EU LIFE Project ECOTEC-STC
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ECOTEC-STC: Evaluation of a biocide-free hull protection and antifouling system with environmental and economical benefits

Layman's Report

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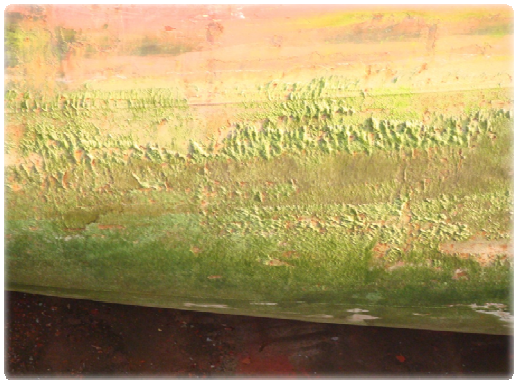
1 INTRODUCTION

Marine structures such as ship hulls need protection against the attachment of marine organisms such as algae and barnacles, known as biofouling. Biofouling negatively affects the hydrodynamics of the hull by increasing the required propulsive power and hence fuel consumption. The increased fuel consumption costs as a result of weed fouling have been estimated to be as much as 40% and even more for shell fouling.



Biofouling increases ship resistance and fuel consumption

Biofouling is traditionally prevented by the use of coatings. At present, toxic copper-based antifoulings dominate the market. self-polishing co-polymers (spc) which gradually leach biocides by a chemical reaction are the most effective and offer a lifetime of up to 5 years. However, the continuing leaching of biocides into the aquatic environment raises major concerns. It has been estimated that the input of copper into seawater from antifouling paints may conservatively be estimated to equate approximately 5000 tonnes per year, whereby the main concern is the localised scale of input in enclosed water bodies such as marinas, ports and harbours.

One alternative to biocidal antifoulings are biocide-free foul release coatings, which aim to prevent the settlement of fouling by providing a low-friction surface onto which organisms have difficulty attaching. If vessels are stationary, settlement occurs, but there is only weak bonding between the fouling organisms and the coating surface. Hence, the organisms are in theory relatively easily removed by the hydrodynamic forces when the vessel is travelling at a sufficiently high speed. The lifetime of foul release coatings, however, is restricted as they are soft and easily damaged.

2 ECOSPEED

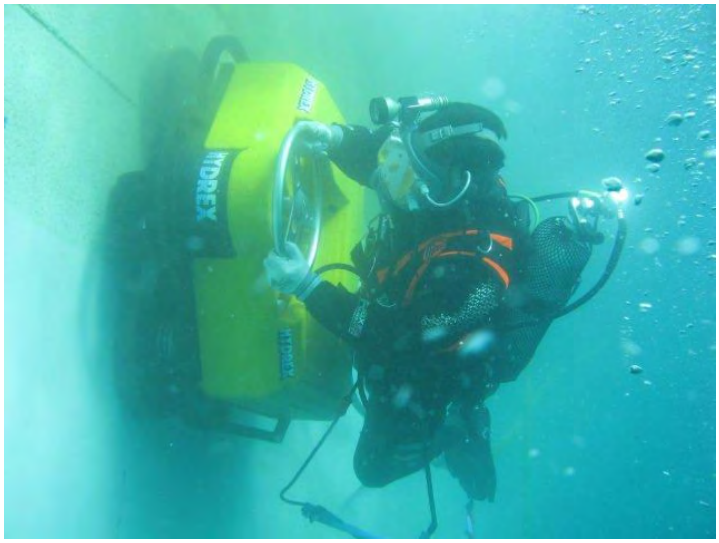
The ECOTEC-STC Research Project concerns an entirely different approach to the coating technologies described above. Ecospeed is an entirely biocide-free antifouling technology that does not rely on just a coating but that essentially involves advanced maintenance technology. Ecospeed is designed for regular underwater treatment which consists of a conditioning aspect and a cleaning aspect and can therefore also be described as a **Surface Treated Coating** (STC). While cleaning removes any fouling, preferably in an early stage of development, conditioning is carried out with specially designed tools to bring the smoothness of the paint surface to an optimum condition.

Ecospeed is composed of a vinyl ester resin which is reinforced with glass platelets. The glass platelets lie in different layers parallel to the substrate. As such, they form a very durable and impermeable protection layer, which is very effective for corrosion protection. There is no need for re-application during the standard life time of a ship, since this coating gives an estimated anti-corrosion protection for 25 years, contrary to the common hull coatings that have to be re-applied every 2 to 5 years. This opens the

prospect of eliminating full repaint processes in drydock altogether, which is a major environmental and economical benefit.

When the coating is fully cured, the material can be conditioned underwater by divers. During this process the surface characteristics are optimized with purpose-designed tools. This results in a smooth surface, as a result of which the ship will experience less drag in the water.

Fouling will eventually occur, especially when ships lie still. This increases the drag the ship will experience in water, which is unfavorable for the fuel consumption of a ship. To minimize this drag and fuel penalty, ships coated with Ecospeed need to be cleaned to remove the organisms that have attached to the hull. The frequency of underwater cleaning depends on factors such as the ship type and the severity of fouling in the operational area.



Ecospeed is a Surface Treated Coating intended for regular underwater treatment

As cleaning and conditioning are performed underwater, no drydocking is necessary. The coating in itself is extremely durable so that even vigorous cleaning does not damage the surface, which is not the case for other antifoulings. As a result, fouling is removed effectively at all times and the frictional resistance is reduced. The combined underwater treatment of cleaning and conditioning offers the major benefit that the surface texture of Ecospeed improves over time and thus, contrary to traditional coatings, improves ship performance all through the service life of the vessel.

3 OBJECTIVES OF THE PROJECT ECOTEC-STC

The objective of the Research Project ECOTEC-STC is to evaluate the environmental and economical benefits of Ecospeed as a biocide-free durable hull protection and antifouling system. The project was divided into several Project Tasks which were all carried out under the supervision and organization of **Hydrex NV**.

Task 2 was to test and modify the maintenance tools to optimize the underwater treatment of STCs and to develop new prototypes.

Tasks 3 and 4 were to demonstrate the ease of application and underwater treatment in participation with several shipowners that were involved as partners in the project: notably **Interscan, Peter Döhle, Exmar-CMB** and **Codralux-Jan De Nul.** Subsequent inspections gave proof of the durability of the coating.

Task 7.5.3 concerned the environmental impact from application and maintenance. The environmental impact of application and underwater treatment was then assessed by the **Rijkswaterstaat Zeeland, the Port of Antwerp** and **ERM**.

Task 7.5.4 involved a risk assessment of transferring non-indigenous marine species (NIS) by underwater cleaning, which was carried out by **ERM**, **Rijkswaterstaat Zeeland** and **the Port of Antwerp**. The findings of this study were then at the end of the project demonstrated by an underwater treatment in the Port of Rotterdam on a 1000-TEU container vessel of the partner **Peter Döhle.**

Task 7.5.5 was to monitor the fuel consumption of sister vessels from the partners **Peter Döhle** and **Exmar-CMB** over a period of two years. The analysis of the provided input was carried out in collaboration with the **Hogere Zeevaartschool** and **VITO**.

Finally, Task 7.5.6 compared the drag and roughness characteristics of Ecospeed with those of other coatings in collaboration with **VITO**.

4 RESULTS OF THE DIFFERENT PROJECT TASKS

A first practical Task (**Task 2**) was to test the tools used for the underwater treatment of Ecospeed and to modify the design parameters in order to facilitate the process and to optimize the surface characteristics of Ecospeed. In addition, new prototypes were developed including a version that is remotely operated.

Semi-automatic maintenance tool in use for the underwater treatment of Ecospeed on large areas.

Tasks 3 and 4 of the Project were to demonstrate the ease of applicability and the durability of the coating by subsequent drydock inspections. Supervised applications were carried out on a variety of ship types from the partners involved, including container vessels, general cargo vessels, an LPG tanker and a split hopper barge.

Fresh application of Ecospeed on a general cargo vessel.

Prior to the application of Ecospeed, the surface is grit blasted to remove possible contaminants and to assure strong attachment of the coating to the substrate. Ecospeed is applied by airless spraying in two coats of approximately 625 microns wet film thickness on the ship in a dry dock, to a total dry film thickness of minimally 1000 microns. The coating cures rapidly and flooding is possible twenty-four hours after application.

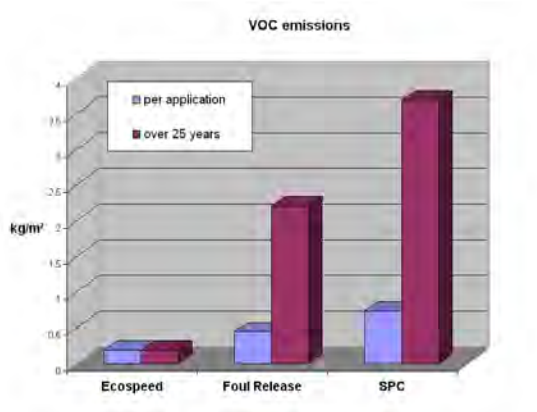
Subsequent inspections of these vessels in drydock showed that only local touch-ups were required on some places that had been mechanically damaged. In a specific example, the condition of Ecospeed on a 1000-TEU container vessel that had been operating two years in the Baltic Sea with severe winter conditions was inspected in drydock in 2010 and found to show only very minor damage. In comparison, the conventional biocidal antifouling that had been on before Ecospeed was found to be in very poor condition.

Comparison of the same container ship with a conventional biocidal antifouling (left) and Ecospeed (right) after spending subsequent periods of 2.5 years operating in the Baltic Sea.

The environmental impacts from application and maintenance were assessed **(Task 7.5.3)**. In a first stage, a literature review was performed to compare the environmental impact of the application of Ecospeed to alternative coatings. In a second stage, experiments were set up to investigate the environmental impact of curing, conditioning and cleaning of Ecospeed.

The findings of the literature review suggest a lower impact on the environment over the lifespan of a vessel from the application of Ecospeed compared to the application of foul release and copper-based spc. Firstly, as Ecospeed only needs to be applied once in 25 years, much less paint is used and much less associated waste is created. It can be estimated that if 80% of the world fleet would switch from biocidal antifoulings to Ecospeed, 12 million litres of paint don't have to be applied every year, which saves significantly on material resources and associated transport costs.

The study also shows that significantly smaller amounts of Volatile Organic Compounds (VOCs) are released into the atmosphere with each application of Ecospeed in comparison to antifoulings. It is estimated that over a period of 25 years, nearly 13 times as many VOCs are emitted with a foul release than with Ecospeed, and more than 23 times as many VOCs are emitted with a copper-based spc coating scheme.



VOC emissions for typical Ecospeed, foul release and copper-based spc schemes.

Experiments were subsequently set up to determine the amount of substances released during curing, conditioning and cleaning of Ecospeed. These tests were carried out in tanks with a restricted amount of water to avoid dilution effects. The effluent analysis under these stringent conditions revealed that emissions to the water will occur. However toxicity tests and oestrogen tests performed on the water samples before and after the treatments, gave no evidence of toxic effects from the released substances. It was therefore concluded to be unlikely that the release of substances during curing, conditioning and cleaning of Ecospeed will have a harmful effect on surface water quality.

Effluent analysis after conditioning Ecospeed

These tests were important in that they confirmed that Ecospeed is free of biocides and that the underwater cleaning of Ecospeed will not result in a pulse release of biocides as is the case with copper-based antifoulings.

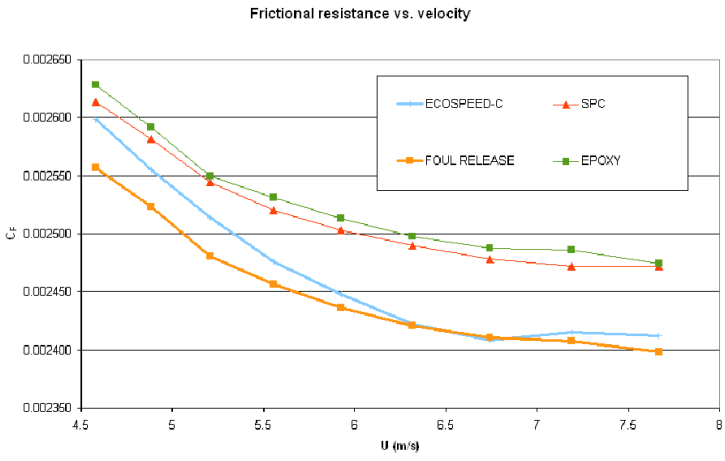
During any underwater cleaning the biofilm that has formed on the hull is released, whereby a risk of transfer of non-indigenous marine species (NIS) arises. NIS are introduced by human activity to a new geographic area and then establish and spread, threatening ecosystems, habitats and/or other species. In marine and coastal environments, NIS have been identified as one of the four greatest threats to the world's oceans. Ballast water and hull fouling are considered the major pathways by which they are transferred. The underwater cleaning of fouled hulls thus poses a risk factor. A risk assessment of transferring NIS during underwater cleaning was therefore carried out (**Task 7.5.4**).

Based on a thorough literature review it was concluded that the underwater cleaning of Ecospeed does not entail an elevated risk for the spread of NIS, if it is conducted timely and properly. Regular inspection is required to be able to remove the biofilm timely by underwater cleaning, so that a better protection against the spread of foreign species can be offered. Underwater cleaning can thus be considered as a Best Available Technology to minimize the risk of transferring non-indigenous marine species. Criteria for environmentally safe underwater cleaning were subsequently put forward.

The impact on fuel consumption and greenhouse gas emissions of Ecospeed in comparison with biocidal antifoulings was studied by the monitoring of sister vessels over a period of two years (**Task 7.5.5**). The basic assumption for this analysis was that any difference in fuel consumption between sister vessels with identical geometry and propulsive configuration is due to the drag characteristics of the coatings. However this assumption only holds when the vessels are sailing in calm water conditions and it proved a very challenging task to filter out the effect of weather conditions and different voyage routes. In addition, the analysis ran into practical problems in that Ecospeed could not be treated as often and as optimally as planned. In the end, no results with enough statistical confidence could be obtained to distinguish differences between the coatings.

Experiments were therefore set up to study the drag characteristics of Ecospeed and other coatings in well-controlled laboratory conditions (**Task 7.5.6**). These results can then be extrapolated to full-scale to determine the fuel consumption for a certain type of ship applied with these coatings in clean conditions.

The drag characteristics of Ecospeed were compared with a copper-based spc, a foul release of the latest generation and an abrasion resistant epoxy for ice-going vessels. Towing tank experiments were carried out with a 6.3m long friction plane which was applied with the different coatings and towed at speeds of up to 8m/s. The resistance of the different surfaces was measured in a 320m long towing tank at CEHIPAR in Spain. The results showed that compared to the spc, conditioned Ecospeed exhibited 1.9% less drag.



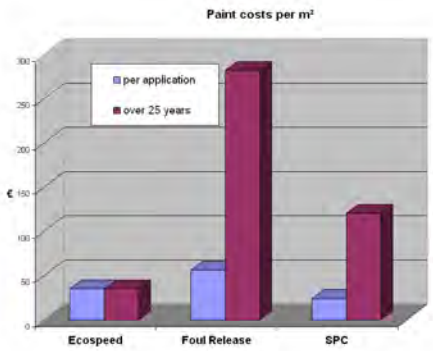
Frictional resistance of the tested coatings versus towing speed.

The roughness characteristics of the tested coatings were also analyzed. Without conditioning, Ecospeed exhibited higher roughness amplitudes than the other tested coatings. However, conditioning reduces the roughness amplitudes and gives a less jagged, more open texture.

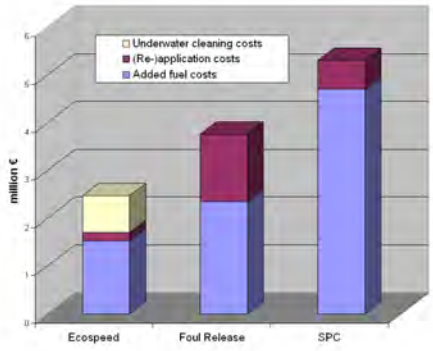
5 ECONOMICAL AND ENVIRONMENTAL EVALUATION

The findings of the ECOTEC-STC Project were brought together to estimate the economical and environmental impact of Ecospeed in comparison to a foul release and a copper-based spc scheme. The total economical impact was compared on three aspects: application costs, added fuel costs and maintenance costs. The total impact was then estimated for a 1000-TEU container vessel which is assumed in this case to undergo underwater treatment every 6 months when coated with Ecospeed.

It is estimated that initially it will be more expensive to apply Ecospeed instead of an spc. When taken over 10 or 25 years, the costs will be much lower, however, as Ecospeed will require only local touch-ups whereas an spc or a foul release will require re-application after 5 years.



Estimated paint costs (in €/m²) for Ecospeed, a foul release and an spc scheme



Estimated economical impact (in million €) over 25 years for a 1000-TEU container vessel with Ecospeed, a foul release and an spc scheme

The added fuel costs are due to the added resistance characteristics of each coating system. The towing tank experiments allow to estimate the inherent added drag levels and the rate of increase over time is estimated roughly from data available in literature. The increase in added resistance for Ecospeed can be expected to be higher than for the other coatings but regular underwater treatment effectively is a preventive measure that keeps the added drag caused by biofouling under control. As a result, by adjusting the treatment interval the added fuel costs are minimized and they are lower than for an spc or even a foul release.

When all the costs aspects are taken together, it is estimated that the overall economical impact of Ecospeed is less than half of an spc and about 2/3 of a foul release for a 1000-TEU container vessel over 25 years.

On a global scale the potential for the reduction in fuel consumption and greenhouse gas emissions is quite enormous. The IMO currently estimates the annual fuel consumption by the world fleet at 310-350 million tonnes, implying an annual CO_2 output of approximately 850 million - 1.1 billion tonnes. If 80% of the world fleet would switch from biocidal antifoulings to Ecospeed, this would save an estimated 28.5 million tonnes in annual fuel consumption and 90 million tonnes in annual CO_2 output.

6 CONCLUSIONS AND TRANSFERABILITY OF ECOTEC-STC PROJECT

The project ECOTEC-STC has shown that Ecospeed as a Surface Treated Coating is a valuable alternative technology to the antifoulings that are currently on the market. From the project tasks that were carried out, it has been demonstrated the Ecospeed exhibits the following environmental and economical benefits:

- The applications and inspections on a variety of ship types (under Task 7.1) have shown that there is **no need for full re-application in drydock**. After supervised application, Ecospeed comes with a guaranteed lifetime of 10 years and an expected lifetime of 25 years.
- Ecospeed has low VOC contents and in comparison with foul release coatings or copper-based antifoulings **fewer VOCs are emitted with each application** (under Task 7.3).
- Effluent analysis (under Task 7.3) has shown that Ecospeed is **100% free of biocides**
- Regular underwater treatment of Ecospeed is put forward (under Task 7.4) as a Best Available Technology to **minimize the risk of transferring non-indigenous marine species (NIS)**
- **Advanced maintenance tools** have been developed (under Task 7.2) to clean and condition simultaneously
- The analysis of the roughness characteristics (under Task 7.6) has demonstrated an **optimization of surface characteristics by underwater treatment.**
- Towing tank experiments (under Task 7.6) have shown that conditioned Ecospeed exhibits nearly **2% less drag than a newly applied copper-based spc**.

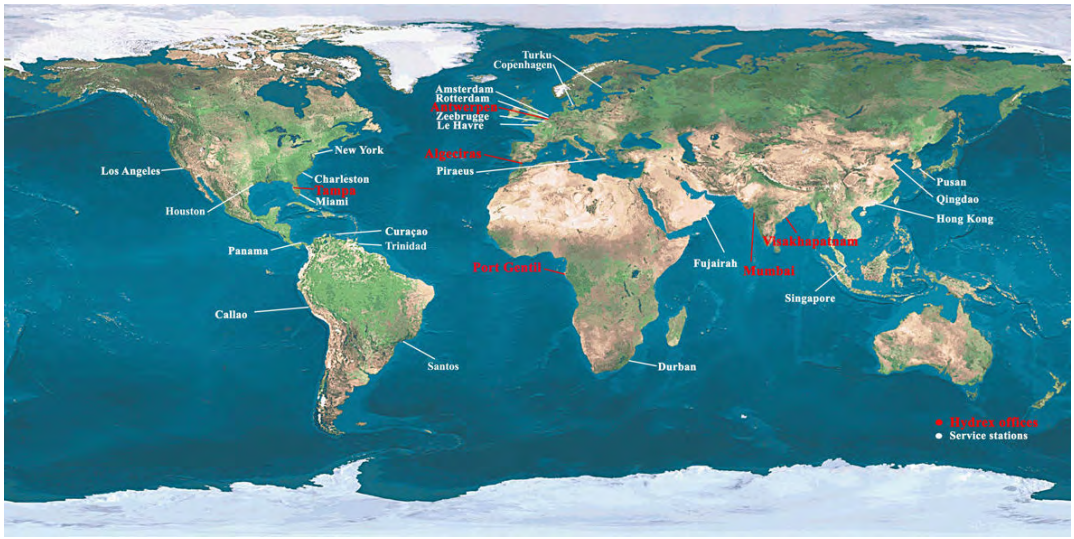
The various results under the ECOTEC-STC project were disseminated widely by various communication means. Several presentations were given on the concept behind Ecospeed and the results obtained from the project. The results were also published in papers, magazines, distributed by electronic magazines and put on the website. In addition, several events were organized with visits to drydocks to witness the ease of applicability and inspect the durability of the coating.

Presentation of the results obtained by the ECOTEC-STC project at Damen Shiprepair, Rotterdam , January 2010.

Event with drydock visit to inspect the durability of Ecospeed.

The dissemination activities and events organized around the Project results engendered significant interest. Proof of increased interest in Ecospeed as an alternative to antifoulings is given by the number of applications since the beginning of the project. Over 100 applications were carried out since December 1, 2006, of which more than 50 were full hull applications. Clear arguments in favour of Ecospeed are the durability and prospect of avoiding repainting, the avoidance of biocides and the prospect of fuel savings.

The collection of fuel consumption data is being continued in order to further demonstrate that the surface texture of Ecospeed keeps improving with each underwater treatment of combined cleaning and conditioning and that, contrary to traditional coatings, ship performance keeps improving all through the service life of the vessel.



The results from the ECOTEC-STC project helped in expanding the services so that the underwater treatment of Ecospeed can be carried out worldwide.

Another important outcome of the Project was the submission of the experimental results to port authorities and environmental agencies worldwide in order to allow the underwater treatment of Ecospeed. Several ports and countries have banned underwater cleaning out of concerns of pulsed release of biocides or an increased risk of transferring NIS. The experimental results and the derived criteria for environmentally safe underwater cleaning have already convinced several economically important ports to overturn the ban.

The ports of Rotterdam, Antwerp, Copenhagen, Oslo and Barcelona, which maintained a ban on underwater cleaning, have all decided between mid 2009 and March 2010 to allow the underwater cleaning of hulls coated with Ecospeed. It is expected that the list will expand in the future. All these ports recognize the negative impact of biocidal paints and they want to support environmentally safe solutions.