VpCI® Technology for Marine and Shipbuilding Industries

CORTEC CORPORATION

Environmentally Safe VpCI®/MCI® Technologies

INTRODUCTION

Corrosion is the undesirable material wear that appears by chemical action of the environment. It causes destruction of structures and equipment as well as loss of valuable resources, contamination of products, reduced efficiency and high maintenance costs.

Damages from corrosion in shipbuilding or the ones that occur in the exploitation of various vessels are especially harsh. Corrosion protection of such structures and constructions make a big part of the cost of manufacturing process. Since all structural metals in certain circumstances are prone to corrosion, the economy is generating significant losses. In 2013, the direct cost of corrosion was 3.1% of the 15.1 Trillion U.S. GDP, which in June 2013 is estimated to equal to $500.7 Billion. If the indirect cost is also 3.1% of GDP, then the total cost of corrosion is $1001.4 Billion annually as of June 2013.

Various significant studies have also shown that more than 30% of the costs can be avoided by using appropriate methods and technologies of corrosion protection.

VpCI CORROSION INHIBITORS®

Inhibitors are used in various applications in shipbuilding, offshore and marine industry. Very often in structures that are present in these industries there are parts that are difficult to access or can even be completely inaccessible for quality and long-lasting protection against corrosion. In these cases the most efficient and economical technical solution is the use of VpCI® corrosion inhibitors.

Marine environment is extremely aggressive and corrosion protection in these areas requires especially careful approach

VpCI® corrosion inhibitors manufactured by Cortec® Corporation, world leader in innovative corrosion protection solutions are a special group of inhibitors that protect the metals from atmospheric corrosion and are able to stop corrosion at a molecular level. These organic substances vaporize and travel to all parts of the metal surfaces reaching even inaccessible areas. After contact with the metal surface, vapor condenses into air and forms a thin monomolecular film that protects the metal (Figure 1). Protective layer re-heals and self-replenishes through further condensation of the vapor. VpCI® reaches every area the metal part, protecting its exterior as well as hard-to-reach interior surfaces. It provides complete product protection during storage as well as during domestic and overseas shipments.

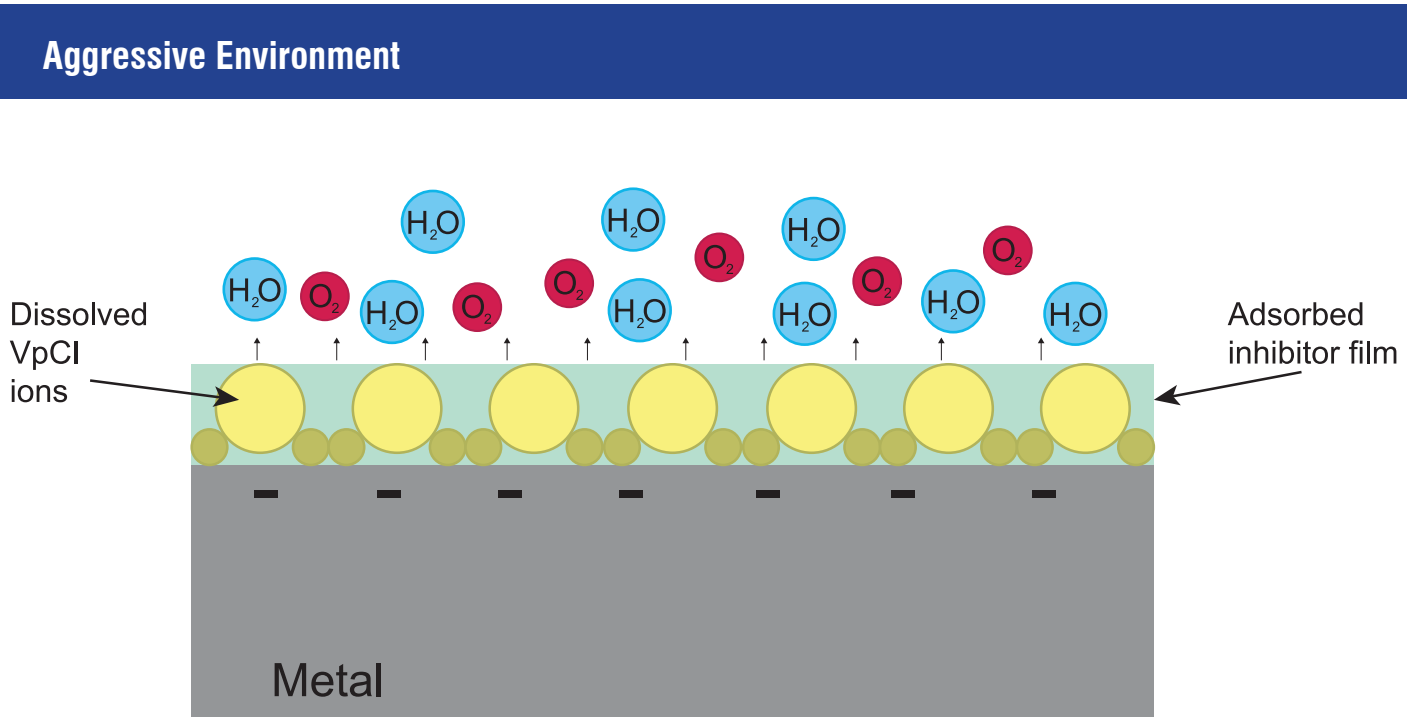


Figure 1. The action mechanism of volatile corrosion inhibitor

BENEFITS OF VpCI® INHIBITORS IN SHIPBUILDING

- The creation of mono- molecular inhibiting layer that protects even inaccessible areas;

  - If the VpCI® layer is disrupted mechanically or by opening the closed area, the layer is continuously replenished by evaporation

- Multifunctional products
- More effective protection
- Environmental Safety
- Easy application
- Improved health, safety, and pollution control
- Elimination of extra processing steps: in most cases there is no need to remove the VpCI®/MCI® product.
- Extended equipment life.
- Little or no surface preparation
- Prevents further corrosion of ferrous surfaces
- VpCI®-layer does not have to be removed prior to processing or use;
- Does not interfere with operation of mechanical components;
- Does not contain silicones, phosphates, nitrites or heavy metals.
- Good temperature resistance All corrosion inhibitors exhibit good thermal stability at temperatures up to 300°C (572°F).
- High resistance of adsorbed protective layer against corrosion.

Strong absorbent protective layer protects the metal from corrosion agents (atmosphere, H_2S, acidity, alkaline environment, salt, etc..) It physically protects the metal surface and prevents contact between fluid and metal. In addition it prevents ions to migrate from the surface of the metal in the solution. The protective layer is maintained and protected even at low pH value.

ISO 9001 • ISO 14001
ISO/IEC 17025

Application of vapor corrosion inhibitors in shipbuilding

The ship is a complex structure that is exposed to very aggressive marine environment (Figure 2). Since it has to submit large and variable loadings, parts of the structure are derived from a number of brackets, frames, stiffeners and reinforcements. Those parts of the structure are difficult for proper preparation and coatings protection. In these cases the application of corrosion inhibitors is best available solution on the market and is becoming a common practice as VpCI® inhibitors are found to be the best solution of corrosion protection for shipbuilding and marine industries.

VpCI® inhibitors are successfully and increasingly used in shipbuilding and marine industries due to their specific action such as filling the space and creating a protective film on the metal surface, which prevents contact with the environment and the media as well as their ability to protect hard to reach areas. They are highly recommended for protection of inaccessible areas of marine structures such as: keel, rudder (and inside of the rudder), rubbing strip etc. They are also applicable and highly efficient in the protection of pipelines, marine and naval equipment as well as electrical contacts. The inhibited layer is constantly replenished so that no regeneration of the protection system is needed.

Figure 2. Complex ship structure

Protection of closed dry areas and void spaces

Indoor spaces on ships are exposed to aggressive impacts of atmosphere that contains a high level of chloride due to the proximity of the sea, high humidity levels and frequent changes in temperature which contributes to severe corrosion of the ship hull. Under these conditions a protection with conventional coatings does not meet required durability due to their inability to reach and protect all areas of the metal. Application of VpCI® corrosion inhibitors is the most convenient way to protect such areas. VpCI® when placed in an enclosed space, vapors and the molecules reach into any openings, pores and cavities of metal equipment.

VpCI® inhibitors can be applied by spraying, fogging or sprinkling. After application, the areas need to be properly closed. The fogging is achieved by using a low pressure hose and can also be used for conventional blasting systems. The dosage or amount of the inhibitor for corrosion protection depends on the size of the area that needs to be protected as well as conditions in that area and the expected durability of protection.

In shipyards corrosion inhibitors are frequently used to protect the interior of the rudder. **Figure 3** shows 1 m^3 of space filled with 500 g Cortec's VpCI®-309 inhibitor, which is enabling protection against corrosion for a period of 3 years. Applying this easy to use corrosion inhibitor results in high quality protection of all parts of the structure.

Figure 3. Protection of the rudder blade with VpCI®

Figure 4 shows the structure of the rudder and demonstrates how complicated it is to perform quality corrosion protection with conventional coatings, special welds and edges which are potential areas of formation of corrosion. Also, after finishing of the rudder the damaged areas of welding are left which cannot be repaired and protected.

Figure 4. Inside the structure of the rudder

Volatile inhibitors are blown in the rudder blade (**Figure 5**) through holes which are then closed with screws, to obtain, after the termination of the inhibitor activity could be easily substituted with new ones. Blowing of inhibitor is finished when on the other side of the rudder VpCI® powder starts to go out through the hole. Then the part closes and the application is moved to the second opening. This ensures that the inhibitor filled the entire space.

Figure 5. Protection with VpCI® 309 inhibitor of the interior of the rudder

Rudder of the ship.

Corrosion inhibitor is blown into the rudder through openings.

This process lasts until the VpCI® inhibitor starts to come out on the other side of the rudder.

Closing of the opening with the tap. Moving on to the next chamber.

VpCI® inhibitors are recommend for use in different dry areas of the ship, stand equipment and machinery, cranes stand and deck cranes, ramps for loading cars and various other narrow spaces. Simple application and no surface preparation is a huge advantage of VpCI® inhibitors in marine and shipbuilding industries. Additionally VpCI® inhibitors can be applied under harshest weather conditions.

Structures that are especially hard to protect with conventional corrosion protection methods are also keel, rubbing strip and ship bow, because they are difficult to access. **Figure 6** shows applying VpCI® inhibitors to such areas.

Figure 6. Application of VpCI® inhibitor to keel, rubbing strip and bow of the boat.

VpCI® 609 powder inhibitor used for 1 year protection of the yacht skeg is shown on the figure 7.

Figure 7. Private yacht, 140 m, 5000 T, 5 decks.

Temporary protection of equipment in the construction phase of the ship and storage

VpCI® inhibitors provide excellent protection in the phase of ship construction as well as equipping and assembly phase. The equipment is wrapped in VpCI® film Inhibitors and therefore isolated from the harsh effects of the marine environment. The construction of the ship is a time consuming job, while the shipyards have a constant problem with lack of space. For these reasons the equipment that has to be installed on the ship is often left in the outside environment. In these cases the equipment needs to be wrapped in Cortec® films which provide strong corrosion prevention. If equipment is covered with regular plastic film (**Figure 8.a**) the package condenses and builds up moisture that also causes corrosion. By placing a VpCI® corrosion inhibitor in the cover (**Figure 8.b**), this moisture that occurs would be filled with vapor inhibitors and non-corrosive to equipment.

This method of corrosion protection is applied for temporary protection of equipment during shipment or storage. It is especially recommend for ocean transport, where the equipment is exposed to very aggressive impacts of the marine environment and the humidity inside the cargo ship space.

Figure 8.a Protection of naval equipment with plastic bags without VpCI®

Figure 8.b Protection of equipment with VpCI® 126 film

Protection of pipeline systems and tanks of the ship

VpCI® inhibitors are recommended for corrosion protection of systems such as the heating and cooling systems, main and auxiliary engines, heating systems for crew and passengers and many more. Economical properties of VpCI® inhibitors are especially evident in systems with recirculation, where VpCI is slowly consumed.

Application of VpCI® inhibitors in the hydrostatic testing has great importance when the water is applied for testing since water can be aggressive for the pipeline material. This would eliminate the possibility of corrosion before the application of certain system.

Application of VpCI® 645 for hydrostatic testing of 12 ship storage tanks using sea water is shown at the Figure 9. It is very important to use products which are environmentally friendly and have water safety permit certificate, because after testing water can be drained out in the sea.

Figure 9. SHIP - ASPHALT CARRIER, 12 asphalt storage tanks /1 tank = 1000 m³, VpCI 645 (100 ml/m³ per tank)

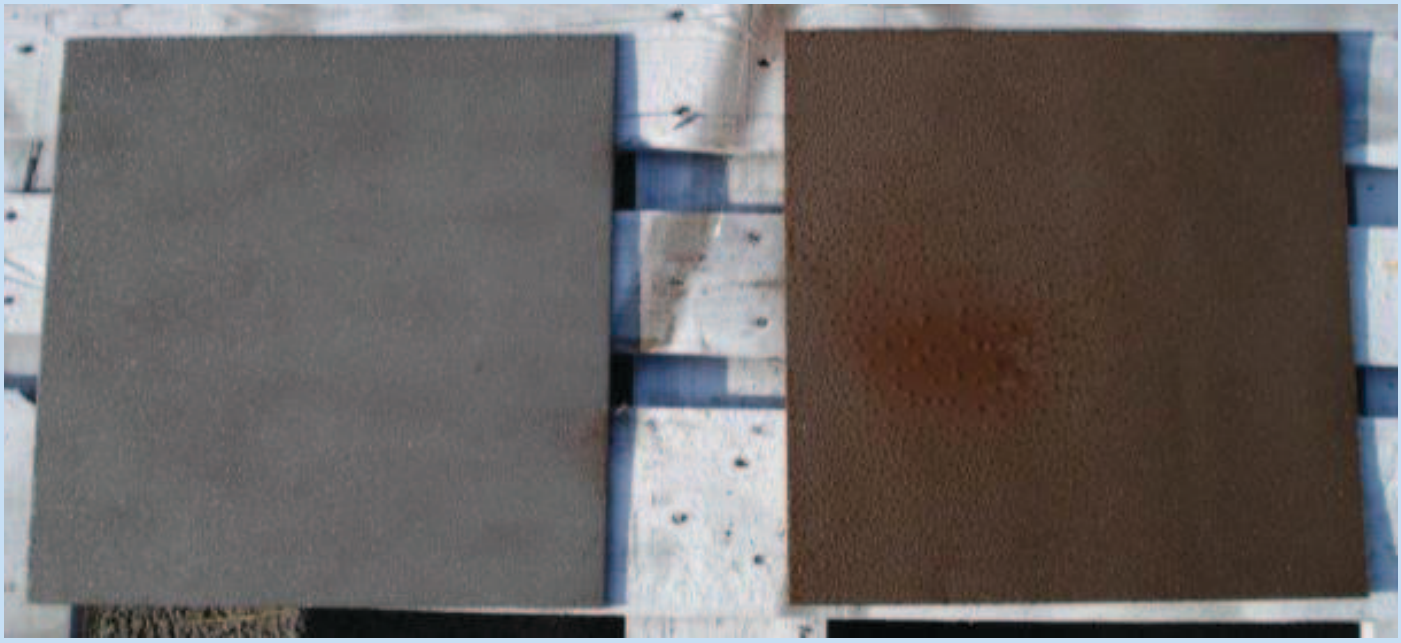
The use of corrosion inhibitors in the preparation of metal surfaces

Abrasive cleaning (shot blasting, sand blasting) is very expensive and not always acceptable method of preparation. It can also be very hazardous to environment. Surface preparation with high pressure water jetting (HPWJ) is more environmentally friendly solution. This method is particularly suitable for the repair of old coating systems because water pressure can be regulated so that only removes poorly adhered, damaged coatings. The lack of this method is corrosion of the treated surface since the steel used as shipbuilding material is not resistant to water. For this reason VpCI® inhibitor is applied in the water which prevents the appearance of corrosion. The inhibitor makes the water non-aggressive for bare steel surface.

The same is applicable for wet blasting process (**Figure 10**) which is a dust-free process for surface preparation with a water-abrasive mixture.

Figure 10. Surface preparation with wet blasting process

After 24 hours in marine environment



With inhibitor VpCI® 611 **Without inhibitor**

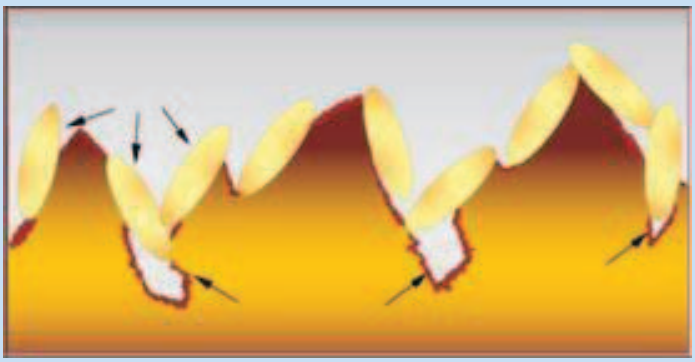
Figure 11. Efficiency testing of corrosion inhibitors in wet blasting process, NCP shipyard, Šibenik

The use of VpCI® inhibitors in the protective coatings system

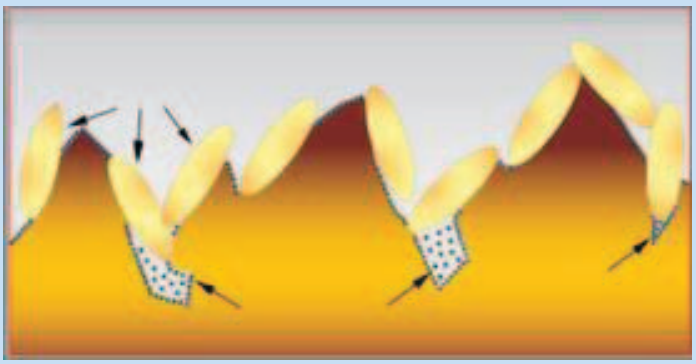
The basic method of corrosion protection in shipbuilding is protection with coatings. The application of the primer coatings with inhibitors that prevent the initiation of corrosion processes is most efficient and environmentally acceptable method of protection.

For many years, Lead based pigments were the most widely used for anticorrosive primers, followed by Chromate-based pigments. Due to recent toxicological and environmental restrictions, these pigments have been or are being replaced. Current trends point to environmentally-friendly pigments among which VpCI® inhibitors are best solution on the market. Application of VpCI® inhibitor in the coatings protects the micro-cavities of the surface roughness and ensures long term protection (**Figure 12**).

Traditional Coatings vs. Micro-Protective Coatings

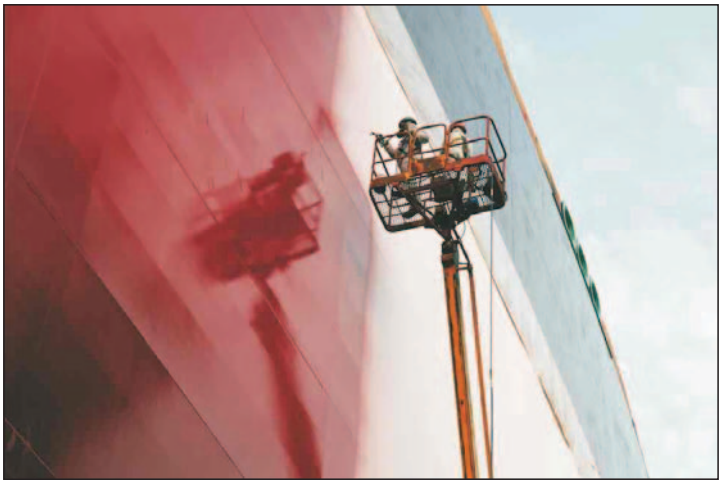


Traditional coating not reaching micro-cavities



VpCI® coating - protects micro-cavities by emitting VpCI® molecules.

Traditional coatings rely on sacrificial metals (zinc, chromates, aluminum) for inhibition. Due to the large particle size of these inhibitors, gaps exist which allow corrosion to start and eventually expand, causing coating failure. Cortec® Nano VpCI® coatings use the patented VpCI® technology to protect the metal substrate with a tight bonding molecular structure. This system eliminates the gaps which occur with traditional inhibitors and prevent corrosion from starting.



Airless painting of the ship

Conservation of non-operational system

VpCI® inhibitors are widely used for temporary conservation of products when not operating, as well as during storage and transport. They are used for the protection of offshore structures, such as 'Gullfaks B' offshore platform in which the VpCI® protects equipment during the non-operation time of two years.

Gullfaks B is an oil and gas producing and drilling platform located in the North Sea (**Figure 13**). The platform was not going to drill more wells for two years and needed to protect all equipment used for drilling. The drilling equipment consists of a big complex system and is located in a extremely corrosive environment. Also during non-operation period the media which is remained in the system can be very corrosive for the equipment materials.

Inhibitors for the protection in this case can be applied in various forms, depending on the elements of the system or equipment that is being protected, for example:

- **VpCI® Emitters** – protection of electrical control devices;
- **VpCI® Additives** – lubricating oil gear and other mechanical assemblies;
- **VpCI® Additives** – corrosion inhibitor added to water for flushing of various pipeline systems
- **VpCI® Packaging** – Equipment is wrapped in VpCI Film
- **Powder-inhibitor** – Fogging of vessels, tanks, protection of pipelines,
- Add a corrosion inhibitor to water for flushing of various pipeline systems for example carbon steel piping in the mud system

Figure 13. Drilling platform ''Gullfaks B''

Cortec products used

1. Cortec Emitters VpCI®-101, VpCI®-110 and VpCI®-150 were installed in electrical enclosures.
2. VpCI®-323 was used as an oil additive in gearboxes and in mud pump transmissions.
3. VpCI®-368 and VpCI®-369 was sprayed on painted and machined surfaces. Loose drilling equipment and wirereels were also packed in Cor-Pak® VpCI® Stretch film.
4. VpCI®-609 was fogged in cement and barite tanks at a typical dosage 0.5 kg per cubic meter. VpCI®-609 was also added at a dosage of 3-5% to water and glycol used for filling of manifolds and flushing of carbon steel piping in the mud system.
5. 1% Cortec M-370 was added to waterbased BOP control fluid.

Preservation contractor described preservation methods and which products to use on the project. Cortec® was the only company able to provide environmentally sound products with a broad spectrum of applications. One stop 'Total Corrosion Protection' solution concept made it simple for customer to deal with only one vendor.

VpCI® inhibitors are ideal for temporary protection when the plant or vessels is not in operation especially in the case when systems are installed in the plant, and therefore are difficult to protect. Example of such application **Figure 14** is the protection of spare equipment on the main deck of a military ship.

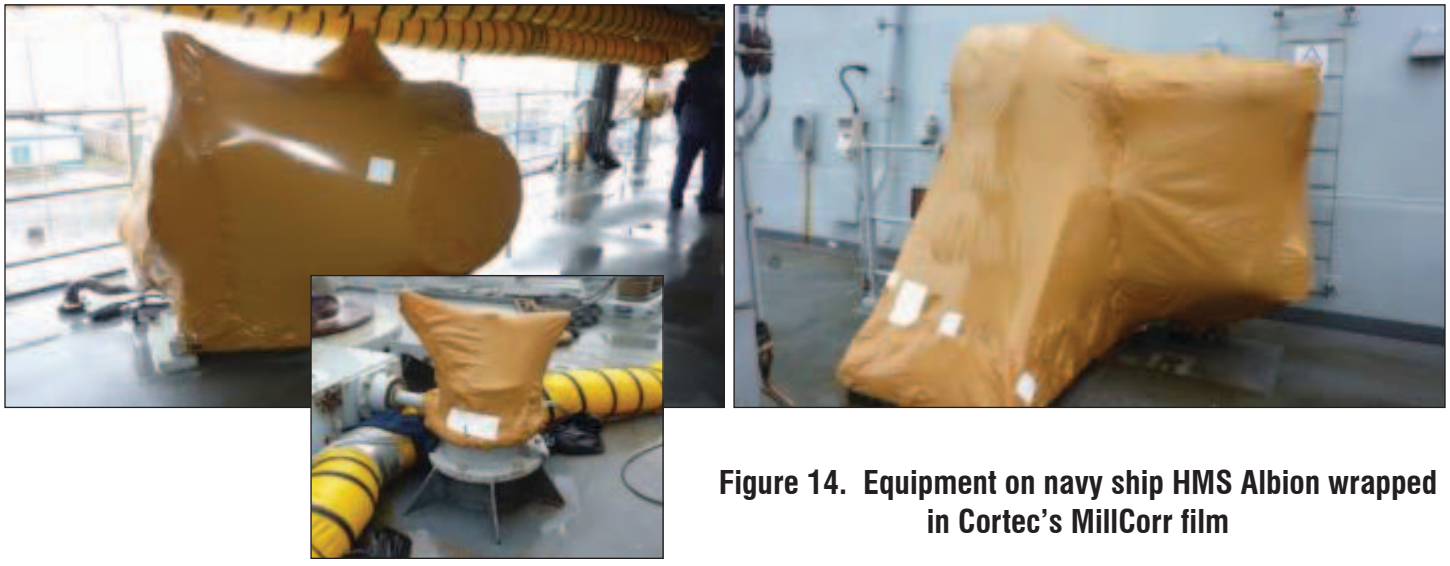
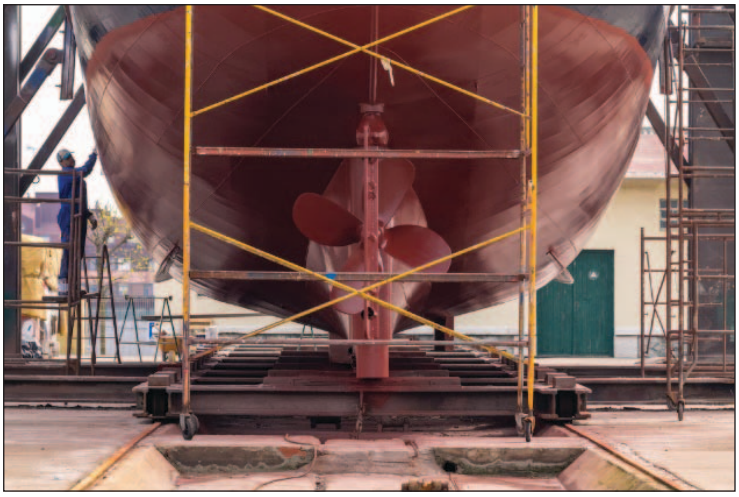


Figure 14. Equipment on navy ship HMS Albion wrapped in Cortec's MillCorr film

BOATBUILDING

Corrosion inhibitors are increasingly used in boat building for temporary protection due to their ability to protect inaccessible parts of the ship structure. Application of inhibitors is shown in **Figure 15**.



The main reason why boat metal parts corrode is the salt spray environment which is trapped in closed areas. In the engine room or engine space salt spray is usually coming in through engine room vents or from evaporating water in the bilge. Cortec VpCI® Emitters are unique devices designed to provide corrosion protection for metal components and parts enclosed in such cabinets. They are easy to install solution and do not interfere with electrical or mechanical performance of the engine and engine parts.

Electrical distribution pedestal

Electric installations on the boat

Rudder device

Storage area

Main engine space

Main engine

Figure 15. Parts of the boat and nautical equipment suitable for use VpCI® corrosion inhibitors

During the winter months boats and yachts on dry berth are exposed to different severe environmental conditions which can cause corrosion on metal parts. The **figure 16** shows the outboard engine wrapped in VpCI® Film, while the **figure 17** shows the complete yacht protected with VpCI® Film.

Figure 16. Outboard engine wrapped in VpCI® Film

Figure 17. Corrosion protection of yacht on dry berth located on coastal area of Croatia

Protection of electrical circuits and control boxes

VpCI® inhibitors successfully protect electrical and electronic components during manufacturing, assembly, storage, transport and application. They protect important components in switch boxes, communication and marine equipment, radio and computing devices, electrical controllers, circuit boards, contacts, motors and generators. Advantages of using inhibitors over other methods of protection is a very simple installation, the constancy of the electrical and mechanical properties and self-healing protective effect during operation mode of the above mentioned elements.

Cortec® VpCI® Emitting Systems offers a complete full-service line of products in convenient-to-use sizes. Integrate all your electronic/electrical protection needs from a single source supplier. Cortec® Emitting Systems Offer — Reliability, Service Life, and Cost Reduction. Corrosion of complex electrical and electronic equipment is an increasingly serious problem causing expensive failures. With Cortec® Emitting Systems, sensitive equipment is protected against corrosion, thereby extending its life and reducing the cost of expensive repairs.

Figure 18 shows the different methods of applying inhibitors to protect electrical circuits and contacts.

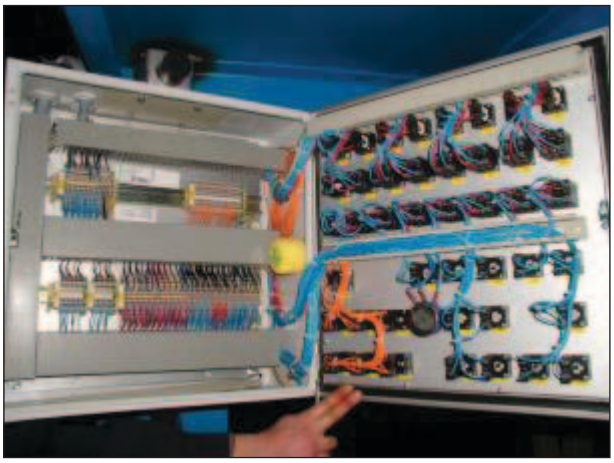


Image 18.a Applying VpCI® Emitter in electric panel

Image 18.b Applying VpCI® 238 for protection of electric contacts

Properly designed and constructed corrosion protection in the construction of the ship is of crucial importance for the functioning of the ship and its use, since the ship is a very demanding and complex structure, exposed to extremely aggressive environments, such as sea water and other demanding exploitative conditions. Because of this, corrosion protection is an important factor in the quality and price of the ship. VpCI® inhibitors have a very high range of application and their utilization is the result of its technological as well as economic progress, when it comes to corrosion protection in shipbuilding.

ISO/IEC-17025
LABORATORY TESTING CERTIFIED

ISO 9001 CERTIFIED
QUALITY SYSTEM REGISTERED

ENVIRONMENTAL
ISO 14001 CERTIFIED
SYSTEM REGISTERED

Environmental (ISO 14001 Certified) Cortec's strong environmental concern is demonstrated in the design and manufacturing of products that protect materials of all kinds from environmental degradation. A strong commitment to produce recyclable products made from sustainable resources has been and will be our future policy.

This brochure was developed in collaboration with Chair of Materials Protection, Faculty of Mechanical Engineering and Naval Architecture University in Zagreb.

Cortec® Corporation World Headquarters:
Worlds Largest VpCI®/MCI® Synthesis Plant

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CortecVCI.com and CortecMarine.com

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