A NEW APPROACH TO THE PROBLEM OF CORROSION CONTROL IN MARINE ENVIRONMENT

By Boris A. Miksic

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Boris A. Miksic is a senior research engineer with Northern Instruments, Inc. of Saint Paul, Minnesota where he is presently involved in research on thin film technology. Miksic is an author of several papers on volatile corrosion inhibitors, and is associated with a project to develop a new class of polymer soluble organic corrosion inhibitors. He has been appointed chairman of a Symposium on VCI's to be held in Houston, Texas in accordance with the Annual Congress of National Association of Corrosion Engineers.

The discovery of compounds capable of suppressing metallic corrosion by means of vapor has opened up a new area in the art of corrosion prevention in marine environments. Volatile corrosion inhibitors (VCI) are powerful and effective in solid or liquid state as well as in vapor form. There are many applications in the marine industry where vapor phase corrosion protection is very valuable, having been successfully applied to protect metal parts continuously during operation. For VIC to be commercially applicable for protection of ship's internal surfaces and equipment, it must meet a specific set of requirements, including easy and economical application along with durable and effective anti-corrosion prevention.

Considering the advantages of VCI's they are a logical substitute for conventional systems. Savings in material and labor costs alone are factors to be considered when designing a maintenance program.

How the method works

The transmission of inhibitors by vapors from an emittor to the metal surface to be protected is the principal advantage of vaporization inhibitors. The volatility of the inhibitors is simply a means of transport. The protective vapors disseminate within the enclosed space until the equilibrium determined by their partial vapor pressure is reached. The inhibitors are crystalline solids whose vapor phase is controlled by the structure of the crystal lattice and the character of the atomic bonding within the molecule. The inhibiting process starts when the vapors reach the metal surface and condense on them forming a thin film of crystals. In the presence of even minute quantities of moisture, the crystals dissolve and immediately develop strong ionic activity. The result of such activity is evolution of a molecular layer which creates the breakdown of direct metal-electrolyte contact followed by a substantial increase of hydrogen overpotential.

The recent synthesis of VCI's which would afford corrosion protection to most of the commonly used non-ferrous metals and alloys as well as ferrous metals has eliminated the limitations of traditional VCI. After years of research, development and testing, Northern Instrument, Inc. has introduced a combination of volatile compounds commercially available. (Fig. 1.) Being a mixed inhibitor, the NI-22790 combination is highly effective and protects metals in low ratios per volume of protected space. It provides many years of protection under conditions of high humidity and frequent temperature changes. Field tests showed NI-22790 capable of affording a supplementary protection to coatings at points of imperfection or damage.

Mixed prohibitors are particularly important for applications in salt spray environments, where there are minute portions of activated metallic surfaces developing an anodic type of reaction extremely dependent upon the rate of depolarization of large cathodic areas. Through the formation of local cathod-anode cells, the whole system is involved in the corrosion process. The only safe method of protection is to strongly polarize both cathodic and anodic areas. (Fig.2.)

The problem of protection

The corrosion of a hollow ship's rudder and similar hull voids is due to condensation of moisture during prolonged periods at sea. The high chloride content in the hull void's inner atmosphere, high relative humidity and frequent temperature changes, result in extensive corrosion of internal surfaces.

The conventional method of protection involves application of anti-corrosion paints and cannot be used with confidence because paint film may be locally damaged by the heat of welding or other assembly operations. The application of paint in hull voids is connected with many difficulties because of shape and numerous remote areas. Downtime and number of man-hours spent on surface cleaning, preparation and application of paint represents an appreciable percentage of the total cost spent on ship's maintenance, yet it is difficult to determine if all surfaces have completely been reached by the paint.

Solution of the problem

To remedy some of the difficulties a method of protection using VCI has been developed and field tested. The method involves blowing the inhibitor powder into the hull void with or without an inert gas carrier.

Application requires relatively simple commercially available equipment and the whole procedure can be done in a relatively short time compared to conventional methods.

Step 1 Empty the hull void to approximately 1-inch of vacuum and repressurize allowing the VIC powder to be drawn into the void. The VIC is placed in a funnel with a hose connecting the funnel to the hull void and a control valve in the hose. The quantity of inhibitor needed to protect the void can be determined in accordance with the following empirical formula:

$$Q = 0.0288 \bullet V \bullet C$$

where Q = Total quantity of VCI powder (ounces)
V = Volume of the void to be protected (cubic feet)
C = Confidence factor (2-3)

i. Apply a half of total quantity Q through upper plug (Fig.3)
ii Repeat the process and apply the second half of powder through the lower plug.

Step 2. After the completion of Step 1, empty the hull void to approximately 12 psi and respressurize to ambient using dry nitrogen, repeating the process three times. Inertion with nitrogen is helpful because nitrogen gas partly replaces air and reduces the oxygen and moisture content to create an atmosphere inhospitable to the formation and growth of corrosion. After completion of steps 1 and 2 plugs are reinserted and the hull void sealed. NOTE: The inertion with nitrogen gas can sometimes be omitted if the size and shape of the void are convenient for direct application of VIC powder.

Once the inhibitor is introduced into the hull void it starts vaporizing and creating a corrosion inhibiting atmosphere. There is no longer fear that further assembly operations, such as welding, will interfere and create a breakdown of the protective film in the void and consequently induce corrosion during prolonged service periods. The protective film is continuously renewed as the composed vaporizes and vapors condense. Any accidental breakdown is instantaneously repaired by recondensation of the VCI vapors. A similar method can be used for protection of empty tanks, cargo holds, boilers, condensors, a and turbines, etc. Protection is achieved in a one-step operation blowing premeasured VCI powder by the help of an applicator. (Fig 4)

Protection of ship's equipment

The protection of small enclosures, electric and electronic equipment can be achieved by using one or more VCI device-containers. (Fig. 5.) These devices are constructed so they can be applied in/on any type of equipment where corrosion occurs. There is no limitation on selection of VCI compounds to be integrated into the chemical package of the device-container. A chemical package usually contains a mixture of vapor phase inhibitors, and can also contain a volatile fungistat for the control of fungal growth and a volatile buffer for creating a uniform concentration hydroxyl ions.

Typical form of corrosion occurring in electric and electronic equipment exposed to marine atmosphere is galvanic corrosion. The VIC devices, designated NIC-1, NIC-2, and NIC-3, were proven effective in preventing galvanic interactions between dissimilar metals. Mixed VCI's lower the role of oxygen diffusion as the controlling factor of corrosion reaction, providing protection for all types of galvanic reactions occurring in humid marine atmosphere. Volatile corrosion inhibitors should therefore be considered as substitute for conventional methods because they are effective, economical and easy to apply.

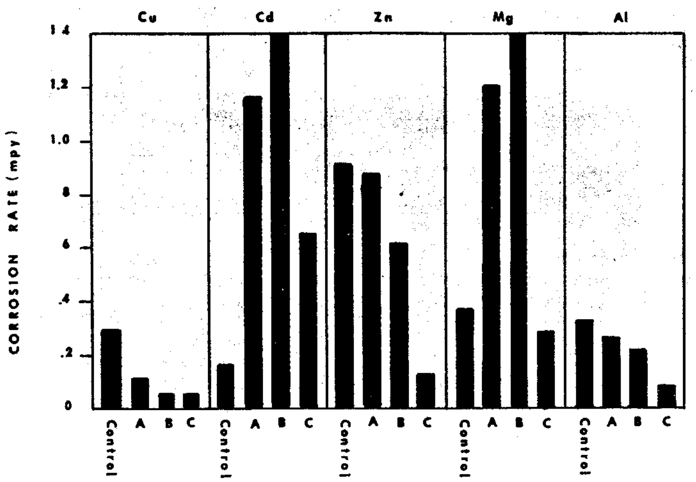

Fig. 1. Effect of VCI's on corrosion rates of non-ferrous metals. A - anodic inhibitor; B - cathodic inhibitor; C - mixed inhibitor; D - no inhibitor.

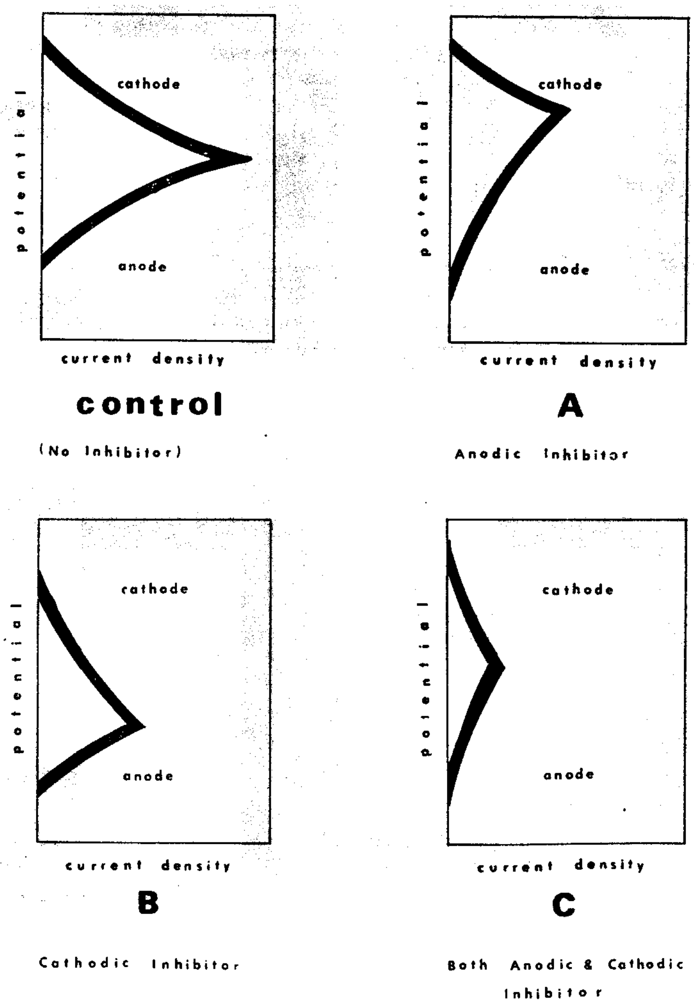

Fig. 2. Qualitative cathodic and anodic polarization curves for steel in absence of inhibitor (control) and in presence of various inhibitors (anodic, cathodic and mixed respectively).

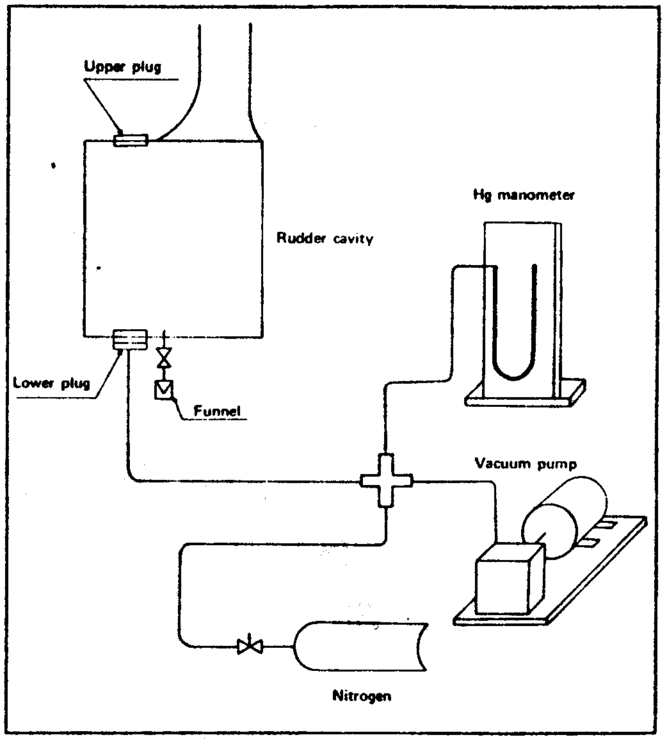

Fig. 3. Application scheme.

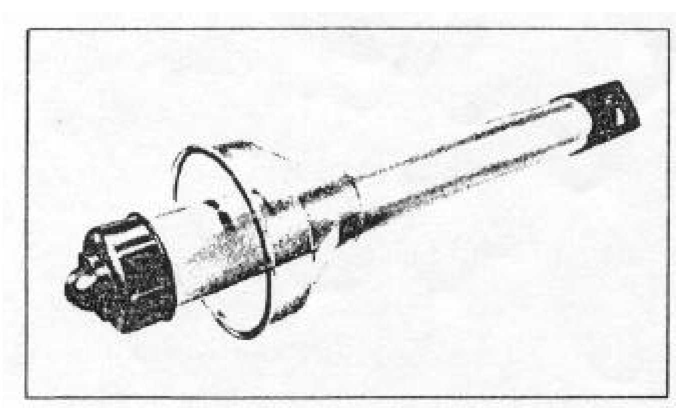

Fig. 4. NI-22790 applicator available in three standard sizes.

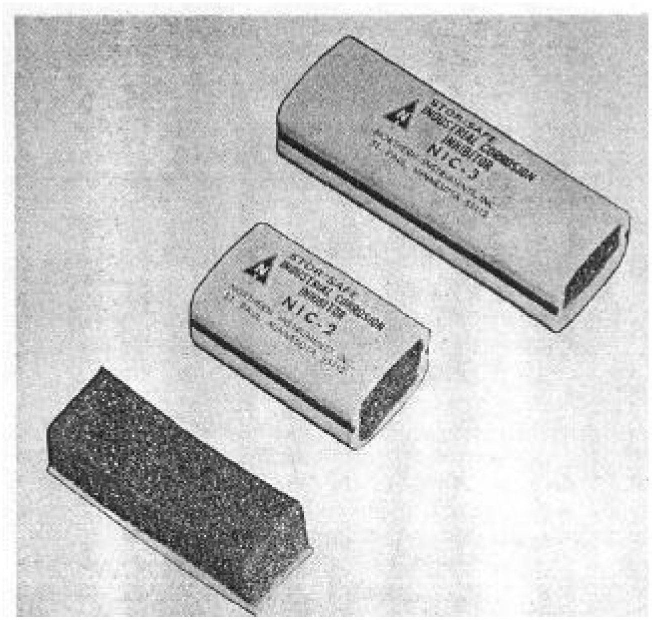

Fig. 5. VCI devices, NIC-1, NIC-2 and NIC-3, for protection of 1½, 5 and 40 cubic feet respectively.