# About Corrosion and Ballast Water Treatment Systems

## Two IMO initiatives relating to Ballast Water are coming into force:

***The Coating Performance Standard for Ballast Tank Coatings (*****PSPC*****) effective 2008***
Defining the system and application of coatings at new buildings with the intention to prevent rapid corrosion and provide a 15-year life for the coating selected.

***The International Convention for the Control and Management of Ships Ballast Water & Sediments (SBWS) effective from 2009***
Intends to neutralise the transportation of "invasive species" from one part of the world to another

1. There are a number of proposed technical solutions for Ballast Water Treatment.
2. <u>All solutions</u> will make changes to the environment in the ballast tanks, some <u>more</u> than others.
3. <u>The two regulations make no reference to each other</u>!

By trying to comply with the two regulations, an owner will pay a higher price for his vessel to comply with the PSPC and get a 15 year coating scheme applied and he install a ballast water treatment system with all its approvals that within some years damage the ballast tank coating system.

In simple terms, catastrophic failure of the ballast tank coating system could be the result and surely at this point, if both of the systems selected have been approved to the IMO standards someone has to pay the cost.

*Who will that be?*

- The ship yard who has recommended both systems?
- The paint manufacturer?
- The maker of the Ballast Water Treatment system?
- The ship owner?

*All parties involved will point their finger at each other;*

- The yard will claim that they have supplied only approved products so the eventual failure is somewhere else.
- The paint manufacturer will prove that the BWTS over some years has broken down the coating system.
- The BWTS manufacturer will most likely run
- The owner will <u>be sitting with all the costs.</u>

When we know the cost of refurbishing/repair coating systems in ballast tanks it is well worth wondering why some owners are careless about these matters. If it is an owner with a short time ownership like 3 – 8 years, it can be understandable, but if it is an owner that traditionally has long term ownership (20 – 30 years) he should think twice when selecting BWTS.

On the following pages, we will discuss what effect the different BWTS technology can have on ballast tank coating and corrosion.

## Ballast Water Treatment Systems and their effect on corrosion

The PSPC aims, as said on previous pages, at only one large round of refurbishing of ballast tanks and as long as the ships has been coated in accordance with the guidelines in the PSPC and provided guidelines for inspection and general maintenance has been followed, this will take place around the time when the ship is 15 years old.

There are a number of proposed technical solutions for Ballast Water Treatment. All solutions will make changes to the environment in the ballast tanks!!

At present very little evidence exists regarding the effect of some of the BWTS and few system manufacturers have carried out testing of the impact of their system on the coatings and on corrosion in the ballast tanks.

**Some of the technologies used to minimize invasive marine species**:

- Filtration
- Hydro cyclones
- Oxygen Removal
  - Nitrogen injection
  - Vacuum Chamber
  - Inert Gas/Stack Gas Injection
- Heating
- Ultraviolet Irradiation
- Chemical Biocides
  - Hydrogen peroxide
  - Peroxide Acetic Acid
  - Chlorine - Chlorine Dioxide – Hypochlorite
  - Ozone

- The different methods of filtration will not affect coating or corrosion.
- System reducing oxygen levels will in general reduce corrosion.
- Ultra Violet Radiation (UV) will in general be neutral when it comes to influence on corrosion.
- It is the different chemical biocides and their oxidation that have the potential to create future corrosion in the ballast tanks.

| **Oxidant** | **Oxidation Potential(in Volts)** |
|---|---|
| Ozone | 2.07 |
| Hydrogen Peroxide | 1.78 |
| Chlorine Dioxide | 1.57 |
| Chlorine | 1.36 |

**The effects of some of the Chemical Biocides used**

- How will the different Chemical Biocides and oxidants produced by the BWTS affect the Ballast Tank Coatings?
- Are these reactions, even if slow, in compliance with the intentions of the PSPC?
- Is it really worth taking the risk to install a BWTS that can cause substantial coating failure in 5 -10 years?

Hydrogen Peroxide

- Decomposition products = $O_2$ and water;
- Increased oxygen promotes corrosion of steel, coatings and any anodes present;
- $H_2O_2$ is an oxidant and damages coatings, seals and plastics if present;

Peroxide Acetic Acid

- Half-life in seawater: 10 - 20 minutes depending on salinity, pH, and temperature
- Decomposition products = acetic acid, $O_2$ and water with hydrogen peroxide intermediate
- Corrosive to steel, coatings and any anodes present

Ozone

- Corrosive to metals and damages coatings, seals, plastics
- Generates chlorine and bromine reaction products that are also powerful oxidants - these damage coatings, seals and plastics
- If CP anodes are present; reacts with the Zn or Mg

Chlorine - Hypochlorite - Chlorine Dioxide

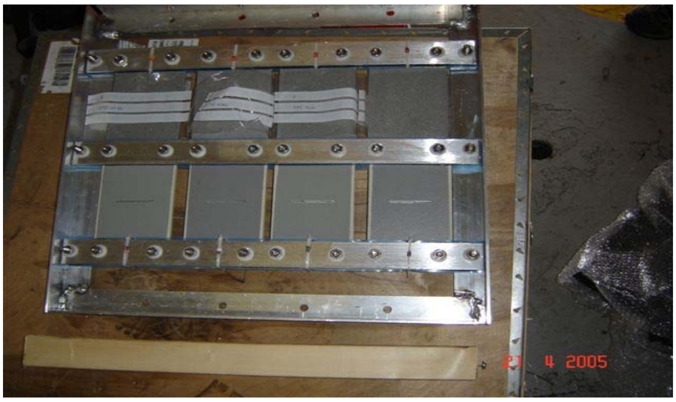
- Strong oxidizing agents
- Reacts with the phenyl ring making up back-bone of epoxy coatings causing embrittlement, cracking, and coating degradation
- Corrosive to steel and any anodes present

Free Chlorine

- Even low concentrations of residual free chlorine appear to be instrumental in causing the destruction of the surface of epoxy coating films similar to UV light as well as adding chlorine to the ortho- position of the bis-A phenol in the epoxy coatings as a part of the degradation process.
- This is separate and apart from the failure of the coating from osmotic activity that leads to metal loss under the paint film from hydrochloric acid (HCl) in the blister fluid.

## What makes OceanSaver different from other suppliers of Ballast Water Treatment Systems?

**The OceanSaver corrosion tests:**
*Requirements to the involved test laboratories and consultants:*
Independent, accredited, recognised in the industry and familiar with water ballast tank coatings and ballast tank corrosion.



*Test plates (coupons):*
The test steel plates where in all tests coated with a common epoxy coating for ballast tanks. (Some with scribe through the coating and some with an anode attached.)

*The first test scheme was on board the "Hoegh Trooper":*
12 months Corrosion test with test coupons placed in different areas in the ballast tanks. The tests were carried out in one tank with untreated and treated tanks for comparison. (Tests were carried out by Safihna and DNV)

*The second test scheme was two different kinds of tests, one land test and one on board test:*
The test programme used the Water Ballast Tank/Wave Tank Test (formerly known as the "Marintek test" – as developed by DNV – to simulate ballast tank corrosion conditions. The test period was 6 months.

The coatings were all well known epoxy types selected from major marine paint manufacturers, a total of 8 different epoxies where tested. Both scribe and anode was used.

The same coating scheme where also tested on board the "Federal Welland"

*Conclusions from the Wave tank test:*

- The test period was too short to find any significant difference in the results between the untreated and the treated tank with regards to corrosion.

- The "OceanSaver" treatment has no recognisable detrimental effect upon the coatings or upon their corrosion protection properties.

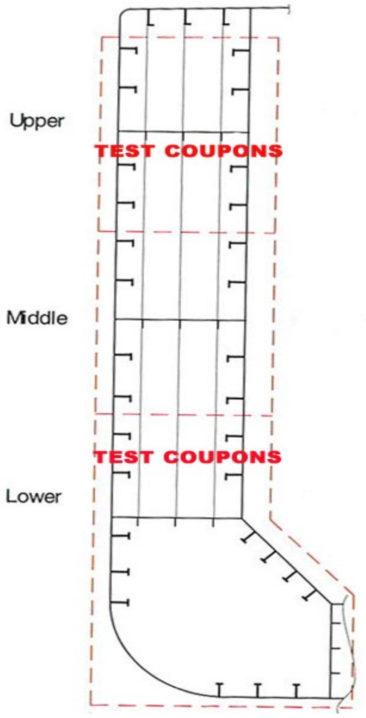
- The results show a higher anode consumption and current demand for the panels in the untreated seawater compared to the nitrogen treated seawater" i.e. corrosion is suppressed under "OceanSaver" treatment conditions.

*The test on board the"Federal Welland":*
This was a corrosion and coating test where the same coatings and coating scheme as in the Wave tank tests where used. Totally 44 panels where prepared for the ship testing and the test lasted 15 months. (Tests arranged by Safihna and DNV / Marintek)

The placement of test coupons on board the "Federal Welland" was as follows:

- No.4 Port Lower, No.4 Port Upper (OceanSaver Treated)

- No.4 Starboard Lower and No.4 Starboard Upper (Untreated Ballast Water)

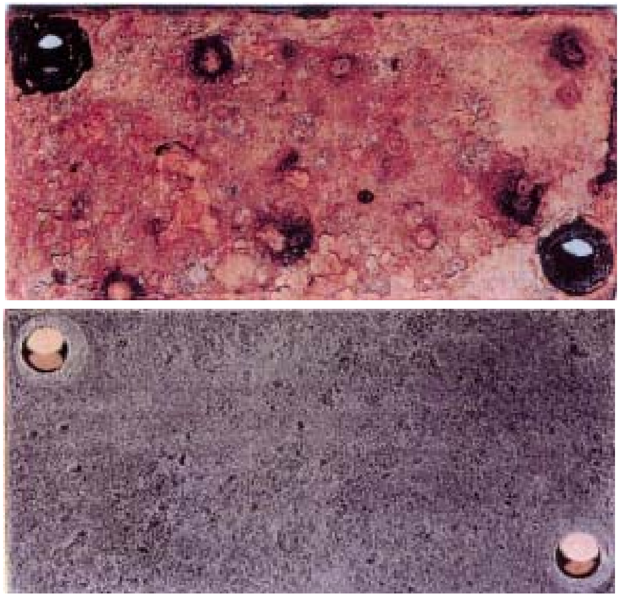


*The overall findings – from in-service exposure on MV "Federal Welland":*
The panels where examined regarding coating condition with respect to blisters, rusting and undercutting from the scribe, and zinc anode consumption.

- No blistering was found on any panels
- "OceanSaver" treatment in no way adversely affected the coatings.
- "OceanSaver" treatment was proved beneficial to the corrosion protection, most noticeably in the upper ballast water tanks, with respect to limiting corrosion creep from the scribe
- "OceanSaver" have inhibited corrosion undercutting in comparison with the corresponding results in the untreated tank to a significant extent, but to a very great extent in the more severe upper tank conditions.
- In the lower ballast tank it was observed a reduction in consumption of zinc anode of (11%).

The above test results verify that the OceanSaver process of supersaturation of ballast water with nitrogen is a significant add-on to corrosion protection.

The test results also confirm other similar tests with the use of nitrogen:



Conclusion based on SHI results when ballast tanks were made inert with Nitrogen was a 90% reduction in the corrosion rate.

Corrosion level in untreated tank was 0,383 mm/year

Corrosion level in Nitrogen treated tank was 0,039 mm/year

*(Matsuda et al., 1999).*

**Expected effect of the Ocean-Saver BWTS**

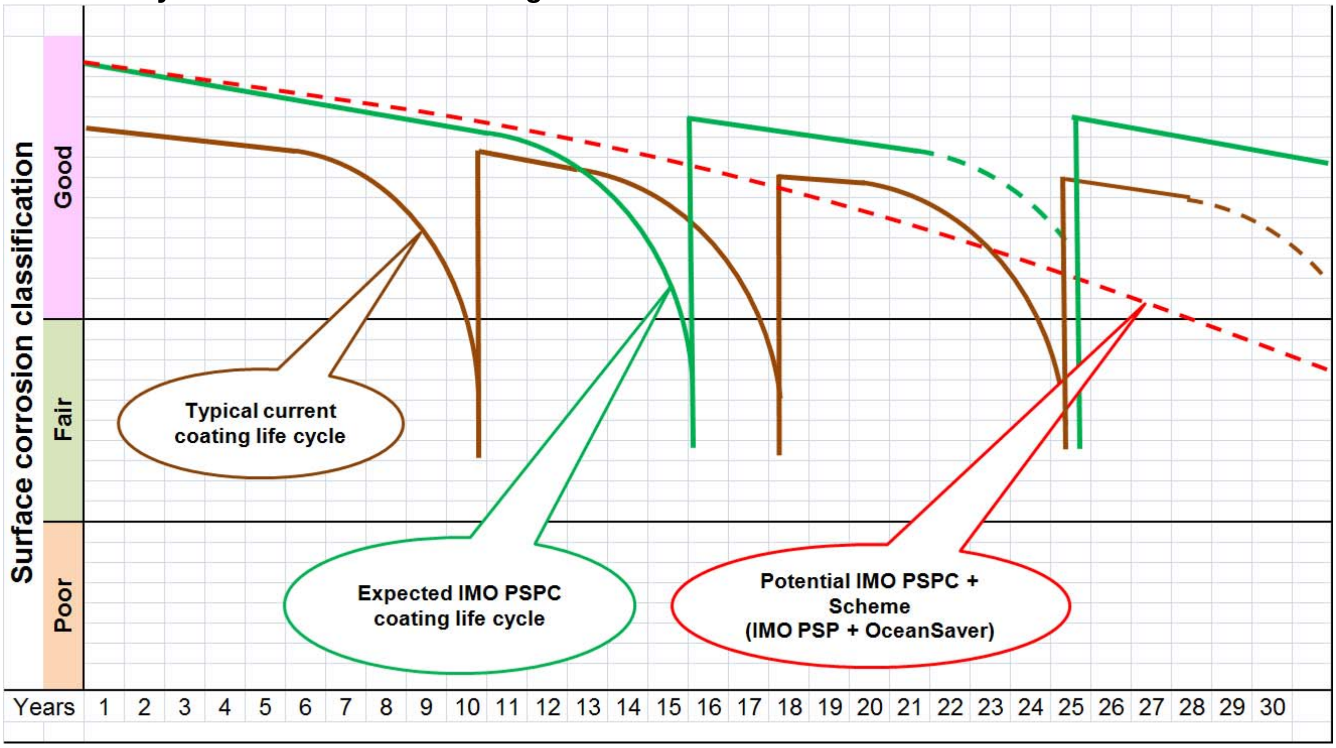
- OceanSaver is in compliance with the PSPC
- OceanSaver will prevent corrosion substantially
- The corrosions test and discussions with consultants and corrosion experts indicates that OceanSaver will give significant reductions in the cost of maintenance of ballast tanks

OceanSaver has as seen above carried out several corrosion tests and the results from these tests indicates that the add-on effect of the OceanSaver system is a significant reduction in corrosion development as well as extension of the lifetime of the ballast tanks coatings.

Provided that the ship when built has been coated according to the PSPC and that the guidelines for regular maintenance of the coating system have been followed, it is likely that a large round of ballast tank refurbishing can be avoided during the whole lifetime of the ship (25 -30 years). This significant opportunity for reduced lifecycle cost is an add-on benefit highly appreciated by ship owners with a long time ownership.

***Provided the guidelines for maintenance of ballast tank coatings in the PSPC are followed, the following scenario can be expected:***

**Life cycle for ballast tank coatings based on 3 different scenarios**




**The costs for refurbishing of ballast tanks**

Refurbishment and recoating of ballast tanks are as mentioned earlier, among the most costly maintenance issues on a ship. The shape of the tanks as well as the total number of square meters to take care of makes this a difficult and time consuming affair. In addition to the refurbishing work the vessels normally would have to change some of the hull plates as well, making the whole affair even more costly.

As shown in the figure above it has been relsatively usual to do major refurbishing up to 3 times in the lifetime of a vessel. With the PSPC it is expected that refurbishing will take place only once in the lifetime of the vessel and it is expected to be around the time when the vessel is 15 years old provided that the guidelince for maintenance has been followed.

The cost of work and coating depends on where in the world the job is taking place, but it will be difficult to get a refurbishing job done according to the guidelines in the PSPC below US $

40 per m$^2$ including work and coating. Price will also be different if the work is done at a shipyard compared to work done while the ship is sailing. In the example below it have been used prices including work and coating from USD $ 27 to 49.

*In the cost example below we have used the following basic figures:*

- Broken down area 25%
- Coating, standard epoxy mastic of well known brand with 80% solids
- Application on the broken down areas 200µm DFT in addition one full coat 200µm over the whole area (stripe coats not included).
- Theoretical consumption 4 m$^2$ per liter at 200µm DFT
- Overspray/paint loss 20%
- Cost for coating per liter USD $ 7 – 9

| Tank area m$^2$ | Work prices per m$^2$ surface preparation and coating application in US$ | Total cost refurbishing work in US$ | Total cost refurbishing work in Euro € | Average cost coating US$ | Average cost coating Euro | Total cost of ballast tank refurbishing in Euro € | Aproximate Budget price OceanSaver in Euro € |
|---|---|---|---|---|---|---|---|
| **50 000** | 40 | 2 000 000 | **1 620 000** | 206 250 | **167 063** | **1 787 063** | **1 050 000** |
| **80 000** | 35 | 2 800 000 | **2 268 000** | 300 000 | **243 000** | **2 511 000** | |
| **100 000** | 33 | 3 300 000 | **2 673 000** | 375 000 | **303 750** | **2 976 750** | **1 350 000** |
| **120 000** | 30 | 3 600 000 | **2 916 000** | 450 000 | **364 500** | **3 280 500** | |
| **140 000** | 28 | 3 920 000 | **3 175 200** | 525 000 | **425 250** | **3 600 450** | |
| **160 000** | 25 | 4 000 000 | **3 240 000** | 600 000 | **486 000** | **3 726 000** | **2 050 000** |
| **180 000** | 23 | 4 140 000 | **3 353 400** | 675 000 | **546 750** | **3 900 150** | |
| **200 000** | 22 | 4 400 000 | **3 564 000** | 750 000 | **607 500** | **4 171 500** | **2 600 000** |
| **220 000** | 20 | 4 400 000 | **3 564 000** | 825 000 | **668 250** | **4 232 250** | |

Taking the cost of refurbishing into consideration it is relatively clear that the OceanSaver system has an add-on benefit that our competitors just can dream about.

When looking at the life cycle diagram it is evident that the saving potential for ship owners is huge if even one round of refurbishing can be avoided.

The figures show potential saving from 1,7 to 4,2 mill Euro €.

If the above is looked at as a cost per year figure, the potential saving over a 30 year period (ships expected lifetime) is; depending on tank area, from Euro € 60.000, - for the smallest vessels to Euro € 140.000,- per year for larger vessels .

In general, any touch up maintenance type of work will have costs per m$^2$ more similar to the smallest areas described above.