and field trials on panels have been conducted in the last years. Field trials with test patches on ship hulls and fully treated ships are ongoing[11]. Special attention must be paid to maintenance, repair, and functionality at focal damage.

3.4 Control of fouling by cleaning

Underwater cleaning has been practiced for many years, but has never been more than a "fill in" activity, used as an expedient to bridge the gap between the exhaustion of the coating and the next dry-docking. Several companies offer a world-wide hull cleaning service. Cleaning is mostly carried out on moored ships or in harbours during loading and unloading by divers using an impeller system with rotating brushes. These cleaning actions have become more restricted because the resulting acceleration of biocide release from the paint causes high levels of pollution. As the cleaning companies are aware of the declining business on biocidal antifouling paints, some of them have since developed a non-toxic hull concept. The idea was to coat the hull with a really hard, smooth anticorrosive system and to maintain it in this condition by regular underwater cleaning over several years. Investigations on the fouling growth arising between cleaning intervals revealed that special coatings are necessary to extend cleaning intervals up to several months.
Fouling development is essentially influenced by the type of service of the ship. Fast ferries with short times in harbours or cruise liners have fewer problems compared to very large, crude oil carriers (VLCC) or carriers which are sometimes moored for several weeks.
More sophisticated systems such as robots are needed to have flexible technique and to allow cleaning to be carried out on demand. A network of hull cleaning stations on all the important trade routes would be necessary with the cleaning entirely automated, either by means of a remote controlled vehicle or along lines of a car wash system. Difficult areas such as bilge keels, rudder and stern arch would still need to be cleaned by divers or coated by non-stick coatings as silicones. Initiatives to modify swim-docks as floating cleaning stations for large ships are published but not yet realised.

4 Review of regulatory procedures concerning efficacy, toxicological aspects and eco labels for biocidal antifouling products in selected countries

The following is a review of some procedures of efficacy, toxicity and ecological evaluation that are currently in place in selected countries (EU, Australia, USA, Canada) for biocidal antifouling products. In most cases there are few guidelines concerning non-biocidal antifouling paints, apart of those outlined in a Canadian eco label. Despite this, some efficacy test procedures may be used to good effect regardless of whether the mode of action of the paint is biocidal or not. For these

[11] Personal communication bioplan

reasons only the few countries that regulate product efficacy or ecological soundness are reviewed in this section and all of the test procedures (biocidal/non-biocidal) that have relevance to the objective have been included and are discussed.

4.1 EU

The European Parliament and of the Council of the European Union have adopted the 16th of February 1998 Directive 98/8/EC concerning the placing of biocidal products on the market (BPD)[12]. The implementation of the Biocidal Product Directive is now coming into effect within EU-countries. Within the establishment process of the BPD an efficacy assessment has been formulated.

4.1.1 Evaluation of efficacy of biocidal antifouling products

With the exclusion of effects on humans and the environment, the applicant has to submit data to ascertain if the efficacy claims of the biocidal product can be substantiated. Data submitted must demonstrate the efficacy of the biocidal product against the target organism(s). Testing should be carried out according to community guidelines or other methods may be used (e.g. ISO, CEN or other international standard method, national and industry standard methods)[13]. As part of the establishment process of the BPD, Technical Notes for Guidance on Product Evaluation (TNsG) were formulated. They contain common principles and practical procedures for the authorisation and registration of products. The appendix to chapter 7, efficacy assessment, outlines the requirements for **biocidal antifouling products**[14].
The parameters that will define the effectiveness and therefore influence the service life of an antifouling product include trading patterns, fouling conditions (tropical or temperate waters, marine or freshwater), physico-chemical conditions of the water, e.g. pH, salinity and temperature and coating type and film thickness
The TNsG describe laboratory-, simulated field- and field tests/in service monitoring and standard methods for the evaluation of efficacy.

Laboratory tests
Laboratory tests are designed to determine whether the biocide is effective against target organisms. These include barnacle larvae, macroalgae spores and microalgae e.g. diatoms. In addition testing should prove that critical leaching rate is achieved to effectively prevent fouling. There is no standardization by ISO, DIN, ASTM or other standardization organisations of laboratory tests for antifouling products. The tests cited above are industry tests applied in research departments of paint manufacturers and fouling research institutions.

[12] OJ L 123, 24.4.98, Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market, 63 pp.
[13] OJ L 123, 24.4.98, Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market, Annex VI 51 and 52, p. 57.
[14] Technical Notes for Guidance in support of Annex VI of Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market, Chapter 7.

Simulated field tests
These tests include static raft testing using panels coated with the test coating and immersed for a period of months at an appropriate locality in a river, estuary or sea, or sections/whole nets or cages treated with the candidate product and immersed at an appropriate site for up to 1 year.
Efficacy data on the candidate antifouling coating should be available following testing over periods of one or more 'seasons' of peak fouling pressure in locations typical of intended usage, according to the label claims. The length of a 'season' may vary from six months to one year, depending on the location of the test site. Since some variation in performance will occur depending on the conditions at each site, it is recommended that a reference coating of proven or known performance (positive control) be included in the tests together with a blank (negative control).

Field tests/in service monitoring
As field tests involve long-term exposure to normal operational conditions, they are regarded as service tests. These include panel tests where coated panels are attached to a vessel for a short period of time, patch tests where vessels are painted with the test coating as a strip or patch on the side of the hull, and in service monitoring of aquaculture nets and cages. No part of the hull can remain unprotected and the remainder of the hull coated with an effective antifouling paint serves as the positive control. If available, reports monitoring the performance of an antifouling product on a fully treated vessel may also be submitted according to the TNsG of the EU-BPD.

4.1.2 Standard test methods

As mentioned above, there are no standardized test methods that cover laboratory evaluation of antifouling biocides/products.

For the generation of simulated field data through raft testing of antifouling coatings there are currently two standard test methods suggested in the TNsG of the BPD. These are:

1. CEPE Antifouling Working Group, 1993
Method of the generation of efficacy data. .

2. American Society of Testing Method: ASTM D 3623-78a, 1987
Standard Test Method for Testing Antifouling Panels in Shallow Submergence.

A summarized description of these methods is given in the annex, chapters 3.1 and 3.3.

Regarding field/in service tests it is stated in the TNsG that there are currently no national or international standards covering the field evaluation of antifouling products.

There are no efficacy tests concerning **biocide-free antifouling paints** suggested by the BPD/TNsG.

4.1.3 Labelling procedures

The antifouling situation is complicated by the fact that most fouling organisms belong to very different ecological groups. This in turn depends on the effect of the local conditions on their growth, there usually being large differences between tropical and temperate regions as well as local variations from one area to another on the same coast. The fouling pressure is not only influenced by the water body but also by the activity level, operational profile and service speed of the ship or man-made installations.

Therefore the TNsG prescribes, whilst it is not feasible to claim efficacy against specific target organisms, applicants should indicate on the product label that their candidate product is an 'antifouling product' and supplement the claim with an indication as to whether the product is effective against one or more of the following fouling groups:

- slime
- aquatic plants (incl. weeds, grasses etc.)
- animal (barnacles, mussels, other shell fouling etc.)

Consequently, label claims shall refer to the spectrum of activity. A statement on the label regarding the anticipated or recommended use(s) for a product will also be required. The uses may include:

- aquaculture - marine/or freshwater
- professional use in coastal or deep sea
- amateur use on yachts.

4.2 Australia

The Australian legislation regarding the approval of antifouling products is very strict and comprehensive. Only chemical and biological products (biocidal products) require registration with the Australian Pesticides and Veterinary Medicines Authority (APVMA). Products which are acting as physical deterrents (biocide-free products)do not require registration. This includes fibre surfaces and non-stick coatings, basing e.g. on silicones.
To register a product with the APVMA, efficacy data must be provided with guidelines set out by the APVMA to ensure enough relevant data is supplied. These guidelines are fairly comprehensive and act as a guide throughout the whole scientific testing procedure. This guide suggests some standard methods of testing that they have deemed suitable for efficacy testing of antifouling paints. The Australian guidelines for efficacy testing of antifouling coatings are summarised below[15].

4.2.1 General practice

All efficacy studies must be fully scientifically documented. Fouling organisms should be identified by type (i.e. macroscopic algae, barnacles, tubeworms etc.) and abundance, percentage surface cover or biomass. Latin binomial names for any organisms should be provided.

[15] Agricultural Requirement Series, "Antifouling Efficacy Data Guidelines", NRA, 2001

Sufficient detail must be provided for the reviewer to understand exactly how the trials have been carried out. For example, target species, surface composition and preparation, number of coats, method of application and wet or dry film thickness should be described.
The design of the efficacy studies must include the following considerations.

- Biocide (active constituent) release rates, erosion (polishing) rates, physical durability and biological activity.
- Representative study sites should be used. Accelerated laboratory-scale tests should closely model typical exposures and extremes (i.e. in pH, salinity, fluid shear, etc.).
- Current application technology/best practice should be used.
- Studies should be carried out over at least one year. Longer trials may also be required to provide evidence of product efficacy and durability of the product over the time period claimed on the label.
- Valid study designs should be used, with appropriate statistical analyses, including sufficient replicates to allow reliable analysis of data.
- Studies should include controls.

When data are conflicting, additional experiments should be carried out until a weight of evidence allows satisfactory conclusions to be made.

4.2.2 Sites

Location details, including climatological data, should be provided for both local and overseas studies. Information on temperature, tides, currents, salinity, pH, light intensity, tropical or temperate zone etc. should be presented in tabular format for each study as an appendix.

4.2.3 Experimental design

Efficacy tests must be designed to allow valid and appropriate analyses of the data.
Assessment of the efficacy of an antifouling system should consider the biocidal activity (release rates), erosion (polishing) rates, physical durability and biological activity of the product. Each of these characteristics should be considered in relation to each component of the product to be registered; the biocide, the end-use product formulation and the type of foul control system.
Biocide release rates and coating erosion can be determined in laboratory tests, raft/panel studies (simulated field tests) or patch/strip tests (field studies).
End-use product formulation can be tested by panel studies on stationary rafts, rotor tests and patch/strip tests performed on vessels in use (field studies).

In order for laboratory, simulated field tests or field studies to result in meaningful data and to be relevant, the following conditions must be met:

- The study conditions must reflect the label recommendations and application technology should address current industry practices. This should be reflected on the product label. For example, the label should specify surface preparation, number of coats required, and rate of application (weight coating/surface area), etc. The instructions listed on the label must be based on the efficacy trials.

- Test objectives should be clearly defined and tests should include only treatments aimed at those objectives, plus adequate controls. These include an untreated (negative) control and/or standard antifouling treatments currently in use.
- The following application details should also be presented: type of application equipment (i.e. spray/brush); application equipment details (pressure of spray, droplet size on nozzle etc.); date of application; surface composition (i.e. wood, steel, aluminium, acrylic etc); surface condition/preparation at application; and coating application specifics (i.e., primer used, coating application rates).

The following standard test procedures are deemed acceptable by the APMVA when used appropriately.
(NB: Only standard test procedures appropriate for non-biocide containing paints are listed. All are simulated field tests.)

- **AS 1580.481.5 (1993)** Durability and resistance to fouling
- **ASTM D 4939-89** Standard Test Method for Subjecting Marine Antifouling Coating to Biofouling and Fluid Shear Forces in Natural Seawater
- **ASTM D 3623-78a (1998)** Standard Test Method for testing Antifouling Panels in Shallow Submergence

A summarised description of test methods is given in the annex, chapter 3.2 and 3.3

4.3 Canada

4.3.1 Registration requirements

There are no efficacy requirements for registration of antifouling paints in Canada unless the active biocide is not previously assessed. Registration of biocide containing paints relies mostly upon biocide release rate data rather than efficacy data[16]. There are no existing registration requirements for non-biocidal paints.

4.3.2 Efficacy evaluation

Only if an active ingredient is to be registered for the first time efficacy data are required for the product. The following standard efficacy testing procedures are deemed to be acceptable. Only standard methods relevant to non-biocidal paints are listed here.

- ASTM D 5479-94 Standard Practice for Testing Biofouling Resistance of Marine Coatings Partially Immersed
- ASTM D 4938-89 Standard Test Method for Erosion Testing of Antifouling Paints using High Velocity Water.
- ASTM D 4939-89 Standard Test Method for Subjecting Marine Antifouling Coating to Biofouling and Fluid Shear Forces in Natural Seawater.
- ASTM D 3623-78a (1998) Standard Test Method for testing Antifouling Panels in Shallow Submergence
- US EPA Pesticide Assessment Guidelines, Subdivision G Product Performance

[16] Pest Control Products Act, "Registration of Antifouling Coatings", Regulatory Directive Dir94-03. PMRA

A detailed description of these methods is given in the annex, chapter 3.3 and 4.2.1.

4.4 USA

The US EPA provides no specific efficacy guidelines for each type of pesticidal product (see annex chapter 4.2). Instead they have published a general guide to efficacy testing for certain subgroups of pesticidal products. Most of the criteria are derived from agricultural pesticides. The guidelines for product performance that relate to antifouling products are given in the annex 4.2.1.
Efficacy data should be derived from testing conducted under conditions typical of actual or proposed use, or, where applicable, under controlled laboratory conditions which simulate actual use. In addition acute toxicology data on the formulated product have to be submitted, as well as product chemistry data[17].

4.5 Korea

There is no law pertaining to registration of antifouling paints in Korea, and no data have to be submitted to substantiate the efficacy of antifouling products. There is, however, an environmental label for paints which is aimed at both lowering the content of harmful substances, along with reducing air pollutants. KELA (Korean Environmental Labelling Association) is the authorized association in Korea and although antifouling paints are not specifically categorised, organic solvent based paints are addressed and the certification criteria have been developed[18].

4.6 Industry

The existing development process of antifouling products is to screen active ingredients under laboratory conditions and to then test the product in simulated field tests and in service conditions. In laboratory settlement assays representative fouling organisms are used. It is common practice to use diatoms, green algae spores and barnacle larvae in settlement assays. The tests are widely used in the screening of promising compounds to be incorporated into a standard paint or in the end use formulation. The tests are designed for biocide-leaching antifouling products and deliver information on acute toxicity, reflected in low or zero settlement. There is no standardisation. Paint manufacturers with in-house research facilities perform these tests in their own laboratories, while smaller companies must commission scientific institutions such as TNO (Netherlands) or Battelle/Poseidon (USA) to conduct lab and simulated field testing.

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[17] Product performance Test Guidelines, OPPTS 810.3000 “General Considerations for Efficacy of Invertebrate Control Agents”, EPA, 1998

[18] www.kela.or.kr/english, “Organic Solvent Based Paint”, Korean Environmental Labelling Association

Stationary panel tests are the next step in the development of new antifouling formulations. Test coatings are painted on panels and exposed on stationary rafts over one or several fouling seasons. Numerous field stations for simulated field testing exist to test coatings intended for use on vessels operating in specific climatic zones. For testing in temperate waters there are stations situated in the Baltic sea (Rostock, Tjarnö, Copenhagen etc.), North sea (Norderney, Helgoland, Den Helder, Newcastle etc.), and Mediterranean Sea (Geneva, Malaga, Piraeus etc.). For testing in tropical and subtropical conditions facilities are available in Australia, Singapore, India and the USA. Companies with private research facilities conduct their testing on private test sites in suitable climatic regions.
Reliable in-service testing depends on the test patches being applied to ships with a similar operational profile (service speed and activity level) to the vessels the coating is intended for, as claimed on the label. Ship owners are often willing to offer paint manufacturers the chance to apply test patches, especially when the costs are taken on by the company and they can benefit from the efficacy of new formulations.
The performance of a coating on a fully treated vessel is monitored by the manufacturer at each dry docking. The ships painted with new formulations are listed in 'track records' to give to the client an indication of the market position of the product and its application on other vessels. 'Track records' record the number of applications, not the performance of the coating. Recently some paint companies have started to offer the performance data of coatings on selected vessels on the internet.
There are no international criteria defining the minimal efficacy level of antifouling products. In theory, microfouling (biofilm, slime) is tolerated on commercial ships, with no development of macrofouling. In practice, the tolerance limit is reached when fuel consumption increases or a reduction of service speed is observed.
There now exist sophisticated computer modelling systems to match the efficacy of particular coatings to vessels, taking into consideration aspects such as function (commercial or military), hull shape, in-service speed, activity level, trading pattern, dry-dock interval and costs. As most antifoulings in use are either eroding or self-polishing, efficacy is positively correlated to dry-film thickness. Increased dry-film thickness creates higher costs but guarantees efficacy until the next dry-docking, while low to critical dry-film thickness in turn reduces costs but creates a risk of fouling over time. Ship owners must make their decisions based on these alternatives.

On recreational vessels even the formation of a biofilm and subsequent discolouration of the hull does not fit within the expectations of a ship owner. Yacht magazines and boating associations are publishing the results of simulated field and field tests of biocidal and biocide-free products with the intent to provide consumer guidance articles to help distinguish between effective and ineffective products[19, 20]. The coatings tested are not encoded thus helping the boat owner to discriminate between different brands.

[19] Bohmann, M. (2002) Öko-logisch?, segeln, 3, 31 – 33.
[20] Weise, R. (2003) Gift ist nicht alles. Palstek, 1, 31 – 35.

4.7 Overview of efficacy requirements for biocidal antifouling products

The regulations associated with the submission of efficacy data in the countries cited above display quite similar procedures. It has to be taken into account that in some countries such as the UK, Sweden, Denmark, and the Netherlands, the approval of antifouling products was already in practice before the entry into force of the European Biocidal Products Directive, from which the relevant directorates amassed extensive experience which is reflected in the BPD.
As depicted in table 2 most countries with registration procedures for antifouling products stipulate laboratory tests for the biocide and the coating itself. Data from simulated field tests and field tests have to be submitted for the coating/product for which approval is sought. Reports monitoring the performance of the antifouling coating/product on a fully treated vessel may be submitted as well.

As in all of these countries biocide-free antifouling paints are not subjected to registration procedures and these guidelines apply to biocidal products only.

Table 2 Types of efficacy studies and standard test methods required in selected countries

Country	EU (BPD)	Australia	USA	Canada
Efficacy studies	Requirements specified for biocidal antifouling products (TNsG)	Most specified and detailed worldwide	Criteria derived from agricultural pesticides	Required only at first registration of biocides
Accepted standards	ASTM CEPE	AS ASTM	ASTM	ASTM
Laboratory tests	Biocide/Standard-Coating	Biocide/ Standard-Coating Leaching rate Erosion rate	Biocide/Standard-Coating	Biocide
Simulated field tests	End product	End product	End product	End product
Field tests	End product	End product	End product	End product

4.8 Existing eco labels for biocidal and biocide-free antifouling products

Eco labels pertaining to biocide-free antifouling products exist exclusively in Canada. The German eco label relating to environmentally conscious ship operation RAL-UZ 110 includes i.a. the use of environmental friendly antifouling paints but without specified certification criteria.

4.8.1 Canadian eco label for biocide-free antifouling paints

Some Antifouling paints have been awarded the Canadian 'Environmental Choice' label for their lack of environmentally harmful ingredients[21]. The human toxicological aspects of the paints are not addressed by this label. The Environmental Choice Program (ECP) is a voluntary eco-labelling program by Environment Canada and is managed by the private organisation 'Terrachoice Environmental Services Inc'. The ECP is one of the only environmental labelling programs worldwide that specifies antifouling paints for award. The certification criteria for an environmentally sound antifouling paint, calls for the absence of biocides, a reduction in the levels of VOCs, as well as specific usage and disposal instructions for the packaging as well as product. The certification criteria for the award of the Environmental Choice are as follows:

1. Must not contain VOCs in excess of 120 g/L as determined by the American Society for Testing and Materials test method, **ASTM D 3960** Standard Practice for Determining Volatile Organic Compound Content of Paints and Related Coatings.
2. Must not be formulated or manufactured with aromatic solvents in excess of 2% by weight, as calculated from records of the amount of constituents used to make the product.
3. Must not be formulated or manufactured with halogenated solvents, formaldehyde, benzene, mercury, lead, cadmium, hexavalent chromium, tin, copper, their compounds, or other biocides.
4. Must include instructions for safe and proper application and removal of the product, as well as the disposal of any unused product and packaging.

At present there are ten biocide-free 'Antifouling Coatings' certified, all manufactured by Alex Milne Associates Ltd. The target species of these certified antifouling products are algae and zebra mussels which suggests that they are intended for freshwater pleasure craft use rather than marine use.

4.8.2 German eco label for environmentally conscious ship operation

In October 2002 a German eco label concerning environmentally conscious ship operation, RAL-UZ 110[22], was introduced. Considerations include the policy and environmental management system of the shipping company. "Management in accordance with ISO 14001" describes how the ship operator strives to systematically implement and document methods of operation in order to improve the protection of the environment. This includes the reduction or elimination of pollutant release into the environment. RAL UZ 110 allows two options to reduce or prevent marine growth at the ship's hull:

1. organotin-free self-polishing antifouling coatings, but no so-called *ablative or self-eroding* paints (Controlled Depletion Polymers /CDP), in which the main biocides are not chemically bound to the matrix, or
2. biocide-free antifouling paints or coating systems.

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[21] www.environmentalchoice.com, "Marine Foul Release Coatings"

[22] Criteria for the award of the Environmental label environment-conscious ship operation RAL-UZ 110, 2002 RAL, Sankt Augustin, 10pp.

The criteria in the RAL-UZ 110 may need adjustment once the criteria for a German eco label on biocide-free antifouling paints have been agreed upon.

5 Discussion on efficacy criteria for biocide-free antifouling systems with industry and experts

As mentioned above, several countries have developed efficacy criteria for biocidal antifouling products which are either in practice (Australia) or in the pipeline (EU-BPD). This considered, the most logical course of action is to make use of the most appropriate of these existing efficacy criteria to produce guidelines for biocide-free products. In addition, specifications are proposed to allow for differences between products intended for professional or amateur use. To get a detailed impression of the attitude of the paint industry on the subject of the “Blue Angel for biocide-free antifouling systems” a survey was carried out including those companies active on the German market. Furthermore, meetings were held between individual paint manufacturers and the European paint maker association, CEPE, and several scientific experts were asked for comments and recommendations through email or private communications.

5.1 Survey among paint manufacturers

In the beginning of February 2004 a survey was carried out among paint manufacturers offering biocide-free antifouling products on the German market. There are 12 paint companies present on the market: Chugoku, DOS, v. d. Linden (Epifanes, Lotrèc), Hempel, Holmenkol, International, Relius, Sigma, v. Höveling, Wohlert. Boot Dock and Hydro Hoist, Boat Lift offer systems to lift boats weighing up to 35 tons at the berthing place, thus sparing the use of antifoulings. The survey was conducted via telephone and private meetings and the results are presented in summary as the representatives where asked informally (Table 3).

Table 3 Survey results describing attitude towards the introduction of the “Blue Angel”, and preferred efficacy procedures of companies producing biocide-free antifouling products.

Company	**Market** Amateur product (Ava) Professional product (Avp)	**Size of company** Large Enterprise (LE) Small or medium Enterprise (SME)	**Attitude to the “Blue Angel”**	**Simulated field tests**	**Field tests patches**	**Field tests full coat**	**Fouling Rating System** CEPE ASTM Own System
Chugoku	Avp, Ava	LE	Neutral		X	X	ASTM and own system
DOS/SealCoat	Avp	SME	Positive		X		Own system
Hempel	Ava, Avp	LE	Not useful	X	X		CEPE
Holmenkol	Ava	SME	Positive			X in combination with cleaning	Own system
International	Avp, Ava	LE	Positive			X	CEPE
Relius	Avp	SME	Neutral			X	Own system
Sigma	Avp	LE	Neutral			X	
v. Höveling	Ava	SME	Positive	X	X	X	Own system
v.d. Linden Lotrèc Epifanes	Ava	SME	Positive	(X)	X	X	Standards required
Wohlert		SME	Neutral	X		X	Own system
Boot-Dock	AVA	SME	Interested			X in combination with cleaning	No system

- Small and medium-sized companies on the German market, mostly producing coatings for pleasure boats, preferred simulated field testing in a selection of fresh and salt water areas rather testing on fully coated ships. The companies were aware of the dubious reliability of static exposure tests for biocide-free antifouling products and preferred sites with exposure to tidal or run-off currents. Companies active on the German market for recreational vessels are regularly testing in approximately 4 freshwater and 4 saltwater areas known to have high fouling pressure. These companies felt that a requirement of 10 fully coated test ships trading in representative waters would be unnecessarily strict. Despite this, all companies recognized that proof of performance on only one or two fully-coated boats is not enough to offer an accurate representation.
- SME’s prefer a first phase submission of simulated field test data and in several years most expect to submit data from fully coated ships, which they judge to be much more valuable than simulated field tests. They anticipate that the Blue Angel will help them to achieve a larger market share.

- One company proposed a list of accepted stations to be used for simulated field tests, to allow for better comparability of data.
- Most LE and SME's active on the global market for commercial vessels preferred to use data from fully coated vessels as proof of efficacy. This sentiment is supported by the common principle that shipping companies can claim compensation from paint manufacturers in the case of failure of an antifouling product. One SME company would prefer to submit data on patches rather than full coated ships to help to facilitate its entry into the market.
- In general all paint companies preferred fully coated vessels as the most valuable source of reliable efficacy data. Both Small and large vessels have problematic areas of hull where fouling develops more easily, thus attributing more value to tests on fully coated ships.
- The survey revealed that most companies have their own files and protocols with regards to the evaluation of efficacy. International companies create data using ASTM methods as required by some customers. The creation of data according to the CEPE method was only mentioned by three companies which hold CEPE membership. In general it was appreciated that having a standard protocol for the evaluation of data from panel and field tests would be advantageous.
- With regards to the exclusion of dangerous substances, some companies proposed to submit a Health and Safety Data Sheet in combination with a confidential submission detailing the product formulation.
- With regards to data on degradability (e.g. binders) some companies proposed that the submission of data created by the suppliers of raw materials be accepted. In this way the pressure is taken off companies to produce data for every ingredient in the formulation.

5.2 Discussion with CEPE and scientific experts

A special meeting was held on September 1st, 2003 with representatives of the UBA, CEPE (CEPE members are: Akzo Nobel International Coatings, Jotun Paints, Sigma-Kalon, Ameron, Chugoku and Hempel A/S), the Lackverband and the contractor.
CEPE and the German Lackverband expressed their objections and comments in detail and CEPE was kind enough to submit their detailed comments on this meeting, which are included in the annex, chapter 5.1.

- In summary, CEPE stated that non-biocidal coatings were not necessarily more environmentally friendly than biocidal coatings unless all aspects of the product were taken into consideration. Both types of paint should be used for the applications for which they are best suited, otherwise the environmental consequences would inevitably be detrimental (increased fuel consumption, organic material from on site scraping, etc.). Risk assessment should provide a solid foundation to ensure only genuine eco-friendly products are awarded the Blue Angel.
- CEPE declared that paint manufacturers do not have access to complete information on raw materials they purchase from suppliers and that these suppliers are responsible for the classification of their own products.
- CEPE pointed out that no standard methods relating to PB-screening exist.

- With regards to the evaluation of efficacy, a strong recommendation was given that the CEPE method become a generalised industry method given its use and acceptance by CEPE member companies, the BPD and individual countries such as the UK, NL, BE, FI, S, and the US. The CEPE method would be sufficiently general to allow comparable testing to be carried out by various institutions and organizations.

A meeting between scientific experts active in the field of antifouling research was held in Osnabrueck on November 19, 2003 (For the list of participants and a more detailed summary see annex, chapter 5). Most of the participants were strongly in favour of the application of ASTM-methods instead of the CEPE method or relevant methods of Standards Australia. As some of the ASTM methods are soon to be revised it is expected that after the revision process they will be more appropriate for biocide-free products. Dynamic testing of panels was agreed to involve unsuitable costs and technical effort, unfortunately necessary in the application of existing ASTM methods. Modifications to reduce the costs involved in these dynamic tests are currently underway, and will be standardized in the coming years.

6 Certification criteria related to efficacy and the exclusion of dangerous substances

6.1 Certification criteria related to efficacy

As described above, the evaluation of fouling resistance and physical condition can be carried out according to several protocols (ASTM, AS, CEPE, company standards). The ASTM method D 3263-78a has the disadvantage of being coupled with a specified panel exposure procedure as it includes a scoring and rating system to determine the degree of fouling which would serve well in conjunction with other ASTM methods.

Just recently, the D01.45 subcommittee of ASTM created a new “Standard Practice for the Evaluation of Biofouling Resistance and Physical Performance of Marine Coating Systems” (ASTM D 6990-03)
This new practice is intended for use in conjunction with existing panel exposure methods and is applicable only to the reporting of coating performance, not to the actual conditions of panel exposure. Thus, it can be used for static or dynamic panel tests and evaluation of patches on ships or full-coated ships.

Coating systems are evaluated in terms of fouling rating, describing the percent coverage of the coating system by fouling organisms, and physical deterioration rating, describing the percentage area of the coating system affected by physical coating damage/failure. This practice provides quantitative guidance to the panel inspector for a consistent evaluation of coating performance from test panels coated with marine antifouling coating systems, regardless of which testing method is being used. In this performance assessment of coating systems both the antifouling qualities and the physical properties of the coating are evaluated and its standardisation allows for more precise and comprehensive evaluation of fouling rate (FR).

There are no standard rating systems for fouling organisms in fresh water, despite the fact that some antifouling paints for pleasure boats are produced and marketed exclusively for the use in freshwater. It is therefore necessary to outline certification criteria appropriate for these coatings. It is proposed to use the rating system of ASTM D 6990-03 to evaluate freshwater antifoulings, disregarding fouling groups not present in fresh water such as barnacles.

It is strongly recommended that the ASTM D 6990-03 evaluation method be accepted as an exclusive protocol to be used when assessing efficacy data.
The CEPE method of the generation of efficacy data includes no scoring system to determine the fouling coverage (for a detailed description of the method see annex 3.3).

Setting limits
There are no standard limits in the shipping industry which describe an intolerable fouling rate and physical condition. On commercial vessels the limits are set when there is a measurable increase in fuel consumption or reduction in service speed. As the amount of friction between the water and the hull depends upon the dominating fouling group, it is difficult to set rigid limits for fouling degree. If only coverage was considered there would be a wide ranging unacceptable degree of growth to be found as microfouling is generally neglected in commercial shipping. The definition of failure can also be an objective concern, varying from customer to customer.
In recreational boating, limits must be more strictly adhered to due to the higher impact of water friction on speed and fuel consumption. In addition, aesthetic considerations play an important role, especially if microfouling is to be tolerated. It is generally found that even biocidal antifouling paints cannot prevent the formation of microfouling. The formation of microfouling leads to discolouration of lightly pigmented antifouling paints, giving cause for claims of inefficacy. With the exception of calcareous micro-layers (e.g. Lake Constance) paint companies do reject these claims.
Tolerable fouling degree limits were fixed individually for both professional and amateur use.

6.1.1 Evaluation of efficacy

The fouling resistance and physical performance of
- non-eroding coatings
- eroding coatings
- electrochemical and acoustic devices
- physical installations (boat lifts)

have to be evaluated according to:

- **ASTM D 6990-03** Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems

An additional method for the evaluation of non-stick coatings is permitted.

The efficacy testing of non-stick coatings calls for careful consideration of their mode of action. Static exposure of non-stick coatings without the influence of currents may result in total failure (e.g.100% surface coverage by fouling organisms). As non-stick coatings act as adhesion inhibitors, standard test methods for measurement of barnacle adhesion strength in shear (**ASTM D 5618-94)** have been developed to overcome this problem. Results of static raft tests can be submitted if they have been combined with adhesion measurements to obtain a performance profile in accordance with the mode of action.

In contrast to all other coating types, efficacy data on non-stick coatings like silicones or fluoropolymers can be submitted by the applicant based on:

- **ASTM D 5618-94** *Standard Test Method for Measurement of Barnacle Adhesion Strength in Shear*

or

- **ASTM D 6990-03** Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems

6.1.2 Efficacy test systems

The submission of efficacy data must be delivered according to the end use of the product (professional, amateur or aquaculture) and according to paint type. They can include simulated field tests and field tests.

6.1.2.1 Simulated field testing
These tests include static raft tests using panels coated with a test coating and submersed for a period of months at an appropriate locality in a river, estuary or sea, or sections/whole nets/cages treated with the candidate product and immersed at an appropriate site. In principle, static tests are of limited value for coatings which require water currents for effectiveness. Most types of biocide-free coatings act through the physical/chemical properties of the surfaces inhibiting or impairing adhesion of fouling organisms and need minimal currents for self-cleaning action. Thus, static field tests exposed to currents or dynamic simulated field tests using rotating drums have been estimated to be of higher value than those unexposed to currents.

Requirements

- Results of panel tests designed according to
  - company standards
  - CEPE standard or ASTM-, AS-standards or other national standards

can be submitted as efficacy data, if all the information on **exposure conditions** can be delivered as listed in the requirements

- Panel tests have to be performed in 4 fresh and/or saltwater areas which are known for high fouling pressure. A list of accepted stations in Germany is given in table 4. Test results from the Mediterranean, subtropical and tropical stations are accepted so long as they contain all the information on exposure conditions listed in the requirements.

Table 4 Stations in Germany accepted for the conduction of simulated field tests

Freshwater

Area	***Station***
Lake Constance	Lindau, Zech Constance Staad Radolfzell Fließhorn
Starnberger See	Starnberg
Ratzeburger See	Ratzeburg
Rhine	Wiesbaden Phillipsburg
Berliner Seen	Spandau

Brackish to marine waters

Area	***Station***
Baltic Sea	Kiel Travemünde Wismar Rostock
North Sea	Meldorf Büsum Cuxhaven Accumersiel Norderney Norddeich

- 5 panels must be exposed as replicates

- The mean value of the fouling and physical deterioration rate must not exeed limits.

- The study conditions (i.e. salinity, temperature) must reflect the label recommendations and the application technology shall correspond to current practices for amateur and professional use. The following application details shall also be presented: type of application equipment (i.e. spray/brush/roller); application equipment details (pressure of spray, droplet size on nozzle etc.); date of application; surface composition (i.e. wood, steel, aluminium, GEP etc.); surface condition/preparation at application; and coating application specifics (i.e., primer used, coating application rates).

- Efficacy data on the candidate antifouling products shall be submitted following testing over periods of one or more ‘seasons’ of peak fouling activity in locations typical of intended usage, depending on the label claims. The length of a ‘season’ may vary from six months to one year, depending on the location of the test site. Location details, including climatological data, shall be provided for each study. For example, information on temperature, tides, currents, fresh or salt water, salinity, pH, light intensity, tropical or temperate zone etc. These details shall be presented in tabular format for each study.

- Since some variation in performance will occur depending on conditions at individual locations, it is recommended that if available, a reference biocidal coating (positive control) of proven or known performance be included in the tests together with a neutral surface (negative control).

- The evaluation of fouling resistance and physical condition has to be performed according to

- **ASTM D 6990-03** Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems

- **ASTM D 5618-94** *Standard Test Method for Measurement of Barnacle Adhesion Strength in Shear (exclusively non-stick coatings)*

6.1.2.2 Field testing, in service monitoring

Field tests can be regarded as the most appropriate test procedure for biocide-free products. Fouling organisms are not killed on contact with the surface of biocide-free products, they are removed by currents due to their low adhesion. Some areas of ship hulls and aquaculture devices are not exposed to strong currents, therefore field tests are required to reveal the true performance of the coating in these critical areas.

Requirements

- The service (i.e. trading waters, fresh-, saltwater) must reflect the label recommendations, and application technology shall address current practices for amateur and professional use. The following application details shall be presented: type of application equipment (i.e. spray/brush/roller); application equipment details (pressure of spray, droplet size on nozzle etc.); date of application; surface composition (i.e. wood, steel, aluminium, acrylic etc); surface condition/preparation at application; and coating application specifics (i.e., primer used, coating application rates).

- For each vessel/boat the following information must be provided:
  - Length, breadth, draught
  - Traded waters, mooring/berthing place
  - Activity level (days at sea/days at harbour)
  - Service speed
  - Date of survey.

- The evaluation of fully treated vessels shall be performed by a division between vertical bottom (bow/mid/stern) and the flat bottom as a whole. In total 7 areas will be evaluated, resulting in a mean fouling rate.

- The evaluation of fouling resistance and physical condition must be performed according to

- **ASTM D 6990-03** Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coating Systems

- **ASTM D 5618-94** *Standard Test Method for Measurement of Barnacle Adhesion Strength in Shear (exclusively non-stick coatings)*

6.1.2.3 Overview of efficacy requirements

In table 5 biocide-free efficacy test procedures are compiled according to their type and intended use (recreational vessels, commercial vessels or aquaculture).

Table 5 List of efficacy requirements according to use and type of antifouling system

Type of AFS	**Evaluation Method**	**Required FR PDR Adhesion strength**	**Required Efficacy for professional products (dry-dock interval)**	**Required Efficacy for amateur products (one fouling season)**	**Required Efficacy for aquaculture products (one fouling season)**
Non-eroding coatings					
Silicone, Teflon coatings	ASTM D 5618-94 **or** ASTM D 6990-03	0.3 MPa **or** 96	Patches on 5 ships **or** 3 full coated ships	5 panels of 4 representative fouling sites **or** 5 full coated boats	5 cages, nets or pontoons
Fibre coatings	ASTM D 6990-03	96	Patches on 5 ships **or** 3 full coated ships		
Eroding coatings	ASTM D 6990-03	96	Patches on 5 ships **or** 3 full coated ships	5 panels of 4 representative fouling sites **or** 5 full coated boats	5 cages, nets or pontoons
Electrochemical/acoustic devices	ASTM D 6990-03	96	Patches on 5 ships **or** 3 full coated ships	5 panels of 4 representative fouling sites **or** 5 full coated boats	
Cleaning devices	ASTM D 6990-03	99	3 full coated ships	5 full coated boats	5 cages, nets or pontoons
Mechanical installations (Boat lifts)	ASTM D 6990-03	99		10 boats	

6.2 Certification criteria related to health and environment

Biocide-free antifouling paints must not contain toxic compounds incorporated as active biocides to achieve antifouling efficacy. Biocides are permitted only as in-can preservatives (see 6.3.1). Antifoulings which incorporate dangerous substances with biocidal properties shall not be awarded.

The two types of coatings must be taken into consideration as the mode of action influences the environmental risk.

Non-eroding coatings
The paint is designed to be stable and inert (chemically non-reactive) during service-life. Performance is directly associated with the stability and integrity of the coating. This refers to non-stick coatings such as silicones and Teflon, as well as fibre coatings.
It is assumed that the environmental impact of non-eroding coatings is low as long as they are used according to the manufacturers' instructions. Silicones are not recommended for the vertical bottom of ships with high mechanical impact or ships trading in ice. As silicones are persistent, the integrity of this coating-type has to be preserved, and the guidelines followed strictly.

Silicone coatings have to be labeled with:
- Not to be used in polar waters
- Not to be used in drifting ice

In addition non-eroding paints may be composed of inorganic substances such as pigments and fillers and other organic additives such as plasticizers and in-can preservatives.
As there is risk of these organic components leaching into the water, they must be degradable in seawater in normal conditions (temperature, density and type of micro-organisms) and should not have potential for bio-accumulation. This refers primarily to organic additives, pigments and fillers.
Data on the degradability of organic components subject to leaching shall be provided by the applicant.

Eroding coatings
The paint is designed to dissolve, polish or slough off over a given period therefore completely entering into the aquatic environment. This is true of all eroding coatings of the ablative or self-polishing type.
Eroding antifouling paints are composed of non-stabile polymers as the binders are designed to ablate or polish-off in contact with water.
In addition eroding paints may be composed of inorganic substances such as pigments and fillers and other organic additives such as plasticizers and in-can preservatives.
As all components of eroding coatings are designed to be released into the water, the organic components must be degradable in seawater and /or freshwater in

normal conditions (temperature, density and type of micro-organisms) and should not have potential for bioaccumulation. This refers primarily to the chemical backbone (binder, e.g. epoxy-like, methyl-methacrylate, rosin etc.) and organic additives, pigments and fillers.
Data on the degradability of organic components in eroding paints shall be provided by the applicant.

6.2.1 Requirements

The Blue Angel for Antifouling paints shall be awarded if the product is designed in a way that good antifouling efficacy is achieved without the inclusion of hazardous substances and detrimental effects on man and the environment are avoided during:

- application
- service life
- disposal after service life

The following guidelines must be followed to ensure product quality.

- No inclusion of biocides, excepting in-can preservatives.
- Low emission output to the environment.
- No substances of high concern, e.g.
  - substances with potential for bioaccumulation.
  - substances which may cause serious and delayed harm to humans and wildlife at very low doses (including where the no-adverse-effect-level is uncertain)
- The potential skills of the user: trainees, amateurs, untrained professionals, trained professionals.
- Provision of detailed information on the preservatives contained in the antifouling product (chemical name, concentration, acute aquatic toxicity)

Products to be awarded shall not contain substances with the following properties

- CMR category 1 and 2 [EU definition] (R45, R46, R49, R60, R61, R64)
- CMR category 3 (R40, R62, R63 and R68)
- high chronic toxicity (R48)
- respiratory sensitizers and highly potent skin sensitizers (R42 and R43)
- persistent substances which are liable to bio-accumulate and/or which are toxic to aquatic organisms (R50/53 or R51/53, R50, R53)

6.2.2 Information source

Information on products and components shall be submitted according to the following sources:

- Harmonised classification in annex 1 to EU Directive 67/548 or the German classification according to TRGS 905 “ Verzeichnis krebserregender, erbgutverändernder oder fortpflanzungsgefährdender Stoffe”,
- Classification based on available scientific knowledge, based on the rules of annex 6 to EU Directive 67/548 (duty of producers to carry out classification)

The products to be awarded may contain residual concentrations as follows:

- Generic acceptance of impurities (< 0.1%) and
- Triggers related to specific substance properties (e.g. sensitizers 0.01%)

Preservatives

Biocides that are used to preserve the product and that are classified as R50/53 or R51/53 are nevertheless permitted, but only if they are not potentially bio-accumulative. In this context, a biocide is considered to be potentially bio-accumulative if the log P_{ow} (log octanol/water partition coefficient) ≥ 3.0 (unless the experimentally determined BCF ≤ 100).
The product may only include biocides as preservatives, and in the appropriate dosage for that purpose. The exact formulation of the antifouling product shall be provided, together with copies of the material safety data sheets of any preservatives added, as well as information on the dosage necessary to preserve the product. A declaration of compliance with these criteria shall also be provided.

Volatile Organic Compounds

The content of Volatile Organic Compounds must not exceed the following limits:

- 250 to 300 g/l for solvent based products(e.g. silicones),
  water based coatings are preferred.

6.2.3 Screening on persistence and bioaccumulation where components have not yet been classified or where no data exist

Screening of all organic components with a concentration > 1% which enter the aquatic environment with a view to persistence and their bioaccumulative potential according to Directive 67/548 (duty of producers to carry out classification) must be carried out when official classification or suitable data are lacking.

The underlying principle is: Substances which are both bio-accumulative and persistent are undesirable. This means bioaccumulative substances should not be persistent, and vice versa. As the term "persistent" is not unequivocally defined, the following concrete requirements shall apply:

- a substance with a log P_{ow} ≥ 3 (unless the experimentally determined BCF ≤ 100[OECD 305]) should be readily biodegradable (one of the tests out of the series OECD 301A-F). Inherent degradability (OECD 302 B or C) is not sufficient, because this would entail the undesirable R 53 classification.

- a substance which is not readily biodegradable but shows a log P_{ow} < 3 (or a BCF ≤ 100) should be inherently biodegradable.

Inorganic substances such as pigments are excluded from this requirement as is the inorganic moiety of organometallic compounds.

The requirements listed above, shall apply to non-eroding as well as eroding paints, taking into account the following considerations:

Non-eroding coatings
Irrespective of the durability of this paint type, some non-eroding coatings contain diffusing or exuding substances entering the aquatic environment either

- incorporated to achieve suitable physical properties (e.g. additives to increase flexibility) and/or
- incorporated to enhance the performance by exudation (e.g. oils)

The producer has to provide information on:

(a) diffusion/exudation rate
(b) biodegradability and bio-accumulative potential as outlined above

Non-eroding preparations containing zinc oxide which is classified as dangerous to the environment in a concentration equal to or greater than 2.5% shall be excluded.

Eroding coatings
Eroding coatings have no inherent durability. The producer has to provide information on

- the chemical erosion mechanism of the paint
- the degradability of the eroding organic substances under relevant conditions (relevant according to intended use and label claim, considering temperature range) according to standardized methods.

Eroding preparations containing zinc oxide which are classified as dangerous to the environment and to which are assigned phrases R50/53 in a concentration equal to or greater than 2.5% shall be excluded.

6.2.4 Tests on ecotoxicity for products where components have not yet been classified or no data exist

For products where components are included which have not yet been classified or no data exist, two basic toxicity tests have to be submitted according to EU 67/548/EEC. Standardized toxicity assays are well established for fresh and salt water testing using unicellular algae or crustaceans for the detection of toxic effects. To avoid the creation of new test systems, the application of these standardized tests is recommended for biocide-free antifouling coatings. Antifouling products can only be awarded if no significant effects are observed.

Preparation and procedure
- Coatings have to be painted on one side of glass plates (10 x 10 cm) corresponding to a surface area of 100 cm^2. Dry film thickness should be as recommended for use. For most of hitherto known coatings the weight of the dry paint film will be above 1000 mg.

In case of multi-layered systems, all layers have to be present.
- A drying time of 24hrs at room temperature will be prescribed to allow solvents to evaporate and avoid false positive results.
- Coated glass plates are immersed in 1 L freshwater (ISO 6341) and the flask will be gently shaken for 24hrs.
- Samples of the water are used for standard limit-tests with a green alga and a crustacea e.g. Daphnia as representative for invertebrates, as prescribed for toxicity testing in the EU-BPD, Annex IIA:

Algae
The algal growth inhibition test (OECD 201)

Crustacea
The acute toxicity test with *Daphnia magna* (OECD 202)

6.2.5 Special requirements concerning cleaning devices and physical installations (boat lifts)

In contrast to paint systems and electrochemical or acoustic devices which are closely connected with the vessel or aquaculture installation, cleaning devices are separately erected. Installations for pleasure boats can be either fixed in a certain location in a marina or erected at the berthing place itself. In Germany the cleaning of the underwater parts of a boat is not allowed at the berthing place or any other location in the harbour where the wash-water, including the removed fouling and paint particles, can enter directly into the harbour water.

The dual effects of cleaning and removed fouling organisms entering the water may lead to an enhanced BOD (Biological Oxygen Demand) and/or COD (Chemical Oxygen Demand). Manufacturers of cleaning devices must submit a detailed plan of waste water management procedures and information material to control the handling of removed fouling.
The cleaning device must include a waste water management system or has to be designed to collect removed fouling organisms for transportation and appropriate disposal.

7 Conclusions and remarks

The feasibility study for the development of certification criteria for biocide-free antifouling systems was instigated by an inquiry by only one paint company. This initiative does not reflect the attitude of antifouling paint makers in general. Through numerous personal communications, emails and telephone calls, it became evident that the attitude towards the “Blue Angel” in general and for biocide-free antifouling systems is very mixed.
Some companies were very neutral and restrained while others became interested during the discussions. Individual companies were definitely in favour of the eco label for biocide-free antifouling systems.

The German Lackverband and the European Paint Maker Association (CEPE) were quite reserved about the feasibility study and were afraid of discrimination towards

biocidal antifouling products. This means that after the creation of an eco label for biocide-free antifouling systems, only few submissions can be expected.
It can be expected that applications will be submitted by companies for professional as well as amateur products but only some of those products may accomplish the criteria.

Market
With the IMO-AFS Convention having taken the first step by banning organotin, the implementation of the EU-BPD and the EU-Chemical Policy, some companies are quite concerned about additional environmental regulations. The paint industry is balancing between complaints by customers[23] of "inefficient green paints" (without organotin or other highly effective biocides) and legislation and environmental standards becoming stricter through increasing concern over the long-term ecological effects on wildlife and humans.
In this situation an eco label for biocide-free antifouling systems, encompassing efficacy concerns and the exclusion of dangerous substances, would help some companies to continue to develop biocide-free products and achieve a larger market share. On the other hand the eco label will serve as a quality label for the consumer in ensuring the purchase of an effective and environmentally friendly product.
On the background of the actual situation of the market for antifouling products, the creation of an eco label covers advantages for all stakeholders.

Proof of efficacy
There are no fixed limits for the efficacy of antifouling systems, neither for professional nor for amateur or aquaculture use. On the base of numerous discussions with paint makers and users, limits were set which may be accepted by a variety of producers and consumers, but will inevitably be criticized by some.
The standards required by pleasure boat owners are sometimes extremely high (light colours, low to zero activity of the boat) and may not be achieved by biocidal products in situations of high fouling pressure. On the other hand fouling communities have to be prevented which affect the movement of the ship.
Requiring a proof of efficacy in the frame of an eco label would lead to a more precise labelling of antifouling products. As described above, biocide-free antifouling system cannot perform at all circumstances (e.g. on pleasure boats with very low activity level). In addition they cannot be used in all waters (e.g. silicones in drifting ice). The proof of efficacy would take off the pressure on manufacturers to offer all-round products.
The consumer will have critically to review his own activity (e.g. requirement of 100% fouling resistance on white pigmented products on boats with zero activity level).
The creation of the eco label will bring this topic up into a more public discussion. The perfect performing antifouling product without the release of harmful biocides can hardly be expected. The creation of the eco label will relate the achievable performance to the environmentally friendly use of antifouling systems.

Exclusion of dangerous substances
There are major obstacles to be faced in the exclusion of dangerous substances:

- The most relevant non-eroding coatings on the market are silicones which are composed of a persistent polymer and exuding, persistent silicone oils. Strictly, the release of persistent compounds should not be accepted while

[23] Global Nature Fund, Antifouling Symposium 2003, 45 pp.

data on bioaccumulation, toxicity, and the release rate of exuding oils under service conditions may not exist.

On the other hand the performance of silicones may be improved by the creation of structured surfaces instead of the incorporation of persistent exuding oils.

Eroding coatings on the market may contain toxic substances, classified as additives, which exert biocidal effects on fouling organisms. In addition, it is unclear, whether any data on the degradability of the binder exists or not. This leaves the open question of whether there will be an eroding paint on the market which will fulfill all of the requirements.

The problems outlined above may result in a situation where only a very restricted number of products will fulfil the certification criteria. On the other hand it may prompt modification of existing antifouling systems to meet the requirements. Furthermore the eco label will bring more attention to new technologies which lie outside the bounds of mainstream coating systems. This is especially true for boat lifting installations for recreational vessels and electrochemical techniques for professional use. Both technologies will encounter no problems with meeting the certification criteria.

In conclusion it can be stated that the creation of an eco label for biocide-free antifouling products will not be appreciated by all consumers and paint manufacturers. It will be faced with a radical changing market and customers eager to get an orientation. The eco label will give guidance to the consumer, not indisputable but effective.

The numerous discussions with paint manufacturers on the criteria have led to a situation where some companies appreciate the criteria as useful tools in research and development of new products.

Annex

to

Machbarkeitsstudie für neue Umweltzeichen nach DIN EN ISO 14024 zu ausgewählten Produktgruppen
Teilvorhaben 3: Biozidfreie Antifouling (AF)-Produkte

Content

1 List of paint manufacturers and distributors offering biocidal and/or biocide-free antifouling systems

SME = Small and medium sized enterprise
LE = Large enterprise
bfp = biocide-free product
bp = biocidal product

ava = amateur use
avp = professional use
aqa = aquaculture use

Manufacturer	Distributor/Germany	Products	Size of company	Use	Holdings
Akzo Nobel/International Coatings Ltd. Stoneygate, Felling Gateshead, Tyne & Wear NE 10 OJY UK Fon:+44 191 469 61 11 www.international-marine.com	International Farbenwerke GmbH Lauenburger Landstr. 11 21039 Börnsen, Deutschland Fon: +49 40 720 030	Bp, Bfp	LE	ava, avp, inu	Nippon Paint Marine Coatings
Anwander + Co. AG Goldschlägistr. 16 8952 Schlieren, Schweiz Fon: + 41 1 730 40 50	Kösling Marinesport Olgastr. 39 88048 Friedrichshafen Deutschland Fon:+49 7541 23793	Bp	SME	ava	
AWLGrip Yachtcoatings N.V Bouwelven 1 2280 Grobbendenk Belgien Fon: +32 14 23 00 01	M. u. H. von der Linden GmbH Werftstr. 12-14 46483 Wesel Deutschland Fon: +49 281 338 300 www.vonderlinden.de	Bp	SME	ava	
Ameron International PC & F Europe P.O. Box 6 4190 CA Geldermalsen, Niederlande Fon:+31 345 587 587 www.abc-3.com	keine Niederlassung in Deutschland	Bp	LE	ava, avp	See Devoe Coatings
A.C.C. Rüegg GmbH & Co Papenreye 19 22453 Hamburg, Deutschland Fon: + 49 40 585 387 www.ruegg.de	A.C.C. Rüegg GmbH & Co Papenreye 19 22453 Hamburg, Deutschland Fon: + 49 40 585 387	Bp	SME	ava	

Manufacturer	Distributor/Germany	Products	Size of company	Use	Holdings
CMP Holdings PTE Ltd. Sakurada Bldg. 1-3 Nishishinbashu 1-chome Minato-ku Tokyo 1053-0003 Fon: + 81 (3) 3506 5858 www.cmp.co.jp	Chugoku Paints Germany GmbH Johannisbollwerk 19 20459 Hamburg, Deutschland Fon: +49 40 31 79 64 80	Bp, Bfp	LE	ava, avp,inu	Alesco
Epifanes Lak-en Verffabrik W. Heeren & ZN B.V. Postbus 166 NL-1430 AD Aalsmeer Niederlande www.epifanes.com	M. u. H. von der Linden GmbH Werftstr. 12-14 46483 Wesel, Deutschland Fon:+ 49 281 338 300	Bp, Bfp	SME	ava	
FRICO-Farben 5200 Brugg (AG) Fon: + 0041 56 441 1024	Esser Lacke Karl-Peter Esser Lackfabrik 79650 Schopfheim, Deutschland Fon: + 49 7622 8063	Bp	SME	ava	
Hempels`Marine Paint A/S Lundtoftevej 150 2800 Kgs Lynby, Dänemark Fon: + 45 93 38 00 www.hempel.com	Hempel Farben Deutschland GmbH Siemensstr. 6 25421 Pinneberg, Deutschland Fon: + 49 4101 7070	Bp, Bfp	LE	ava	Pleasure boat products of Hempel are distributed by VOSSCHEMIE GmbH Esinger Steinweg 50, 25436 Uetersen Fon: +49 4122 7170
Holmenkol Sport Technologies GmbH & Co KG Leonberger Str. 56-62 71254 Ditzingen Fon: + 49 7156 357 271	Holmenkol Sport Technologies GmbH & Co KG Leonberger Str. 56-62 71254 Ditzingen Fon: + 49 7156 357 271	Bfp	SME	ava	

Manufacturer	Distributor/Germany	Products	Size of company	Use	Holdings
Dr. KEDDO GmbH Innungsstr. 45 50354 Hürth, Deutschland Fon: +49 2233 932370 www.dr.keddo.de	Dr. KEDDO GmbH Innungsstr. 45 50354 Hürth, Deutschland Fon: +49 2233 932370 www.dr.keddo.de	Bp	SME	ava	
Jobeck GmbH Industriestr. 8-9 83734 Hausham, Deutschland Fon: + 49 8026 39 45 13	Jobeck GmbH Industriestr. 8-9 83734 Hausham, Deutschland Fon: + 49 8026 39 45 13	Bp	SME	ava	
Jotun A/S P.O. Box 2021 3248 Sandefjord, Norwegen Fon: + 47 33 5 70 00 www.jotun.com	Jotun (Deutschland) GmbH Winsbergring 25 22525 Hamburg, Deutschland Fon: * 49 40 85 19 60	Bp	LE	ava, avp	Joint venture of Jotun with Nippon Oil & Fats and Kansai Marine Paints to Sea Star Alliance
KUMGANG KOREA CHEMICAL Co Ltd Dept. 1301-4, Seoche-Dong Seoche-Ku, Seoul, Korea Fon: +82 2 34 80 57 11 4 www.kccworld.co.kr./korea	Kumkang korea Chemical Co., Ltd. Osterbekstr. 90c 22083 Hamburg, Deutschland Fon: + 49 40 2780 9267	Bp	LE	ava, avp	
Lotréc AB Box 3023 18103 Lidingö, Schweden Fon:+ 46 8 544 809 00 www.lefant.com	M. u. H. von der Linden Gmbh Werftstr. 12-14 46483 Wesel, Deutschland Fon: + 49 281 33 83 00	Bfp	SME	ava	
META Chantier Naval Route de Lyon 69172 Tarare Cedex, Frankreich Fon:+ 04 74 63 13 58	Kapt. Johannes Streckebach Bernadottestr. 73 22605 Hamburg Fon:+ 49 40 880 43 77 www.streckebach.de	Bp	SME	ava	

Manufacturer	Distributor/Germany	Products	Size of company	Use	Holdings
NAUTIX SA Z.I. des 5 chemins 56520 Guidel, Frankreich Fon:+ 33 297 65 32 69 www.nautix.com	Werder Systems Allmend Zentrum 4 CH-8427 Rorbas Schweiz Fon: + 41 8817354	Bp	KMU	ava	
Osnatol-Werk GmbH & Co KG Bahnhofstr. 14 49191 Belm-Vehrte Fon: + 49 5406 83 00 90	HSF Hansa Schiffsfarben Freegenweg 3 21037 Hamburg Fon: + 49 40 736 77 40 www.hansamarin.de	Bp	KMU	avp	
Plastimo 15, rue Ingenieur Verriere BP 435 56325 Loreint Cedex,Frankreich Fon: +33 297 873 659	Fon.+ 49 6105 92 10 10 Telefon für Deutschland	Bp	KMU	ava	
Industrial Property of Scandinavia AB Varvagen 7 16931 Solna, Schweden Fon: +46 8 735 4045	Procoat K. Foerster Technischer Vertrieb Ahornweg 2 24558 Henstedt-Ulzburg, Deutschland Fon: +49 4193 928 63	Bfp	KMU	ava	Ragn-Sells group
Relius Coatings GmbH & Co Donnerschweer Str. 372 26123 Oldenburg, Deutschland Fon: + 49 441 34 02 0 www.relius-coatings.de	Relius Coatings GmbH & Co Donnerschweer Str. 372 26123 Oldenburg, Deutschland Fon: + 49 441 34 02 0 www.relius-coatings.de	Bp, Bfp	KMU	ava, avp	Degussa

Manufacturer	Distributor/Germany	Products	Size of company	Use	Holdings
Sealcoat/Scancoat Ltd. No. 258 ChuangXin Middle Road Jikou Village, Tang Town Pudong New Zone 201203 Shanghai, China Fon:+ 86 21 589 63 533 www.sealcoats.com	Dauter Oberflächenschutz GmbH Röndahler Weg 15 21376 Salzhausen	Bfp	SME	ava, avp	
Sehestedter Naturfarben Dritte Haut Laden, Adolf Riedl Alter Fährberg 7 24814 Sehestedt Deutschland Fon: +49 4357 1049 www.chito.com	Sehestedter Naturfarben Dritte Haut Laden, Adolf Riedl Alter Fährberg 7 24814 Sehestedt Deutschland Fon: +49 4357 1049 www.chito.com	Bfp	SME	ava	
Sigma Coatings Amsterdamseweg 14 1422 AD Uithoorn, Niederlande Fon: + 31 297 54 17 00 www.sigmakalon.nl	Sigma Coatings Farben- und Lackwerke GmbH Moorfleeter Str. 42 22113 Hamburg Deutschland Fon: +49 40 73 60 210	Bp, Bfp	LE	avp	Elf-Aquitane Fina-Total
Sikkens Yachtpaints P.O. box 986 3160 AD Rhoon, Niederlande www.sikkensyachtpaints.com	Yachtpartner GmbH Loggerstr. 12 26386 Wilhelmshaven Deutschland Fon: +49 4421 96 70 10	Bp	SME	ava	Akzo Nobel
Top Master Paints Vertriebs GmbH Kiepelbergstr. 14 27721 Ritterhude, Deutschland Fon: +49 4292 40 92 46	Top Master Paints Vertriebs GmbH Kiepelbergstr. 14 27721 Ritterhude, Deutschland Fon: +49 4292 40 92 46	Bp	SME	ava	Bergolin Gruppe

Manufacturer	Distributor/Germany	Products	Size of company	Use	Holdings
v. Höveling Yachtfarben e.K. Dieselstr. 4c 21465 Reinbek, Deutschland Fon: +49 40 72 77 030	v. Höveling Yachtfarben e.K. Dieselstr. 4c 21465 Reinbek, Deutschland Fon: +49 40 72 77 030	Bp, Bfp	SME	ava	
Veneziani Yacht paints Piazza Tommaseo 34121 Trieste, Italien Fon:+ 39 40 37 83 911 www.veneziani.it	Metzler Farbenhaus Saseler Chaussee 162 22393 Hamburg Fon: +49 40 600 11 00 www.farbenhaus-metzler.de	Bp	SME	ava	
Wohlert Lackfabrik GmbH Max-Planck-Str. 17 27721 Ritterhude Deutschland Fon: + 49 421 63 20 03	Wohlert Lackfabrik GmbH Max-Planck-Str. 17 27721 Ritterhude Deutschland Fon: + 49 421 63 20 03	Bp, Bfp	SME	ava	

Mechanical devices (Lifts)

BOOT-DOCK Öschgasse 18 D-88525 Dürmentingen Fon: + 49 7586 9181 180	BOOT-DOCK Öschgasse 18 D-88525 Dürmentingen Fon: + 49 7586 9181 180	Bfp	SME	ava	
HydroHoist International, Inc. P.O. Box 1286 Claremore, OK 74018 Fon: +001 918 341 6811	HydroHoist GmbH Europe Barry Irvin Ludwig Lange Str. 11 D-67547 Worms Fon: +49 6241 95480 Fax: +49 6241 954829	Bfp	SME	ava, avp	

Electrochemical installations

Jobeck GmbH Industriestr. 8-9 83734 Hausham, Deutschland Fon: + 49 8026 39 45 13	Jobeck GmbH Industriestr. 8-9 83734 Hausham, Deutschland Fon: +49 8026 3945 13	Bfp	SME	ava	

2 Registered antifouling paints in selected countries

2.1 Organotin Free Antifouling Paints Registered in Australia

State of 2003

Company	Product Name	Biocide	Code Number
Resene Paints Ltd.	ABC-3	Cuprous Oxide Thiram Zinc Oxide	42420
Hempel	Olympic 76600 (7154)	Cuprous Oxide Zinc Oxide	42603
	Nautic 7190	Cuprous Oxide Diuron	46920
	Mille Dynamic 71700	Cuprous oxide Diuron	46919
	Mille Dynamic ALU 71600	Cuprous Thiocyanate Diuron	46918
	Seatech	Cuprous oxide Diuron	49687
	Pacific 7609	Cuprous Oxide	46921
	Antifouling Globic	Cuprous Oxide	54514
International (Akzo Nobel)	Intersmooth 360 Ecoloflex	Cuprous oxide Zinc Pyrithione	51971
	Interspeed Super Topcoat	Cuprous oxide Diuron	47588
	Interviron Super Basecoat	Cuprous oxide Diuron	47587
	VC Offshore Extra	Copper metal Diuron	49609
	Longlife high strength	Cuprous oxide Diuron	49606
	Interspeed 2000	Cuprous Thiocyanate Diuron	49607
	Cruiser superior	Cuprous Thiocyanate Diuron	49608
	Bottomkote	Cuprous Oxide	49610
	Micron CSC	Cuprous Oxide Diuron	49611
	Coppercoat	Cuprous Oxide Diuron	49612
	Coppercoat Extra Trade	Cuprous Oxide Diuron	49992
	Biolux Micron Extra	Cuprous Oxide Diuron	53398
	Biolux Micron Optima	Cuprous Oxide Zinc Pyrithione	49871
Jotun	Sea Guardian	Cuprous Oxide	40163
	Supertropic	Cuprous Oxide	40164

	Seasafe	Cuprous Thiocyanate Zinc Oxide Zineb	46487
	Sea Victor 50	Cuprous Oxide Zinc Oxide	46488
	Sea Victor 40	Cuprous Oxide Sea-Nine 211 Zinc Oxide	46489
Kansai 1	Rabamarine AF100	Cuprous Oxide	48675
Norglass	Topflight	Cuprous Oxide	54048
Wattyl Marine Coatings	Ecol IV Black	Cuprous Oxide	52864
	Ecol IV Red/Brown	Cuprous Oxide	52961
	Newport 77	Cuprous Oxide Diuron	52243
	Newport 88 Hard Racing	Cuprous Oxide	52241
	Newport 99	Cuprous Thiocyanate	52240
	Seapro	Cuprous Thiocyanate	40185
	Sigmaplane Ecol	Cuprous Oxide Diuron	40186
	Sigmaplane Ecol HA 120	Cuprous Oxide Diuron	52242
	Sigma Alphagen 20	Cuprous Oxide	56205
	Seapro Plus	Cuprous Thiocyanate Diuron	56524
	Trawler	Cuprous Oxide Diuron	54009
Tasmanian Paints	Coppertox Longlife	Cuprous Oxide Zinc Oxide	42439
	Membrane CR95	Cuprous Oxide Zinc Oxide	42708
	Fishermans	Cuprous Oxide Zinc Oxide	42709
	CR97 CTC	Cuprous Thiocyanate Thiram Zinc Oxide	42710
	Atlantic Controlled Solubility	Cuprous Thiocyanate Diuron Zinc Oxide	48843
Asian Paints (Qld)	Transocean Cleanship 2.95	Chlorothalonil Diuron	48969
	Transocean Longlife 2.77	Diuron	48970
Rextel Pty Ltd (US paint Corporation)	AWLSTAR Gold Label	Cuprous Oxide	49377
Ameron	ABC #3 Antifouling	Cuprous Oxide Thiram Zinc Oxide	55875

2.2 Organotin Containing Antifouling Paints Registered in Australia

State of 2003

Company name	Product Name	Biocide	Code No.
Jotun	Antifouling Seaconomy 300	Tributyltin Oxide Cuprous Oxide Zinc Oxide	40165
	Antifouling Alusea	Tributyltin copolymer resin Zinc Oxide	40166
	Antifouling Seamate HB99	Phenothrin Tetramethrinn	41077
	Antifouling Seamate HB66	Cuprous Oxide Zinc Oxide Tributyltin Oxide	41078
Wattyl Marine Coatings	Sigmaplane HA Aluminium Antifouling	Tributyltin Oxide	41441
Hempels Marine Paints	Antifouling Classic 7655	Cuprous Oxide Zinc Oxide Tributyltin Fluoride Tributyltin Oxide	42602
	Antifouling Nautic 7690/7695	Cuprous Oxide Zinc Oxide Tributyltin Oxide	42692
International (Akzo Nobel)	Intersmooth 327 Hisol 900 Antifouling	Zineb Cuprous Oxide Tin Organic Compound	54443

2.3 Organotin Free Antifouling Paints Registered in New Zealand

State of 2003

Company Name	Product Name	Biocide	Code No.
Akzo Nobel Coatings Limited	Longlife	Cuprous Oxide Diuron	3930
	Interspeed BRA240 Red	Cuprous Oxide Zineb	4019
	Interspeed 642 BQA 407 Red/BQA 412 Blue	Cuprous Oxide Diuron	4475
	Intersmooth Ecoflex 360	Cuprous Oxide Zinc Pyrithione	5189
	Interclene 165 BWA 900 Bright Red	Cuprous Oxide Diuron	5389
	Coppercoat Extra	Cuprous Oxide Diuron	5430
	Trilux	Copper (i) Thiocyanate Dichlofluanid	5435
	Ultra	Cuprous Oxide Dichlofluanid	5690
	Micron Extra	Cuprous Oxide Diuron	5691
	Intersmooth Ecoloflex 460	Cuprous Oxide Zinc Pyrithione	5714
	Interspeed 642 BQA 405 Dark Red	Copper (i) Oxide Diuron	5715
	Ultra Dover White	Cuprous Oxide Dichlofluanid	5744
	Micron Extra Dover White	Cuprous Oxide Diuron	5745
	Longlife Extra Blue (blue, Red and Black)	Cuprous Oxide Diuron	6076
Altex Coatings Limited	AF1000	Cuprous Oxide Thiram Zinc Oxide	4525
	Awlcraft No. 5	Cuprous Oxide Thiram Zinc Oxide	3856
	Alloy antifouling	Copper (i) Thiocyanate Diuron Zinc Oxide	4880
	Coastal Copper Antifouling	Copper (i) Oxide Thiram	5857

		Zinc Oxide	
	AF3000 Ablative Antifouling	Copper (i) Oxide Thiram	6094
		Zinc Oxide	
Asian Paints (SP) Ltd	Transocean Longlife Tinfree Antifouling 2.71	Chlorothalonil Cuprous Oxide	4930
	Transocean Cleanship 200 Antifouling 2.74	Chlorothalonil Cuprous Oxide	
B M Pacific Ltd	Seahorse Formula 1000	Cyclopropyl-n'(1,1,dimethylethyl)-6-(methylthio)1,3,5-triazine,2,4,di=	4945 5170 6089
	Seahorse Propulsion		6090
	Corroless Aluminium Safe Antifouling		
	Corroless Heavy Duty Copper Antifouling		
Courtaulds Coatings (NZ) Ltd	Cruiser Superior	Copper (i) Thiocyanate Diuron	4217
	V C Offshore Extra Pack A	Diuron	4706
	V C Offshore Extra Pack B	Cuprous Oxide	4707
	Optima Base (Part A)	Cuprous Oxide	4976
Fortec Paints Ltd	Seastar 100	2-(tert-butylamino)-4-cyclopropylamino-6-methylthio-1,3,5-triazine Cuprous Oxide	5180
Gavan Holdings Ltd	Mille Dynamic 7170	Cuprous Oxide Diuron Zinc Oxide	4352
	Hempels Antifouling Nautic	Cuprous Oxide Diuron Zinc Oxide	4971
	Hempels Antifouling 7177	Cuprous Oxide	5662
Gemco Ltd	Gemcoat AB	Cuprous Oxide Thiram Zinc Oxide	5574
Jotun Paints New Zealand Ltd	Antifouling Seaguardian	Cuprous Oxide	4202

	Antifouling Seavictor 40	Cuprous Oxide Zinc Oxide	5009
	Antifouling Seasafe	Copper (i) Thiocyanate Zinc Oxide Zineb	5010
	Norimp 2000	Cuprous Oxide	5648
Kaanga Farm	Flexgard VI	Cuprous Oxide	5712
Kaeo Paint Supplies	Rabamarine A/F 100	Cuprous Oxide	5056
	Captain A/F ASCA	4,5-dichloro-2-octyl-3(2h)-isothiazolone Zinc Pyrithione Ziram	5057
	Nu Crest	4,5-dichloro-2-octyl-3(2h)-isothiazolone Cuprous Oxide	5058
Protec Creative Coatings Ltd	TFA Antifouling	Cuprous Oxide	4550
Protective Paints Ltd	271 Longlife Antifouling	Chlorothalonil Cuprous Oxide	3851
	AF500 Cleanship Antifouling	Chlorothalonil Cuprous Oxide Mancozeb	4595
Warpaint Marine Systems Ltd	War Paint Marine Fouling Inhibitor	Cuprous Oxide	4257

2.4 Antifouling Paints Registered in Canada

State of 2003

Company Name	Product Name	Biocide	Code No.
American Chemet Corp.	High Performance Chemical copper	Cuprous Oxide	21241
	Lolo Tint 97 Cuprous Oxide (Technical)	Cuprous Oxide	21242
	Technical Purple Copper 97N	Cuprous Oxide	21243
	Red Copper 97N Cuprous Oxide (Technical)	Cuprous Oxide	21244
Akzo Nobel Coatings BV	Sikkens Classic Antifouling (Red, Brown, Blue, Black)	Cuprous Oxide	21345
	Sikkens Vinyl Antifouling 2000 (White)	Cuprous Oxide	22400
	Sikkens Vinyl Antifouling 2000 (Red, Brown & Black)	Cuprous Oxide	22401
International Paint Inc.	Interlux Micron CSC Black 483 (CU477483) & other Colours	Cuprous Oxide	21351
	Interlux Micron Shark White 484 (CU471484)	Cuprous Oxide	21352
	Interlux Bottomkote XXX Blue 69 (CU474069) & Other Colours	Cuprous Oxide	21354
	Interlux Fibreglass Bottomkote Blue 669 (CU474669) & Other Colours	Cuprous Oxide	21355
	Interlux Fibreglass Bottomkote Racing Bronze 999 (Anti-fouling)	Cuprous Oxide	21372
	Interlux Viny-lux (Blue 340-CU47430 & Black 360)	Cuprous Oxide	21356
	Interlux Viny-lux	Cuprous Oxide	21358

Red 350 Vinyl Antifouling Paint (CU479350)		
Interspeed BLA110 Premium Red	Cuprous Oxide	21378
Union Jack BCA350 Copper Red (ZA469005)	Cuprous Oxide	21379
123 Paint Vinyl Antifouling (ZA469033)	Cuprous Oxide	21396
InterClene BRA542 Black (ZA467003) & BRA540 Red (ZA463007)	Cuprous Oxide	21397
Kosmopolitan-TF KL-990 AFP (Various Colours)	Cuprous Oxide	21652
Tarr & Wonson Copper Paint Red 503-C	Cuprous Oxide	21841
Sea Jacket ACS Antifouling Bottom Paint (Various Colours)	Cuprous Oxide	21840
VC 17M Teflon Antifouling Red V107 & Blue V106 & Graphite V105	Metallic Copper	22020
VC 18 Powerboat Antifouling Paint With Teflon (3 colours)	Metallic Copper	22021
VC-Offshore Teflon Antifouling Saltwater Formula (Three Colours)	Cuprous Oxide	22022
InterViron BRA643 A/F Series (Ocean Green,Red, Black, Blue)	Cuprous Oxide	22717
C-Shield Red Antifouling Paint (469040)	Cuprous Oxide	22718
C-Swift Antifouling Paint (3 Colours)	Cuprous Oxide	22727
C-Union Jack Antifouling Paint Red	Cuprous Oxide	22728

	C-Speed Antifouling Paint (Red) 469038	Cuprous Oxide	22820
	Aquarius Polishing Water Based A/F Series (Various Colours)	Cuprous Oxide	24389
	Interclene 140 BWA 360 Antifouling Red	Cuprous Oxide	24390
	Interclene BCA127 Premium Antifouling Red	Cuprous Oxide	24391
	Interlux Fibreglass Bottomkote Anti-fouling Paint (High Solids Series)	Cuprous Oxide	24392
	Micron CSC Extra Antifouling Paint Red	Cuprous Oxide	24393
	UltraKote A/F 2449H Red And 2669h Blue	Cuprous Oxide	24394
	UltraKote A/F Series(Blue, Green, Red, Brown, Black)	Cuprous Oxide	24395
	Tri-Lux II Antifouling Paint	Copper Thiocyanate	25544
	Tri-Lux II Antifouling Paint	Copper Thiocyanate	25545
	Fibreglass Bottomkote ACT Antifouling paint	Cuprous Oxide	26709
	Interclene BRA 570 Antifouling Series	Cuprous Oxide	27098
Kop-Coat Inc.	Petit Marine Paint (Anti-fouling) 1636 Yacht Red Copper	Cuprous Oxide	21370
	ACP-50 Ablative Copper Polymer Antifouling Bottom Paint 1370 Green	Cuprous Oxide	24097
Kop-Coat Inc. Woolsey Division	Woolsey Vinelast 733 Green Anti-fouling Finish	Cuprous Oxide	21646
	Petit Premium Line Premium Performance Antifouling Finish	Cuprous Oxide	21703

	(3 colours)		
Consolidated Coating Corp.	Pacific Sailor Triple A Antifouling Paint Red	Cuprous Oxide	21401
	Pacific Sailor Copper Bottom Paint Red	Cuprous Oxide	21402
	Pacific Sailor Vinco Antifouling Red Paint (64-0866)	Cuprous Oxide	21985
Matchless Inc.	Matchless Super Marine 711 Red Antifouling Paint	Cuprous Oxide	21462
	Matchless Ocean Marine 1311 Red Copper Antifouling Paint	Cuprous Oxide	21463
	Matchless Boat and Yacht Coating 325 Red Bottom Antifouling	Cuprous Oxide	22571
	Matchless Boat and Yacht Coating 342 Premium Antifouling Black	Cuprous Oxide	22572
	Matchless Boat and Yacht Coating (340 Red)	Cuprous Oxide	22573
Hempel Coatings (Canada) Inc.	Hempels Antifouling Olympic 7660-5111 Red 7660-5030 Red 7660-1999 Black	Cuprous Oxide	21656 21657 21658
	Hempels Antifouling Pacific U7609-5000 Red	Cuprous Oxide	21659
Flexabar Corp.	Flexgard XI Waterbase Preservative	Cuprous Oxide	21986
	Flexgard VI Waterbase Preservative	Cuprous Oxide	23803
Nordox Industries AS	Nordox Cuprous Oxide Powder	Cuprous Oxide	22088
Canbro Inc.	Copper Flake Powder 566	Metallic Copper	22089
Griffin L.L.C	Kocide Copper Hydroxide	Copper Hydroxide	23105
Laurentide	Atlantic Antifouling	Cuprous Oxide	23511

Atlantique Ltee	Paint Copper Bottom Red		
	Co-Op Marine Antifouling Copper Bottom Red 55-1605	Cuprous Oxide	23512
Flexdel Corp.	Aquagard Waterbase Antifouling Bottom Boat Paint	Cuprous Oxide	24409
Bardyke Chemicals Ltd.	Cuprous Thiocyanate Technical	Copper Thiocyanate	25546
Jotun Paints Inc.	Jotun Hydro Clean Anti-Fouling 60A2000, 60A2001, 60A2002, 60A2003	Cuprous Oxide	25788
Ameron International	Amercoat ABC #4 Antifouling Paint	Cuprous Oxide	26589
	Amercoat ABC #3 Antifouling Paint Red	Cuprous Oxide	26991
Solignum Inc.	Solignum EX-84 Waterbase Preservative Net Coating	Cuprous Oxide	27153

2.5 Antifouling Paints Registered in the United States

State of 2003

Company Name	Product Name	Biocide	Code No.
Ameron Protective Coatings division	ABC #2 282-S-4754 Marine Antifouling Paint #2 Red	Cuprous Oxide Tributyltin Oxide	008120-00066
	Amercoat 275E Red Antifouling	Cuprous Oxide	008120-00024
	Amercoat 277E Antifouling Black	Cuprous Oxide	008120-00026
	Amercoat 279 Chlorinated Polymeric Antifouling Red	Cuprous Oxide	008120-00050
	Devran 216-S-3873 Marine Antifouling Paint 216 Red	Cuprous Oxide	008120-00064
	Formula 129 Marine Antifouling Paint Vinyl Black	Cuprous Oxide	008120-00057
	Navicoat 1000 Green antifouling Paint MD-3558	Cuprous Oxide	008120-00063
Anker Marine Paints	Anker Marine Paints Antifouling, Cold Plastic	Cuprous Oxide	009868-00002
Atofina Chemicals Inc.	Biomet 300 Antifouling Agent	Tributyltin Methacrylate	005204-00063
	Biomet 302 Antifouling Agent	Tributyltin Methacrylate	005204-00065
	Biomet 303/60 Antifouling Agent	Tributyltin Methacrylate	005204-00080
	Biomet 304 Antifouling Agent	Tributyltin Methacrylate	005204-00067
	Biomet 304/60 Antifouling Agent	Tributyltin Methacrylate	005204-00081
	Biomet 309 Antifouling Agent	Tributyltin Methacrylate	005204-00088
Bayside Marine	Shipbottom Antifouling Bottom Paint Horizon Blue	Cuprous Oxide	0056970-00001
Continental Industrial Coatings Inc	F-105 Cold Plastic Red Antifouling Mil-P-19451 B	Cuprous Oxide	067898-00001
Extensor AB	VC 17M Antifouling	Metallic Copper	045168-00001

	VC 17M Teflon Antifouling Bottom Paint Original Color V105E	Metallic Copper	045168-00005 045168-00007 045168-00006 045168-00008
Goodrich Company	Nofoul Rubber Antifouling Rubber	Tributyltin Oxide	001225-00011
Hempel Coatings (USA) Inc	Antifouling Combic 71990-19990	Cuprous Oxide Irgarol	010250-00052
	Antifouling Combic 7199E Red 51110	Cuprous Oxide Sea Nine-211	010250-00051
	Antifouling Globic SP-Eco 81952 Light Red	Cuprous Oxide Sea Nine-211	010250-00055
International Paint Inc.	Antifouling Olympic HI 76600-51110 Red	Cuprous Oxide	010250-00054
	Multi-Micron Antifouling Blue	Cuprous Oxide Zinc Pyrithione	002693-00200
	Superyacht 800 Antifouling White	Copper Thiocyanate Zinc Pyrithione	002693-00203
	Aquarius Antifouling Bottom Paint 568 Navy Blue	Cuprous Oxide	002693-00172
	Bottomkote Antifouling 49 Red	Cuprous Oxide	002693-00012
	Bottomkote Antifouling 49 Red	Cuprous Oxide	002693-00058
	Bottomkote Antifouling 69 Blue	Cuprous Oxide	002693-00059
	Fiberglass Bottomkote Antifouling Paint Black 779	Cuprous Oxide	002693-00107
	International NB Supertop Antifouling Paint NB1609	Cuprous Oxide	002693-0054
	Intersmooth 360 Ecoloflex SPC Antifouling BEA 368	Cuprous Oxide Zinc Pyrithione	002693-00187
	Intersmooth 365 Ecoloflex SPC Antifouling BEA 363	Cuprous Oxide Zinc Pyrithione	002693-00188
	Interviron BRA740-Red	Cuprous Oxide Sea Nine-211	002693-00180
	Antifouling Latenac	Cuprous Oxide	002693-00070

	Antifouling Red (Component A) 3020 Plus Component B 3021		
	Mil-P-16189B Formula 129/63 Antifouling Paint, Vinyl Black	Cuprous Oxide	002693-00056
	Mil-p-15931B Formula 121/63 Antifouling Paint Vinyl Red	Cuprous Oxide	002693-00046
	Offshore Antifouling Red 1605	Cuprous Oxide	002693-00033
	Red Hand Antifouling 72 Blue	Cuprous Oxide	002693-00090
	Red Hand Antifouling Bottom Paint 50 Red	Cuprous Oxide	002693-00064
	Super Viny-lux Vinyl Antifouling Red 459	Cuprous Oxide	02693-00121
	Supertrop Antifouling Bottom Paint 46 Red	Cuprous Oxide	002693-00011
	Supertrop Antifouling Paint 45 Blue	Cuprous Oxide	002693-00097
	Tri-lux 11 Antifouling 490 Blue	Copper Thiocyanate	002693-00140
	Viny-lux Vinyl Antifouling Paint 350 Red	Cuprous Oxide	002693-00019
Jotun Paints Inc.	Viny-lux Vinyl-base 340 Antifouling Blue	Cuprous Oxide	02693-00018
Kop-Coat Inc.	Jotun Marine Coatings 60A5000 Seavictor 50 Antifouling REd	Cuprous Oxide Sea Nine-211	002568-00099
	2000 Soft Sloughing Type Antifouling Paint	Cuprous Oxide	060061-00005
	ACP-60 Ablative Copper Polymer Antifouling Bottom Paint	Cuprous Oxide	060061-00081
(Pettit Marine	Neptune II Water	Cuprous Oxide	060061-00077

Paint)	Based Antifouling Finish 550 Blue		
(Pettit Marine Paint)	SR21 Fresh Water Antifouling	Irgarol	060061-00110
(Pettit Marine Paint)	Trinidad SR Antifouling	Cuprous Oxide Irgarol	060061-00095
(Pettit Marine Paint)	Antifouling Trinidad 1274 Blue	Cuprous Oxide	060061-00049
(Pettit Marine Paint)	Horizons Ablative Antifouling Bottom Paint	Cuprous Oxide	060061-00101
(Pettit Marine Paint)	Hydrocoat Ablative Antifouling Paint	Cuprous Oxide	060061-00087
(Pettit Marine Paint)	Sea Mate Antifouling Bottom Paint	Cuprous Oxide	060061-00031
(Pettit Marine Paint)	UnepoxyAntifouling 1522 Brown Atlantic Formula	Cuprous Oxide	060061-00058
(Pettit Marine Paint)	Unepoxy Antifouling 1820 Black Tropic Formula	Cuprous Oxide	060061-00057
(Pettit Marine Paint)	Unepoxy Standard Antifouling Bottom Paint	Cuprous Oxide	060061-00063
(Pettit Marine Paint)	Unepoxy Tin Free Antifouling 1619 Red For Tropic	Cuprous Oxide	060061-00065
(Pettit Unepoxy)	Unepoxy Tin Free Antifouling 1628 Red For Tempera	Cuprous Oxide	060061-00064
(Pettit Unepoxy)	Standard Antifouling Bottom Paint 1810 Black	Cuprous Oxide	060061-00054
	Tropic Antifouling Bottom Paint 1219 Blue	Cuprous Oxide	060061-00066
(Z-Spar „The Protector“)	Vinelast Antifouling Finish 720 Permanent Red	Cuprous Oxide	060061-00033
(Z-Spar Supertox)	TF Hard Type Antifouling Paint B-90 Red 91 Blue	Cuprous Oxide	060061-00011 060061-00010
Kush Paint Co.	TF Hard Type Antifouling Paint B-70 Red 71 Blue 74 Black	Cuprous Oxide	060061-00012 060061-00015 060061-00014

Mobile Paint Manufacturing Company Inc.	303 Black 300 Copper Antifouling Paint	Cuprous Oxide	055236-00001
Muralo Co. Inc.	Jack Tar Vinyl Antifouling Blue 473-33	Cuprous Oxide	001719-00034
New Nautical Coatings Inc.	Muralo Marine Copper Antifouling Bottom Paint 1331 Blue	Cuprous Oxide	039702-00002
	Sea hawk Monterey Water Borne Antifouling Coating	Cuprous Oxide	044891-00009
Sealife Marine Products Inc.	Sea Hawk Sharkskin Antifouling Paint	Cuprous Oxide	044891-00011
The Sherwin Williams Co.	Sealife 1000 Antifouling Marine Paint	Cuprous Oxide	070214-00001
	8010-682-6437 Paint, Antifouling, Vinyl Red Mil-P-15931B, Formula 121/	Cuprous Oxide	000577-00553
	Black Vinyl Antifouling Paint Formula 129, Military Specification	Cuprous Oxide	000577-00551
	Paint, Antifouling, Cold Plastic Shipbottom, Formula 105 Mil-P-19451B	Cuprous Oxide	000577-00555
	Pro-line 1080-H Hard Vinyl Antifouling Paint	Cuprous Oxide	000577-00549
	Red Vinyl Antifouling paint Formula 121	Cuprous Oxide	000577-00550
Sigma Coatings USA B.V.	Vinyl Waterbase Antifouling paint 888	Cuprous Oxide	000577-00552
U.S. Paint Corporation	Sigmaplane Ecol HS Antifouling Redbrown 5297 HS-RD	Cuprous Oxide	011350-00033
Valspar Corporation	Awlgrip Awlstar Antifouling Gold Label	Cuprous Oxide	041750-00002 041750-00001

Walker Brothers	BP401 Medium Green BP501 Light Blue Valspar Marine Bottom Antifouling paint 3594	Metallic Copper Cuprous Oxide	008177-00011
	Escolux Bronze Pacific Sailor Copper Bottom Antifouling Red Paint	Cuprous Oxide	067471-00002
	Pacific Sailor Triple A Antifouling Red Paint	Cuprous Oxide	067471-00004
	Pacific Sailor Vinco 42 Antifouling Paint	Cuprous Oxide	067471-00003 067471-00005
	65 Antifouling paint		

2.6 Antifouling Paints registered for Use in the UK

As there are more than 150 antifouling products registered in the UK, a selection is given

State of 2003

Company name	**Product name**	**Biocide**	**Code number**
International Coatings Ltd.	VC 17m	Copper	7061
	VC 17m-EP	Copper	6102
	VC 17m-HS	Copper Zinc Pyrithione 2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5960
	VC 17m	Copper (metallic)	4780
	VC 17m	Copper (metallic)	4218
	Tropicana	2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	
	Antifouling Paint 161P (Red and Chocolate to TS10240)	Cuprous Oxide	3401
	Boatguard	Cuprous Oxide	3399
	Bottomkote	Cuprous Oxide	5903
	Interclene Premium BCA300 Series	Cuprous Oxide	3372
	Interclene Super BCA400 Series (BCA400 Red)	Cuprous Oxide	4084
	Interclene Underwater Premium BCA468 Red	Cuprous Oxide	5059
	International TBT Free Copolymer Antifouling BQA100 Series	Cuprous Oxide	3375
	Interspeed System 2 BRO 142/240 Series	Cuprous Oxide	5634
	Micron 400	Cuprous Oxide	5728

	Series		
	Micron CSC 100 Series	Cuprous Oxide	5731
	TS 10240 Antifouling	Cuprous Oxide	3386
	ADA160 Series		
	Interspeed Antifouling BWO900 Series	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5636
	InterViron Super Tin-Free Polishing Antifouling BQO400 Series	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5637
	Micron CSC 200 Series		
	VC Offshore	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4777
	Interviron Super Tin Free Polishing Antifouling BQO420 Series	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	5642
	Micron CSC 300 Series	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	5724
	Cruise UNO	Cuprous oxide Dichlofluanid	7526
	Interspeed Ultra	Cuprous oxide Dichlofluanid	6660
	Micron Extra	Cuprous oxide Dichlofluanid	6663
	New Improved Cruiser Premium	Cuprous oxide Dichlofluanid	7095
	Professional Self Polishing Antifouling	Cuprous oxide Dichlofluanid	7259
International Paint Ltd.	Blueline Copper SBA100	Cuprous Oxide	5140
	Copperpaint	Cuprous Oxide	4119
	Hard Racing	Cuprous Oxide	3393

	Interclene Extra BAA100 Series	Cuprous Oxide	3371
	Interspeed System 2 BRA143 Brown	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4301
	Interviron BQA450 Series	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4657
Camrex Chugoku Ltd.	TFA 10 LA	Chlorothalonil Cuprous Oxide	5361
	Seatender 15	Chlorothalonil Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	5348
	Seatender 12	Chlorothalonil Cuprous Oxide Diuron	5324
	TFA 10	Chlorothalonil Cuprous Oxide Diuron	5346
	Seajet 037	Cuprous Oxide	5319
	Seatender 10	Cuprous Oxide	5321
Camrex Holdings BV.	C-Clean 400	Chlorothalonil Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	5947
	C-Clean 300	Chlorothalonil Cuprous Oxide Diuron	5942
	C-Clean 100	Cuprous Oxide	5946
	C-Clean 200	Cuprous Oxide	5943
	Seatender 7	Cuprous Oxide	5320
	C-Clean 400	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One Chlorothalonil	5947
Chugoku Paints BV	Sea Grandprix 500 TCI	Chlorothalonil Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7107
Akzo Nobel UK Ltd.	Vinyl Antifouling 2000	Cuprous Oxide	5633
Nautix SA	A3 Antifouling	Cuprous Oxide 2-(thiocyanomethylthio)Benzothiazole	4367
	A3 Teflon Antifouling	Cuprous Oxide 2-	4368

		(thiocyanomethylthio)Benzothiazole	
	Performer	Cuprous oxide Dichlofluanid	7163
Flexbar Aquatech Corporation	Flexgard VI	Chlorothalonil Cuprous Oxide	6035
Sigma Coatings Ltd.	Sigmaplane Ecol HA 120	Chlorothalonil Cuprous Oxide	5788
	Antifouling	Diuron 2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	
	Sigma Pilot Ecol Antifouling	Copper Resinate Cuprous Oxide Zineb	4933
	Sigma Alphagen 20	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7089
Avon Technical Products	Avonclad	Copper	6396
Copperbot Ltd.	Copperbot	Copper	6860
Wessex Resins and Adhesives	Copperbot 2000	Copper	6680
Aquarius Marine Coatings Ltd.	Coppercoat	Copper	7532
	Coppercoat	Copper Diuron	6428
	AMC Sport Antifouling	Cuprous Oxide	6395
Synthetic Solutions Ltd.	Copperguard	Copper	6670
Ecosea Ltd.	Cupro FF	Copper	7378
Mirocoat Ltd.	Miricoat A.F. Coating	Copper	5587
Ameron BV.	Amercoat 70ESP	Copper (metallic)	3203
	ABC#4 Antifouling	Cuprous Oxide	6535
	ABC#3E Antifouling	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7051
Hippo Marine Products Ltd.	CU15	Copper (metallic)	5872
Blakes Marine Paints	Algicide Antifouling	Cuprous Oxide	6535
	Blakes Hard Racing	Cuprous Oxide	7385

Antifouling		
Blakes Seatech	Cuprous Oxide	7381
Antifouling 7820D		
Blakes Tiger Cruising	Cuprous Oxide	6945
Blakes Tiger Cruising	Cuprous Oxide	7384
Antifouling		
Blakes Titan	Cuprous Oxide	7388
Antifouling		
Broads	Cuprous Oxide	7345
Antifouling		
Broads Freshwater	Cuprous Oxide	3220
Cruising Performer	Cuprous Oxide	7504
Antifouling		
Pilot	Cuprous Oxide	3226
Antifouling		
Shearwater Racing	Cuprous Oxide	3228
Antifouling		
Super Tropical	Cuprous Oxide	3229
Antifouling		
Super Tropical Extra	Cuprous Oxide	3230
Antifouling		
Tiger Xtra	Cuprous Oxide	7514
Algicide	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5738
Aquaspeed	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4511
Broads Antifouling Red	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6878
Broads Black Antifouling	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5739
Broads Freshwater Red	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5736
Challenger Antifouling	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4099
Hard Racing Antifouling	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-	5704

		6-Cyclopropylamino-S-Triazine	
	Pilot	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	5959
	Seatech	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	7117
	Tigerline	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	6872
	Titan FGA Antifouling	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	5681
	Titan Ultra	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	7096
	Waterline	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	7099
Mark Dowland Marine Ltd.	Even Tin Free	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino- 6-Cyclopropylamino-S-Triazine	5841
Witham Oil and Paint (Lowestoft) Ltd.	Antifouling Paint 161P (Red and Chocolate to TS10240)	Cuprous Oxide	3503
	Unitas Antifouling Paint Chocolate	Cuprous Oxide	3499
	Unitas Antifouling Paint Red	Cuprous Oxide	3498
Jotun Paints (Europe) Ltd.	Antifouling Mare Nostrum	Cuprous Oxide	5812
	Antifouling Sargasso	Cuprous Oxide	6073
	Antifouling Seaguardian	Cuprous Oxide	3856
	Antifouling Seaguardian (Black, Blue and MD)	Cuprous Oxide	4273
	Antifouling Seaquantum FB	Cuprous Oxide	7047
	Antifouling Super Tropic	Cuprous Oxide	3413
	Antifouling	Cuprous Oxide	6470

	Supertropic SeaPrince	Cuprous Oxide	4957
	Antifouling	Cuprous Oxide	4958
	Seavictor 50	4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	
Steen Hansen Maling AS	Aqua-guard	Cuprous Oxide	7215
	Copper Net	Cuprous Oxide	6034
	Aqua-net	Cuprous Oxide	6897
	Net-Guard	Cuprous Oxide	5657
Mariner Paints	Aquacleen	Cuprous Oxide	5667
	C-Worthy	Cuprous Oxide	5476
	Speedclean Antifouling	Cuprous Oxide	5077
	Superspeed	Cuprous Oxide	6210
Marineware Ltd.	Aquagard (flexgard XI)	Cuprous Oxide	6589
GJOCO A/S	Aquasafe	Cuprous Oxide	5983
	Aquasafe W	Cuprous Oxide	6353
Johnstones Paints Plc.	Armachlor AF275	Cuprous Oxide	5929
	Armacote AF259	Cuprous Oxide	5928
	Armarine AF259	Cuprous Oxide	5926
	Armarine AF275	Cuprous Oxide	5927
NOF Europe NV	Awlgrip	Cuprous Oxide	5065
	Awlstar Gold Label Antifouling		
Carmyco S.A. Paints-Varnishes-Adhesives	Carmypaint SV-881	Cuprous Oxide	7208
Valiant Marine	Cobra V	Cuprous Oxide	5194
Compass Yachtzubehor Handel	Compass Antifouling 1000	Cuprous Oxide	7330
	Compass Antifouling 3000	Cuprous Oxide	7331
Coopers Marine Paints	Coopers Coploymer Antifouling	Cuprous Oxide	5609
New Guard Coatings Ltd.	Cupron Plus T.F.	Cuprous Oxide	5661
	Eurosprint N.F.	Cuprous oxide Dichlofluanid	7498
	Raffaello 3 NF	Cuprous oxide Dichlofluanid	7500

Indestructible Paint Company	Double Sheild Antifouling	Cuprous Oxide	6040
W and J Leigh and Company	Envoy TF100	Cuprous Oxide	3951
	Envoy TFSP100 Tin Free Self Polishing Antifouling	Cuprous Oxide	7151
	Envoy TFSP500 Tin Free Self Polishing Antifouling	Cuprous Oxide 2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine+ 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7150
	Grassline Type M396 Antifouling	Cuprous Oxide 2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine+ 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7075
	Envoy TF400 Antifouling	Cuprous Oxide Cuprous Thiocyanate 2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7072
	Envoy TF 500 Antifouling	Cuprous Oxide Cuprous Thiocyanate 2-Methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	7073
C.W. Wastnage Ltd.	Flagship Antifouling	Cuprous Oxide	5825
Aquatess Ltd.	Flexgard VI-II Waterbase Preservative	Cuprous Oxide	6543
Hempels Paints Ltd.	Hempels antifopuling Olympic 86951	Cuprous Oxide	7374
	Hempels Copper Bottom	Cuprous Oxide	4274
	Hempels Net Antifouling 715GB	Cuprous Oxide	6342
	Hempels Tin-Free Antifouling 7660	Cuprous Oxide	3338

Hempels Classic Tin-Free 7611	Cuprous Oxide	7344
Hempels Antifouling Classic 7611 Red (Tin Free) 5000	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5064
Hempels Antifouling Nautic 8190C	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6043
Hempels Antifouling Olympic HI-7661	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4898
Hempels Hard Racing 76480	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5538
Hempels Mille Dynamic 71700	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	5574
Hempels Antifouling Bravo Tin Free 7610	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	4482
Hempels Antifouling Globic SP-ECO 81900	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	6531
Hempels Antifouling Globic SP-ECO 81990	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	6532
Hempels Antifouling Tin Free 743GB	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	3329
Hempels Antifouling Tin Free 751GB	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	3333
Hempels Antifouling Tin Free 751GB	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	3336
Hempels Tin Free Antifouling	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	3337
Hempels Antifouling Globic SP-	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	6877

	ECO 81920 Hempels Antifouling Globic SP-ECO 81950	Cuprous Oxide 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One	6879
	Hempels Antifouling Rennot 7150	Cuprous oxide Dichlofluanid	3364
Polymarine Ltd.	Inflatable Boat Antifouling	Cuprous Oxide	6647
Marclear Espana	Marclear Full Strength EU45 Antifouling	Cuprous Oxide	5987
	Marclear High Strength Antifouling	Cuprous Oxide	5264
Tulloch Enterprises	Netrex AF	Cuprous Oxide	5684
Morenot AS	Metwax NI3	Cuprous Oxide	7539
Ernesto Stoppani SPA	Noa-Noa Rame Black/Red	Cuprous Oxide	4795
	Vinilstop 9926 Red	Cuprous Oxide	4798
Norland Distributors	Nordrift Antifouling	Cuprous Oxide	5993
Marine and Industrial Sealants	Penguin Racing	Cuprous Oxide	5673
	Penguin Non-Stop	Cuprous oxide Dichlofluanid	5671
MB Marine Coatings Ltd.	Professional	Cuprous Oxide	5981
Attiva Spa	Professional UK	Cuprous Oxide	7506
A and M Paints	Scotwest Antifouling	Cuprous Oxide	6120
Bradite Ltd.	Shiprite Racing	Cuprous Oxide	6147
	Shiprite Sailing	Cuprous Oxide	6302
	Shiprite Traditional	Cuprous Oxide	6178
	Shiprite Speed	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6603
HMG Paints Ltd.	Slippy Bottom SuperSpeed	Cuprous Oxide	7423

	SP 53		
Skipper (UK) Ltd.	Standard Antifouling	Cuprous Oxide	6194
	Viniline	Cuprous Oxide	6193
	Longlife Antifouling	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6195
D.R. Margetson	Superspeed	Cuprous Oxide	5191
Teal and Mackrill Ltd.	Teamac Tropical Copper Antifouling (C/260/65)	Cuprous Oxide	3496
Spencer Coatings Ltd.	Transocean Cleanship Antifouling 2.90	Cuprous Oxide	7135
X M Yachting	XM Anti-Fouling C2000 Cruising Self Eroding	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6176
	XM Anti-fouling P4000 Hard	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6175
	XM Antifouling HS3000 High Performance Self Eroding	Cuprous Oxide 2-methylthio-4-Tertiary-Butylamino-6-Cyclopropylamino-S-Triazine	6124
	CX 2000 XM Antifouling Cruising Self Eroding	Cuprous oxide Dichlofluanid	7354
	HX 3000 XM Antifouling High Performance Self Eroding	Cuprous oxide Dichlofluanid	7353
	PX 400 XM Antifouling Hard Antifouling	Cuprous oxide Dichlofluanid	7355
Waterline	Halcyon 5000 (base)	Cuprous oxide Dichlofluanid	5396
Plastimo International	New Antifouling 1.1	Cuprous oxide Dichlofluanid	7288
	New Antifouling	Cuprous oxide Dichlofluanid	7290

1.2 New Antifouling 1.3	Cuprous oxide Dichlofluanid	7292

3 Standard and Industry Methods of Testing Antifouling Coating Efficacy (in summary)

3.1 CEPE (Conseil Européen de l'industrie des Peintures, des Encres, d'Imprimerie et des Couleurs d'Art)

Antifouling Coatings - Method for the Generation of Efficacy Data
The method was published in 1993 and is currently under reconsideration.

Definitions
Antifouling coatings are defined as preparations, in the applied form of surface coatings, containing one or more active substances.

Scope
The purpose of this method is to determine, by raft testing, the effectiveness of an antifouling coating relative to an uncoated substrate… The results obtained by the raft testing described in this method are purely an indication of the products' ability to prevent settlement of fouling organisms under static conditions…
The present method is not applicable to evaluate complete coatings systems or the relative life-time of coatings. Thus the results obtained by the described method are not serving to demonstrate actual performance in service

Procedure
The A/F paint is applied onto one or more raft panels and exposed from the raft along with an uncoated substrate… Application of paint is made by brush, roller, spray or specialised application equipment…
At given intervals, the panels are assessed for presence of fouling organisms. Assessment is done quantitatively and, as minimum, semi-qualitative (slime, algae, animals)… To prove efficacy, the minimum immersion time for testing is 6 months….
Resistance to fouling at the raft site is demonstrated if no or minimal colonisation of the surface is observed relative to the uncoated substrate.

3.2 Standards Australia

AS 1580.481.5 (1993)
Durability and resistance to fouling
This Standard sets out a procedure for assessing the performance of marine underwater paint systems exposed, under static conditions, to a marine environment as defined by this Standard. It provides for the determination of:
(a) Protection of the substrate from deterioration and corrosion with or without cathodic protection
(b) Durability and resistance to fouling of paint systems applied to the above mentioned substrates.
Principle
The paint systems to be tested are applied to prescribed test panels which are then affixed to a specified test rack and immersed at a specified depth from the test raft. The paint systems are examined periodically for permanent settlement of fouling

organisms and for film integrity. The substrate is examined for signs of deterioration or corrosion where appropriate.

3.3 American Society for Testing and Materials

ASTM D 6990-03
Standard Practice for the Evaluation of Biofouling Resistance and Physical Performance of Marine Coating Systems
This new practice is intended for use in conjunction with currently accepted panel exposure methods. It is applicable only as a method of evaluation of coating performance and does not outline any conditions of panel exposure. Thus, it can be used for static or dynamic panel tests, for the evaluation of patches on ships or full-coated ships.

Once this new practice is approved, any instruction for the inspection and evaluation of panels will be removed and replaced with a reference to this new rating practice. This applies to:
- D 3623 - Method of Testing Antifouling Panels in Shallow Submergence
- D 4938 - Test Method for Erosion Testing of Antifouling Paints Using High Velocity Water
- D 4939 - Test Method for Subjecting Marine Antifouling Coatings to Biofouling and Fluid Shear Forces in Natural Seawater
- D 5479 - Practice for Testing Biofouling Resistance of Marine Coatings Partially Immersed
- D 5618 - Test Methods for Measurement of Barnacle Adhesion Strength in Shear.

Coating systems evaluated using this method are given a fouling and a deterioration rating. The fouling rating expresses the percent of coverage of the coated panel by fouling organisms while the physical deterioration rating expresses the percentage area of the coating system displaying physical coating damage/failure(s). This practice provides quantitative guidance to the panel inspector for a consistent evaluation of coating performance from test panels coated with marine antifouling coating systems, regardless of which testing method is being used. In this performance assessment of coating systems both the antifouling qualities and the physical properties of the coating are evaluated and its standardisation will result in more precise and comprehensive evaluation of fouling rate (FR).

Fouling Rate
The antifouling performance of the marine coating system is graded using the following protocol.
- The fouling rating for a coating system free of adherent biofouling settlement shall be recorded as 100.
- The fouling rating for a paint film free of macrofouling settlement but partially or totally covered by microfouling growth (adherent slime) shall be recorded as 99, irrespective of the percent area covered by the “adherent slime.”
- Upon settlement of macrofouling forms, the total sum of percentage of area covered by macrofouling shall be deducted from 100. The fouling rating, then, essentially reflects non-fouled area.

Physical condition

The physical condition of the coating is graded using the following protocol.

- Individual physical performance failure, qualitative and quantitative, shall be evaluated for each test panel. Observations of erosion, wearing, blistering, alligatoring, checking, cracking, chipping, peeling, flaking, and damage shall be made
- Grading of physical performance of the marine coating system is performed through the generation of a physical deterioration rating (PDR). The range of the PDR is 0-100.
-The physical deterioration rating for a coating system free of physical deterioration shall be recorded as 100.

ASTM D 4939-89

Standard Test Method for Subjecting Marine Antifouling Coatings to Bio-fouling and Fluid Shear Forces in Natural Seawater.

Determination of antifouling performance and reduction of thickness of marine antifouling (AF) coatings by erosion or under specified conditions of hydrodynamic shear stress in seawater alternated with static exposure in seawater. An antifouling coating system of known performance is included to serve as a control in antifouling studies.

Significance and Use

Effective antifouling coatings are essential for the retention of speed and reduction of operating costs of ships. This test method is designed as a screening test to evaluate antifouling coating systems under conditions of hydrodynamic stress caused by water flow alternated with static exposure to a fouling environment. A dynamic test is necessary because of the increasing availability of AF coatings that are designed to ablate in service to expose a fresh antifouling surface. Because no ship is underway continually, a static exposure phase is included to give antifouling micro-organisms the opportunity to attach under static conditions. After an initial 30 day static exposure, alternated 30 day dynamic and static exposures are recommended as a standard cycle. The initial static exposure is selected to represent ships coming out of dry dock and sitting pier-side while work is being completed. This gives the paint any time to lose any remaining solvents, complete curing, absorb water, and in general, stabilise to the in-water environment.

This test method is intended to provide a comparison with a control antifouling coating of known performance in protecting underwater portions of ships hulls. This test method gives an indication of the performance and anticipated service life of antifouling coatings for use on seagoing vessels. However the degree of correlation between this test method and service performance has not been determined.

ASTM D 4938-89

Standard Test Method for Erosion Testing of Antifouling Paints using High Velocity Water.

Test method to determine the erosion rates for marine antifouling paint systems immersed in flowing natural seawater.

Significance and Use

This test method is intended to measure the erosion rates of ablative antifouling paints systems exposed to flowing water at velocities designed to subject the paint system to shear stresses experienced in service. Measurement of erosion rates are necessary to help in the assessment of ablative antifouling paint thicknesses required for fouling control between scheduled dry dockings of ships, in the selection of materials, in producing quality assurance, and in understanding the performance mechanism. The test is intended to serve as a guide for predicting the service life of ablative antifouling paint s in order to calculate the necessary paint thickness to fit specified deployment cycles. Erosion rates of antifouling paints in service will vary depending on such factors as berthing location, geographic area of operation, salinity, pH, and temperature of seawater. It should also be recognised that some areas of the ship are subject to different erosion rates. The degree of correlation between results obtained from this test method and shipboard service has not been determined.

ASTM D 3623-78a (1998)

Standard Test Method for testing Antifouling Panels in Shallow Submergence

Procedure for testing antifouling compositions in shallow marine environments and a standard antifouling panel of known performance to serve as a control in antifouling studies

Significance and Use

This method is designed as a screening test in evaluating antifouling coating systems. Results of the standard system in a specific marine environment are included to assist in interpreting results. Antifouling systems providing positive comparisons with the standard system should be considered acceptable for use in protecting underwater marine structures. The degree and type of fouling will vary depending on the environment. Hence, differences in geographic location of the test sites, in time of year when panels are exposed, and in weather conditions from 1 year to the next can affect results. Therefore, a fouling census on a non-toxic surface is taken. For the exposure to be valid the non-toxic surface should show heavy fouling, and the standard system should show significantly less fouling than the non-toxic surface.

ASTM D 5479-94

Standard Practice for Testing Bio-fouling Resistance of Marine Coatings Partially Immersed

This practice covers a procedure for testing a bio-fouling resistant coating system or antifouling systems, or both, when subjected to in-situ partial immersion exposure. This partial immersion enhances settlement of certain marine fouling organisms and increases the rate of possible physical deterioration.

Significance and Use
This test method is designed as a screening test to evaluate the performance of applied coating systems and other materials designed to resist biofouling settlement. The degree and type of fouling will vary depending on the environment. Differences in geographic location of test sites, time of year, when panels are exposed, and weather conditions from one year to the next, can affect results. Such variables are accounted for by taking a census on a non-toxic surface. For the exposure to be valid, the non-toxic surface should show heavy fouling accretion.

ASTM D 5618-94
Standard Test Method for Measurement of Barnacle Adhesion Strength in Shear
This test method covers the measurement of barnacle adhesion in shear to surfaces exposed in the marine environment. It is used to establish the ability of a surface to reduce bio-fouling adhesion. Surfaces with known barnacle adhesion strengths are included to serve as controls.

Significance and Use
This test method is designed as a screening test in the evaluation of coating systems and other materials designed to resist bio-fouling attachment. The degree and type of barnacle fouling will vary according to the geographic location of test sites and the time of year when tests are implemented. Surfaces with known barnacle adhesive shear strength should be exposed to provide comparative data.

4 International legislation and registration procedures of antifouling products by country

The following is a brief overview of the current regulation situation in the countries that harbour ports most important to the shipping industry. A lot of these countries require registration of antifouling products as a way of controlling their use and environmental impact. Where these registration procedures are in action there is often a lot of information available about the registered products on the internet, but it helps if you know where to look. The following is a brief guide to regulation and registration procedures, authorities and other information published online where it is available.

4.1 EU

In the past, several European countries like the Sweden, United Kingdom, The Netherlands and Switzerland established registration and authorisation procedures for biocidal products including antifouling paints. In other European countries including Germany antifouling products could be marketed without registration, apart from selected dangerous substances already regulated by the EU. The marketing and the use of dangerous substances is regulated by the EU-Directive 76/769/ECC[1]. As these differences between countries constitute barriers, not only to trade in

[1] EU Directive 76/769/EEC relating to restrictions on the marketing and use of dangerous substances. RL 2002/62/EC

biocidal products but also to trade in products treated with biocides, thereby affecting the functioning of the EU market, the Commission proposed the development of a common framework of biocide regulations. These relate not only to the market placement and use of biocidal products but also establish a higher degree of protection for humans, animals and the environment. To achieve this it was necessary to provide common principles for the evaluation and authorisation of biocidal products to ensure a harmonised approach by Member States. The European Parliament and of the Council of the European Union adopted the Directive 98/8/EC concerning the placing of biocidal products on the market (BPD)[2] on the 16th February 1998
The implementation of the Biocidal Product Directive is now coming into effect within EU-countries.

Within the framework of the BPD several processes are taking place: Identification, notification and subsequent review regulation. The first review guideline regulated the first phase of the review program and established the identification and notification of existing biocidal substances by March 2002. The second review guideline came into force in November 2003 with the exhaustive list of 580 identified and 360 notified existing biocidal substances. This will now regulate the dossier submission and review of notified biocidal substances between 2004 and 2008. Identified but un-notified biocides shall be banned by 01/09/06. Biocides that were not listed are no longer to be used in biocidal products.
At present there is debate, mostly dominated by consideration of the discrimination criteria separating biocidal and non-biocidal products. This debate was instigated by the definition given in article 2, paragraph 1, the labelled and intended use of a product, defined by the manufacturer, determines if a product is a pharmaceutical, cosmetic or biocidal product. This definition is based mostly on the use of the biocide incorporated into the product. According to the 2nd Review Regulation 44 antifouling biocides have been notified[3]. The review process for antifouling biocides is expected to take place from 2005-2008. The dossier submission is planned for 11/2005-04/2006, but evaluation and decision process will not be finished before 2008, with the possibility of running over time.
Biocides and biocidal products are defined in the Directive 98/8/EC, concerning the placing of biocidal products on the market[4], article 2, 1, as follows:

a) Biocidal products
Active substances and preparations containing one or more active substances, put up in the form in which they are supplied to the user, intended to destroy, deter, render harmless, prevent the action of, or otherwise exert a controlling effect on any harmful organism by chemical or biological means.

b) Low-risk biocidal product
A biocidal product which contains as active substance(s) only one or more of those listed in Annex I A and which does not contain any substance(s) of concern. Under the conditions of use, the biocidal product shall pose only a low risk to humans, animals and the environment.

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[2] OJ L 123, 24.4.98, Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market, 63 pp.
[3] http://ecb.ips.it
[4] Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing the placing of biocidal products on the market. OJL 123, 24/4/98, art.2.

c) Basic substance
A substance which is listed in Annex I B, whose major use is non-pesticidal but which has some minor use as a biocide either directly or in a product consisting of the substance and a simple diluent which itself is not a substance of concern and which is not directly marketed for this biocidal use..

d) Active substance
A substance or micro-organism including a virus or a fungus having general or specific mode of action on or against harmful organisms

All biocidal products must be labelled according to the EC-Guideline 1999/45/EC concerning the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous preparations, from July 2004. All notified existing biocides can be produced, sold and stored until 2010 resp. until the decision about the inclusion of biocidal substances in the Annex I of the BPD.

4.1.1 Germany

Up to now Germany had no registration procedure. Germany implemented the BPD into its national legislation on 20/06/02[5]. The BAuA is the present authority for approval or withdraw of biocidal products. Just recently the BAuA published a document on its homepage as a guide for authorization of biocidal products www.baua.de/amst.

4.1.2 United Kingdom

Registration of antifouling products (defined as non-agricultural pesticides) is undertaken by the Biocides and Pesticides Unit within the Health and Safety Executive.
Information about registration procedures is available free from the BPU in the form of 'The Registration Handbook', a printed guide. This guide can be ordered from the HSE website. (www.hse.gov.uk)

Previously all registered products within the UK were published annually in 'Your Guide to Approved Pesticides – the Bluebook – Pesticides 200X', however, to make this information more accessible by the public there is no longer a printed version of Pesticides 200X. The on-line list of approved products 'Pesticides 200X' can be found at the following address:
www.hse.gov.uk/hthdir/noframes/bluebook/bluebook.htm . This is a list of categorised registered pesticide products. Scroll down to 'Antifouling products' to open a PDF file of antifouling products, listed alphabetically by active ingredient. Information supplied is active ingredients, product name, marketing company details, and specified uses. Please note that some antifouling products may have repeated entries where there are two or more active ingredients.

[5] Biozidgesetz vom 20. Juni 2002 (BGBl. Teil I, Nr. 40, S. 2076 vom 27. Juni 2002

Registration of Diuron in antifouling products was revoked in the UK in 2000, in view of its low degradability in seawater and low safety margin for adverse human haematological effects.
ZPT (zinc pyrithione) is approved in a number of products for amateur and professional use.
Although RH 287 (4,5-Dichloro-2-n-octyl-4-isothiazolin-3-on active portion of Sea-Nine 211) is currently approved in the UK as a booster biocide in a number of antifouling products, it is a skin sensitising compound and is predicted to be a skin and eye irritant, therefore causing amateur use of products containing RH-287 to be revoked in the UK in 1999. In 2000, the Advisory Committee on Pesticides recommended that although professional use of RH-287 should be permitted to continue, additional personal protective equipment and further data have been required. Actually, professional products based upon RH-287 can be marketed/used in the UK as antifouling products but may only be applied to vessels over 25 metres in length.
Zineb is the only Dithiocarbamate still used as a co-biocide, being strongly synergistic with copper. After a review of booster biocides in 2000, the UK Advisory Committee on Pesticides recommended that the approval of Zineb in professional and amateur use should continue.
It was also recommended that all amateur uses of antifouling products containing Chlorothalonil should be revoked after studies on human toxicology indicated that the risk of skin sensitisation was unacceptably high. Amateur and professional use of TCMTB (Thiocyanomethylthiobenzothiazole) was revoked due to failure to supply outstanding data requirements.
The amateur use of Irgarol 1051 was revoked due to environmental concerns and professional use was revoked due to failure to supply data requirements

General information relating to the Control of Pesticides Regulations and the Biocidal Products Directive/Regulations can be found on our website at the following address: www.hse.gov.uk/hthdir/nofames/bpau.htm

The HSE is also responsible for implementing the Biocidal Products Directive within the UK

4.1.3 Denmark

Control and registration of biocidal products is done by the Danish Environmental Protection Agency in the Danish Ministry of Environment (www.mst.dk/) but at present this registration procedure does not extend to antifouling products.
In September 2003 the Ministry of the Environment published the Statutory Order no 792 of September 2, 2003 on restrictions on import, sale and use of biocidal antifouling paint. The order includes:

- Import, sale and use of antifouling paint containing the biocides Diuron (CAS no. 330-54-1) or Irgarol (CAS no. 28159-98-0) on vessels of a total length of less than 25 metres, as defined by ISO 8666, shall be prohibited.

- Import, sale and use of biocidal antifouling paint on pleasure craft which are used predominantly in freshwaters shall be prohibited.

- Import, sale and use of biocidal antifouling paint, for which the release of copper exceeds 200 μg Cu/cm^2 within the first 14 days and 350 μg Cu/cm^2 within the first 30 days counted from the day it was applied, shall be prohibited on pleasure craft of more than 200 kilograms used primarily in salt waters.

- Import, sale and use of biocidal antifouling paint on pleasure craft of less than 200 kilograms used primarily in salt waters shall be prohibited.

- Import, sale and use of biocidal antifouling paint on pleasure craft releasing substances that meet the requirements of classification for environmental impact with the risk phrase “May cause long-term adverse effects in the aquatic environment” (R53) alone or in combination with other risk phrases concerning harm to the aquatic environment, shall be prohibited after 1 January 2006.

A good source of information about antifouling product use in Denmark is the publication 'Inventory of Biocidal products used (in) Denmark', by the Danish EPA. This inventory surveys all of the biocidal products within the 23 product groups that are being evaluated in the EU Biocidal Products Directive. The information contained in this inventory was drawn from the Danish product register, Statistics Denmark and from private companies. For each of the product groups, including antifouling products, the report includes descriptions of application and function of biocidal products used in Denmark (and active ingredients), companies active in the market and rates of consumption. This inventory can be accessed at www.mst.dk/news/01010000.htm by scrolling down to the link 'Inventory of Biocides Used in Denmark'.

4.1.4 Sweden

Antifouling products may not be imported or manufactured within Sweden without first being approved by the National Chemicals Inspectorate, KEMI (www.kemi.se). There is a number of antifouling products for pleasure boats approved for use on the West coast.
In the Baltic Sea there is at present only one antifouling product approved and it contains capsaicin (capsaicin is a pepper derivate) as active substance. This product is approved for use also on the West coast. No antifouling products with copper or Irgarol are approved today for use on pleasure boats in the Baltic Sea since 2001.
No antifouling products have been approved for use on pleasure boats in freshwater since 1992.
Products with copper and Irgarol are approved also for professional use on ships longer than 12 m and with main trade in the Baltic Sea (except the Bothnian Sea), the North Sea or the oceans.
Products with Sea-Nine are approved only for professional use on ships longer than 12 m and with main trade in the North Sea or the oceans.
Products with zinc pyrithione are approved only for professional use on ships longer than 12 m and with main trade in the Baltic Sea (except the Bothnian Sea), the North Sea or the oceans.
No antifouling products with Diuron have been approved since the first approval process of antifouling products in 1992.

KEMI has an online products register database, but it is only in Swedish. The antifouling homepage is at:
www.kemi.se/Kemi/Kategorier/Bekampningsmedel/Batbottenfarger/batbotten.html
From here select the link "Lista - godkaenda produkter" (List of approved products) where you will find a list of all the products approved (godkaenda) for use on pleasure boats (fritidsbåtar) and ships (fartyg).
To find information about the active ingredients in each registered product either select the product you are interested in or select "Mer information" (more information) and then "Visa verksamma aemnen" (Show active ingredients). Here you will obtain information about the active ingredients and their concentration within each product.
A short lesson in Swedish:
Preparatnamn = name of the product
Doelj verksamma aemnen = hide active ingredients
Sortera på aemnen = sort according to active ingredient
Visa anvaendningsområden = show area of use
Also, Klass 3 means that the product can be used by everyone, klass 1 and 2 means that the product can be used only by professional users in some cases needing special education.

4.1.5 Finland

Antifouling products are chemicals used to control the growth and settlement of fouling organisms (microbes and higher forms of plant or animal species) on vessels, aquaculture equipment and other structures used in water.

According to the amendment of the Chemicals Act (1198/1999), approval for antifouling products with either chemical or biological mode of action had to be applied for in Finland by the end of 2001. Thereafter only products for which applications had been made to the Finnish Environment Institute during 2001 or which have been approved according 28 § of the Chemicals Act may be placed on the Finnish market.

An application for approval had to be submitted to the Finnish Environment Institute before 1 January 2002 for any antifouling product that has been on the market in Finland or in some other EU Member State on 13 May 2000 and which is intended to be placed on the market in Finland after 31 January 2001. After the application has been submitted, supplying the Finnish market may continue until any other decision has been made by the Finnish Environment Institute.

Since 1 January 2002 it has been prohibited to place on the Finnish market antifouling products for which an application for approval was not been submitted before 1 January 2002. Approval for these products may be applied for later, according to the procedures given in 28 § of the Chemicals Act.

These transitional provisions are applicable during the 10-year transitional period (until 13 May 2010 at the latest), and in the case of a single product until a decision on the inclusion of the active substance(s) into an annex of the BPD has been made according to the Directive.

A list of antifouling products permitted on the Finnish market can be found at: www.environment.fi>legislation, permits>permits>chemicals requiring>authorisation of antifouling products.

4.1.6 The Netherlands

The Authority concerned with the registration of antifouling paints is the College voor de Toelating van Bestrijdingsmiddelen (Board for the Authorization of Pesticides), www.ctb-wageningen.nl . On this website you can choose to view the registered products, listed either by product name, registration number or biocidal product types (http://vti28.vertis.nl/portal/page?_pageid=33,47205&_dad=portal&_schema=PORTAL) . On this website is also a list of authorized active substances (http://vti28.vertis.nl/portal/page?_pageid=33,47211&_dad=portal&_schema=PORTAL) . All the lists of registered products and chemical names are in Dutch. Inter alia Irgarol 1051, Diuron , Dichlofluanid and Zineb are permitted as antifouling biocides.

4.1.7 Malta

The importation, manufacture, sale, and use of antifouling products in Malta is regulated by the Pesticides Control Act, Cap. 430,
www.maf.gov.mt/docs/laws chp430.pdf
Responsibility for registration of antifouling products lies with the Pesticide Control Board within the Ministry of Agriculture www.maf.gov.mt/mafboards.htm. There is no online list of registered products.

4.1.8 Switzerland

Antifoulings of any type (biocidal and biocide free) may only be marketed in Switzerland if the manufacturer is in possession of a marketing permit. The department responsible for the issuing of permits is the Swiss Agency for the Environment, Forests, and Landscape, SAEFL (http://www.umwelt-schweiz.ch/buwal/eng/). When requesting a permit for antifouling paints the name of the product, full composition, intended use and method of application must be supplied. The company submitting the application must be domiciled or have an agency in Switzerland.
(Ordinance relating to environmentally hazardous substances, 9 June 1986)
The list of registered substances can be found at http://www.umwelt-schweiz.ch/buwal/eng/fachgebiete/fg_stoffe/recht/antifoul/index.html

4.2 United States

All biocidal antifouling systems used within the USA, imported or transported across state lines must be registered federally as well as within the states they are to be used. Registration of pesticide products is done federally by the Environmental Protection Agency. Within the EPA the Office of Pesticides, Antimicrobial Division, is

responsible to the registration of these pesticide products. State government can implement more stringent restrictions and choose not to register paints that are registered federally if they are inclined to, but cannot change labelling requirements.
The law governing the management of antifouling paints in America is the Federal, Insecticide, Fungicide and Rodenticide Act (FIFRA). The pesticide registration and classification procedures can be found in the electronic Code of Federal Regulations (CFR 152) at www.access.gpo.gov/ecfr. Most of the registered antifouling paints in America contain some form of copper as the primary active ingredient with some using Sea-Nine, Irgarol or Zinc Pyrithione as a co-biocide. Only antifouling systems that contain a biocide need to be registered with the EPA.
ZPT was registered by the U.S. EPA for use as an antifouling biocide in 1997. Copper pyrithione is not yet registered for use by the U.S. EPA, but a registration application has been filed. The manufacturer obtained U.S. EPA registration for Sea-Nine 211 in 1994 and this was the first organic biocide registered for use in antifouling paints within the USA.
The U.S. EPA registered Irgarol as an antifouling biocide in 1994. After the submission of additional ecological effects data and environmental fate data, 7 antifouling paints containing Irgarol were registered for use in the US.
Information concerning pesticide products registered federally (registration details and active ingredients) can be found at the Department of Pesticide Regulation in the Californian branch of the EPA at www.cdpr.ca.gov/docs/epa/epamenu.htm. In the Pesticide Product Database you can only search by PC code, product name, company name, or registration number, therefore it helps to know what products you are looking for. Information included in the database is the marketing company's details, registration date and active ingredients (with all alternative chemical and common names included).
California have had a heightened interest in the use of antifouling paints since some parts of San Diego Bay have been found to contain higher levels of dissolved copper then the state and federal standards allow. The University of California's Sea Grant Extension project is now trying to promote the use of non toxic antifouling products through investigation of new biocide free antifouling systems and subsequent education of the target boating groups (www.seagrant.ucdavis.edu). The Regional Water Quality Control Board is currently carrying out analysis of the total maximum daily load of copper in the Shelter Island yacht basin and depending on the results of this study California may implement stricter rules concerning the use of copper-containing antifouling products in California.
More detailed information about pesticides registered for use in the USA is available by subscription to the National Pesticide Information Retrieval System (NPIRS), under the administration of the Center for Environmental and Regulatory Information Systems, Perdue University, Indiana (www.ceris.perdue.edu/npirs). Here you can access registered pesticide product information, the pesticide document management system, data submitters list, tolerance indexes, and the federal register archive.
All reports used or compiled by the EPA in the process of product registration are available through the Freedom of Information Office, with the exclusion of information designated as confidential by the manufacturing company involved.

4.2.1 US EPA Pesticide Assessment Guidelines related to antifouling products

(1) Efficacy data should be derived from testing conducted under conditions typical of actual or proposed use, or, where applicable, under controlled laboratory conditions which simulate actual use.
(2) The test substance should be the formulated product evaluated at various dosage levels including those dosage rates associated with its proposed use. It should be tested under all techniques intended to be used in applying the product.
(3) Data on the compatibility of the test substance with other sub-stances will be developed in accordance with OPPTS 810.1000 if the test substance will be used in sequence or with another substance.
(4) Data should demonstrate the effect of the test substance on various life stages of pests and other significant factors. The data should clearly establish the method of action of the test substance in repelling, destroying, or mitigating pests.
(5) The efficacy of the test substance should be established with reference to the applicable suggested performance standard.
(i) The suggested performance standards contained in the following guidelines are generally stated in terms of percent control, based on a comparison of treated organisms and untreated control organisms. In certain situations, the test substance may be evaluated in comparison to a product of known efficacy. Under some other circumstances, the performance standards are expressed as acceptable levels of damage.
(ii) The conditions under which the suggested performance standards apply are listed in the following guidelines. These performance standards are not intended to be absolute or inflexible.
(iii) An analysis of variance and multiple range test or other appropriate statistical analysis should be conducted to determine the reliability of data, when a question of relative effectiveness occurs.
(6) Dose response data should accompany applicable site/pest crop combinations. The benefits such as increased yield, unblemished fruit, reduction in nuisance pest levels to be derived from each dosage rate to be registered for control of a particular pest should be clearly defined and reported. Dose response data for crops other than the pesticide site/pest combination will be considered if submitted and referenced.

4.2.2 Data required for registration of biocidal antifouling products include:

- Acute toxicology data on the formulated product
- Product chemistry data
- Chronic toxicology data on the active ingredient.
- Environmental fate data on the active ingredient
- Phytotoxicity data if risks are suspected to non-target plant species
- Fish and wildlife data, if applicable

4.2.3 Labelling requirements

There are 4 toxicity categories and a pesticide is assigned to a category based on its highest hazard potential. The Hazard indicators include Oral LD50, Inhalation LC50, Dermal LD50, eye effects and skin effects, physical and chemical Hazards. The substance is labelled with a signal word (danger; warning, caution) and precautionary statement for each hazard according to its respective category.

4.3 Canada

Import, sale and use of biocidal antifouling coatings in Canada is regulated under the Pest Control Products Act, administered by the Pest Management Regulatory Agency of Health Canada, www.hc-sc.gc.ca/pmra-arla/english/index-e.html. All antifouling paints must be registered with the PMRA and also must meet the required daily leaching rates if they contain copper.
Copper based antifoulings can be used if the maximum daily release rate does not exceed 40 micrograms per square centimeter per day.
There is no online list of registered products, but this list, as well as information about registered pesticides, is available by contacting the Pest Management Information Service, a part of the PMRA. Contact details are www.hc-sc.gc.ca/pmra-arla/english/pdf/info/2002-e.pdf , Email: pmra_infoserve@hc-sc.gc.ca, Ph: 1-800-267-6315 or outside of Canada +1(613)-736-3799
A new addition to the Health Canada is the ELSE label database and search engine. You can search for specific label information at www.eddenet.ca/4.0/4.0.asp .

4.4 Australia

Registration of pesticide products is done federally through the Australian Pesticides and Veterinary Medicines Authority (formally the National Registration Authority) (www.apvma.gov.au). State government is responsible for controlling the use of these registered products. Twice a year the APVMA meets with state government representatives to discuss areas of concern in a registration liaison committee.
Registered product information is available through the PUBCRIS database on the APVMA website www.apvma.gov.au/pubcris/subpage /pubcris.html. In the PUBCRIS database you can search for company name, product name, active constituents, or host and pest organisms. Information available for each registered paint, active constituents, states registered, approved labels and packaging information.
Paints that do not require registration include silicone coatings, fibre flock coatings, and foul release surfaces.
In Australia cuprous oxide, cuprous thiocyanate and Thiram are registered but not yet fully assessed. Diuron was grandfathered into the present system but is currently undergoing review, to be completed 2004. Sea-Nine 211 was only recently registered and assessed.
Zineb is registered for agricultural and antifouling use.

Irgarol has been considered but not approved by the APVMA for use as an antifouling biocide. Chlorothalonil is presently registered for use as active ingredient but not yet fully assessed and Dichlofluanid has never been considered by the National Registration Authority for the use as antifouling biocide. Zinc pyrithione was only recently registered and assessed (2002).
The Antifouling Program is assisting with development of alternative antifouling products, education of the public and industry, and is cooperating with the NRA on assessment and registration of new antifouling products. For more information see www.ea.gov.au/coasts/pollution/antifouling/index.html

4.5 New Zealand

The body responsible for registration of antifouling products is the Agricultural Compounds and Veterinary Medicines Group within the New Zealand Safety Authority (www.nzsfa.govt.nz/acvm) but this is now changing. Hazardous Substances that were previously regulated under such as the Dangerous Goods Act 1974, the Explosives Act 1957, the Pesticides Act 1979, or Toxic Substances Act 1979, and were physically present in New Zealand on 2nd July 2001 are now to be regulated by the Environmental Risk Management Authority. All existing toxic substances used in New Zealand are now being transferred to the new Hazardous Substances and New Organisms legislative regime.

The HSNO act allows for the management of all of the hazards associated with manufactured or imported products by one authority, the ERMA. Registered antifouling paints are allocated classifications with regards to flammability, toxicity, ecotoxicity, identification, packaging, disposal, emergency management, tracking and approved handlers. Information of this type which is not available under current pesticide management systems must be provided in the transfer to the new system as any pesticides that can not be transferred will become illegal. Antifouling paints are expected to be transferred by November 2003, but until then will still be regulated under the old system.
The ACVM database of currently registered pesticides is still current and can be found on the internet at www.nzfsa.govt.nz/acvm/registers-lists/db-reg-px.htm . You can do a search specifically for antifouling paints and the database provides information on product name, formulation type, product type, name of licensee, active ingredients, content units of actives (g/l) and date of registration. Please note that in this database some paints are listed more than once where there is more than one active ingredient. The ACVM group participate twice a year in the Registration Liaison committee, a meeting between the federal NRA and state government representatives in Australia. In this way Australia and New Zealand are able to Cooperate and provide perspectives on similar areas of interest or concern about pesticides or product registration within the Ag-vet industry.

4.6 ANZECC

Ministerial representatives from Australia, New Zealand and New Guinea, constituted the Australian and New Zealand Environment and Conservation Council (ANZECC) (www.ea.gov.au/cooperation/anzecc), and although no longer active, authored “The

Code of Practice for Application, Use, Removal and Disposal of Antifouling Paints" along with many other practical environmental documents. This code was put together by the ANZECC Maritime Accidents and Pollution Prevention Group within which are representatives from Australian and New Zealand government and private associations concerned with the issue of antifouling procedures. Fouling problems in Australia and New Zealand as well as current and alternative antifouling systems were reviewed in the preparation of the Code and implementation of its practices are required of all Australian shipping authorities and commercial vessels.
The ANZECC Code of Practice for Antifouling and In-water Hull Cleaning (in PDF format) can be found on the Environment Australia website www.ea.gov.au/coasts/pollution/antifouling/pubs/antifoulingcode.pdf

4.7 Hong Kong, China

Antifouling paints must be registered in Hong Kong and are controlled by the Department of Agriculture Fisheries and Conservation. Only pesticides that have been registered with the AFCD may be distributed or used within Hong Kong. Individual products need not be registered as long as they contain the registered active ingredients at the concentrations permitted. The permitted active ingredients, concentration limits and formulations are listed on the AFCD website. The 8 antifouling formulations registered for use in Hong Kong are as follows:

Copper (I) oxide [65%]
Copper (I) oxide/4,5-dichloro-2-n-octyl-3(2H)-isothiazolone [40%/2%]
Copper (I) oxide/Diuron [50%/5%],
Copper (I) oxide/Zineb [65%/15%],
Copper (I) oxide/Irgarol 1051 [50%/5%],
Copper (I) thiocyanate/Diuron [30%/5%],
Copper (I) thiocyanate/Irgarol 1051 [25%/5%],
Copper (I) oxide/Zinc pyrithione [48.20%/4.29%]

TBT containing paints are strictly regulated and no person may import, supply, be in possession of, or use any TBT-based antifouling paint unless the have a valid permit issued by the Agriculture, Fisheries and Conservation Department.
Information regarding legislation and registration of antifouling paints (including list of registered antifouling formulations) can be found at www.afcd.gov.hk [Follow the links as follows: Public information > Plants and pesticides > Pesticides > Notes on antifouling paint].

4.8 China/India

There are no restrictions on the use of antifouling products.

4.9 Japan

There has been no registration procedures for non-TBT containing antifouling paints in Japan since 1986. Control of chemical products in Japan is done through the control of the active ingredients. The Law Concerning Examination and Regulation of

Manufacture of Chemical Substances (LCERMCS) specifies certain antifouling actives for control and restricts tin compounds. There are 6 antifouling actives specified under LCERMCS. The 'specification' of a substance under this law allows the Ministry of Economy, Trade and Industry (METI) to monitor its usage and control its use if necessary. These and another 8 antifouling actives are also specified under the Pollutant Release and Transfer Register (PRTR) which is correlative with the Toxic Release Inventory of the USA EPA (www.epa.gov/tri/), and allows for the tracking of the life of these chemicals in Japan.
Information about biocidal actives that are controlled under this system is available through the various websites of the METI, Ministry of Land, Infrastructure and Transport and the Ministry of Environment, but as yet this information is only accessible in Japanese. At the time of writing there is no way to access this information in English but in the future it is possible that this information may be available through the Japanese Paint Manufacturers Association, www.toryo.or.jp
(pers. comm., Mr. Eiichi Yoshikawa of Chugoku Marine paints and the Marine Environmental Protection Committee, IMO)

4.10 South Korea

There is no authority registering antifouling paints in South Korea. Antifouling paint companies must provide certification of non-TBT containing product, through companies such as the Korea Register Office of Shipping or Germanischer Lloyd (classification companies).
TBT containing antifoulings were banned for domestic vessels <25m in March 2000 and all TBT antifouling paints will be banned on all vessels in 2003.
(pers. com. Kumkang Korea Chemical Company, Hamburg)

4.11 South Africa

Antifouling products must be registered with the National Department of Agriculture under the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947. Lists of registered pesticides can be found at www.nda.agric.za/ by selecting the link [Regulatory and Other Services> Agricultural Production Inputs] but at time of writing there were no antifouling products with current registration status. The NDA can be contacted at +27 12 319 6000.
(pers.com. NDA registrar)

5 Comments and recommendations

Several scientists of authorities and universities were contacted to ask for remarks and recommendations on the efficacy criteria
In detail the following authorities and scientists were asked for a critical review:

Competent Authorities

Denmark
Danish Environmental Protection Agency
Helle Petersen

UK
Health and Safety Executive
Chris Walton
Mike Potts

Austria
Umweltinstitut des Landes Vorarlberg
Martin.Rinderer

The Netherlands
College voor de toelating van bestrijdingsmiddelen - CTB
Verkleij C.M.A.
Goewie C.E.

Finland
Finnish Environment Institute
Hannu Braunschweiler

Sweden
National Chemicals Inspectorate
Kurt Haglund <Kurt.Haglund@kemi.se>

Switzerland
Bundesamt für Umwelt, Wald und Landschaft
Edward Back
Anna Waelty

U.S.A.
US Environmental Protection Agency
Jill Bloom

Australia
Australian Pesticides and Veterinary Medicines Authority
Ken Hoy

Experienced scientists

Australia
Defense Science & Technology
John Lewis

U.S.A.
Naval Surface Warfare Center
Haslbeck Elizabeth

Florida Institute of Technology
Geoff Swain

The Netherlands
TNO
Dr. Job W. Klijnstra

In a post-meeting of the International two-days Symposium on biocide-free antifouling paints, held in November 2003 in Osnabrueck, the efficacy criteria were discussed with experienced scientists like G. Swain, FIT, E. Haslbeck, NSWC, J. Lewis, DST; Doose, J., Arendt, H., German Navy; Poremski, J., Schablowski, D. UBA; Urban, M. BAM; Daehne, B., Wiegemann, M., Watermann, B., LimnoMar.
The meeting was strongly in favour of the application of the proposed ASTM-methods instead of the CEPE method or relevant methods of Standard Australia. Even some of the ASTM methods are currently going to be reviewed, the expectation is that after the revision process they are even more appropriate for biocide-free products than before. Concerning the dynamic testing of panels, the meeting agreed on the impeding costs and technical effort, necessary for the application of the existing ASTM methods. Some modifications are currently going to be developed which may be standardized in a couple of years.

5.1 CEPE Paint Manufacturers' Comments to Blue Angel Award Criteria Health and Environment

In addition a special meeting was held with the antifouling working group of CEPE on September 1, 2003 at the UBA in Berlin.
After the meeting CEPE submitted its basic objection, remarks and recommendations which are given below.

- Risk assessment should form the main basis for the award. The award should not only rely upon hazard criteria.

- Industry is uncertain if the Blue Angel Award will have an effect for commercial vessels. However niche market vessels might be a possibility such as smaller local ferries and perhaps the cruise ships market. The award is seen mainly for pleasure craft market.

- Products need to be as effective as non-awarded products. Otherwise the higher price will not be justified and pleasure craft owners will most probably not buy the products.

- Industry is uncertain if the award for A/F will be successful. A/F paints are not considered suitable for awarding compared to products for the decorative market.

- Experiences from Scandinavian countries show that product efficacy is extremely important for yacht owners otherwise “homemade paints” might be used. The following Swedish web page includes a discussion forum for the boat owners. www.marinan.com/klotterplanket/segel - search “bottenfärg”. The page is in Swedish. One of the recipes includes cayenne pepper mixed with penicillin! Another letter suggests using only toxic paints if you can get hold of them outside Sweden! Another suggests mixing copper powder and epoxy.

- Information on content of the substances that are classified in a product is found on the product MSDS. The information-trigger is according to EU legislation. The exact concentration is not revealed but ranges are given. This fulfils the requirement for notification procedure in certain countries for biocidal as well as non-biocidal paints.

- Information on concentration of preservatives is not necessarily found on product MSDS. The information-trigger is according to EU legislation. The exact concentration of preservatives or any other constituents can only be submitted under confidentiality agreements.

- Paint manufacturers have access to a certain level of information from the raw material suppliers. Information/ test results needed to classify the raw materials are not necessarily revealed to paint manufacturers. The raw material suppliers are responsible for the classification of their own products. The paint manufacturers usually relate to the classification before accepting the raw material for use in their products.

- If a substance is not on Annex 1 in Directive 67/548/EEC the supplier is required to self-classify their substance. Paint manufacturers do not have the detailed information, which forms the basis for the self-classification.

- Classification of substances is an ongoing process. Some substances are classified by EU and are to be found on the Annex 1. Other substances are at present self-classified but will appear on Annex 1 after EU evaluation either with the same or a different classification. Already EU classified substances might change classification after a re-evaluation process.

- Paint manufacturers are constantly evaluating raw materials. Substitution due to undesired properties is considered case by case. Many issues need to be discussed when substituting raw materials such as compatibility with other paint constituents, evaluation of change of performance etc. It may not always be possible to substitute right away. As it requires changes in paint formulation additional test packages need to be performed. In some cases substitution may show not to be possible.

- Paint manufacturers do not necessarily have detailed information on binders. Information to UBA can only be obtained through direct contact between UBA and raw material suppliers. This is often also the procedure when applying for registration in countries with regulatory schemes. The contact between the authority and the supplier is established by the paint manufacturer.

- The award criteria state that PB screening of erodable binders should be performed under relevant conditions. But what is “relevant conditions”? For commercial ships, it might be tropical water conditions as commercial vessels applied in Germany might never sail in cold German waters again.

- It is uncertain if all components of paint are degradable in seawater. Paint consists of up to 30 different components. Only limited results on degradability of these components are expected to be found. It is expected to be a considerable amount of work to test each component of the paint. REACH will uncover this problem.

- The criteria on substance risk phrases R50/53, R51/53, R50 or R53 will with the present products be difficult to fulfil.

- Authorities do not normally require TOC/DOC for A/F paint. A harmonised method on generation of a leachate has not yet developed.

- To our knowledge there are not yet any water-based silicones on the market.

- Non-biocidal coatings are not necessarily more environmentally friendly than biocidal coatings when seen in a full perspective. Both types of paint should be used for the applications where they are best suited otherwise the environmental draw back will be too large (increased fuel consumption, organic material from on site scraping, etc.).

- We are uncertain that the Blue Angel project on A/F paints will be a big success as it is very closely related to acceptable efficacy by the user.

- The paint industry is very much occupied with the Biocidal Products Directive at present and in the years to come. Performing tests and developing the documents for compliance verification for the award will be a time consuming task.

- Furthermore the new EU chemical legislation (REACH) will increase the information level and eliminate the most problematic substances based upon a risk assessment approach. This is a resource demanding process also for the

paint industry as downstream users. It should be seriously considered to await the entry into force of EU New Chemical Policy.

- The paint industry as such cannot commit to participate in the Blue Angel project. It will be up to each company to decide if they want to apply for the Blue Angel award. The decision will be based upon their own judgement of the market advantage.

- The aim in The Biocidal Products Directive (and other EU Directives) is to introduce uniform measures all over the European market region also for antifouling products. The paint industry finds that local initiatives like national eco labelling disturb the intentions of establishing uniform initiatives.

Comments to suggested biotests on leachate.

- The main comment pertaining to paint leachate tests is that the leachate in the Petri dish does not reflect what actually leaches from the paint.

- Of the 2 possibilities described in the set up proposed by Dr Watermann the best option would be to discard water every 24 hours and measure the total volume after 216 hours. In this way the chances of chemical interference on the rate of leaching would be less. The formation of the biofilm seems to be more accurate but it is still not completely true to what actually happens on the paint film surface

- The overall comment is that the test method is not an accepted harmonised test method.

Comments to award criteria on efficacy

- The CEPE method is a generalised industry method and covers CEPE companies own internal standardised methods.

- The method is accepted under BPD.

- The method is accepted for data submissions to ex. UK, NL, BE, FI, S, US.

- The method is accepted for both pleasure crafts and commercial vessels. For commercial vessels the market regulates the efficacy.

- The CEPE method is sufficiently general to allow tests to be carried out by various institutions and organizations. It is, therefore, independent of one singular commercial organization. The test equipment can be purchased from more than one source

CEPE Paint Manufacturers are:

Akzo Nobel International Coatings, Jotun Paints, Sigma Kalon, Ameron, Chugoku and Hempel A/S

6 Recommended ASTM Standard Methods

- D 6990-03 Standard Practice for Evaluating Biofouling Resistance and Physical Performance of Marine Coatings Systems
- D 5618–94 Standard Test Method for Measurement of Barnacle Adhesion Strength in Shear