

EFFICIENCY OF THE CATHODE PROTECTION IN THE SPORTS CRAFTS, FISHING AND CABOTAGE BOATS

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Abstract

This paper studies the efficiency of sacrificial anodes in nautical engineering, marine and maritime. The anode design, quality manufacturing process and proper installation are critical processes for maximum protection of equipment and vessels.

The damage, which causes corrosion, can be reduced; can even be avoided by protection methods economically profitable. The predictable future savings will come by the correct use of the current state of knowledge. This acquired knowledge is not always used rationally despite the great progress and current knowledge we have about the physical-chemical corrosion phenomena. Aspects relating to the assembly, distribution and support must be optimized for optimum performance and facilities are properly protected.

Determine guidelines to consider in the design of the equipment (compatibility and incompatibility of the materials), the manufacturing quality of the elements to prevent galvanic corrosion, as in the embodiment of different patterns of maintenance in the case of pleasure craft, fishing boats and coastal represent very substantial costs and losses of the life of the vessels and their vital components.

Keywords

Efficiency, zinc anode, galvanic corrosion, cathodic protection.

1. INTRODUCTION

The economic losses due to corrosion in industrialized countries are substantial. These losses amount to 3.5% of gross national product. Corrosion is responsible for that 1/4 to 1/3 of world steel production, is dedicated to the replacement of damaged metal structures.

These numbers can be considered conservative, since in most cases only include the direct costs relating to preventive measures, as far as maintenance is concerned, or replacement of corroded parts. These costs do not include a real assessment of the derived primary branches of the problem, such as production losses, breakdowns induced by the effect of corrosion (on machinery, hull and equipment of the vessel), the costs of maintenance shutdowns, the safety factors in the design to prevent the problem and decrease the quality of production. This phenomenon affects very considerably to the maritime safety, It's the beginning of many interruptions of operation and sometimes the origin of accidents "unexpectedly".

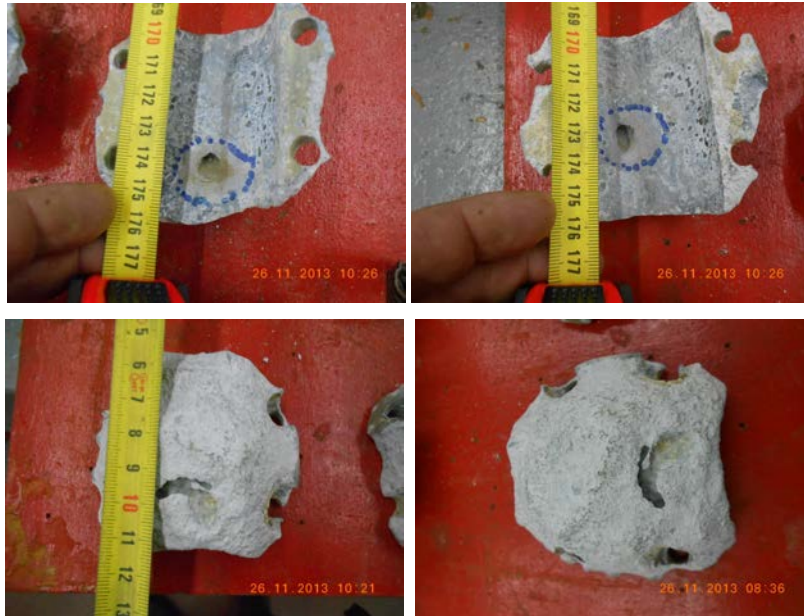
2. PRINCIPAL CHARACTERISTICS OF THE QUALITY OF AN ANODE

The quality standards of an anode directly affect their chemical composition, casting quality, size, weight, shape and attachment method. These aspects are the responsibility of the designer and manufacturer since then are a function of the quality of manufacture. During the tests on different types of anodes we have verified that in certain cases, these quality aspects have not been taken into account rigorously during the manufacturing process. In particular the main defects detected in anodes are related to flatness defects in the contact surfaces when these are designed for attachment to the surface to protect (lack of coupling).

In the majority of the cases, the defects are a result of processes of shrinkage cavity in the casting mold. In other cases, the defects on the surfaces and the detected deformations are a consequence of deformation and alteration of self-casting mold (errors in temperature ranges of manufacture) [3]. The deformations are particularly relevant in special cases, as shown in Figure 1, as in the propeller shaft anodes. The assembly is performed in two halves bolted on the cylindrical surface of the shaft of the boat, very frequent situation in vessels mounted on struts external axes in these cases is observed by simple visual inspection of the contact surface of certain anodes significant losses of the contact surface and consequently loss of protective efficacy in this type of anodes, why manufacturers recommend extreme quality on axis of such anodes or possibly proceed to a grinding surfaces once both halves out of the mold, this correction would significantly improve the effectiveness of these protective elements [1].

The increase in manufacturing quality of the anodes is not only recommended for the anode axis described above, there are the multitude of anodes bolted type for all applications on structures and naval equipment type market, which should be subjected to examination, in order to improve their effectiveness [4]. In particular, the improvements should focus on increasing the quality of the contact surface; this contributing significantly improved the effectiveness of protection.

Figure 1 - Zinc sacrificial anode with defects in the internal and external interface



source: authors

The "quality of the contact surface" (see Figure 2) has to be evaluated during installation and especially during the renovation of a sacrificial anode [2]. There are many factors which contribute to "driving difficult", through the contact surface of the anode, in particular, between the anode and the surface to be protected, this is due to the presence of paint and corrosion products from the anode itself and the element on which it is installed.

These features and more make the installation of a sacrificial anode not be easy.

Figure 2 - Zincs defects in the internal contact



source: author

It is common users of boats or ships, performing installation tasks anodes. The cumulative defects of part (anode quality) and other (quality system), together constitute

an important factor to take into account the high percentage of loss of efficacy in inducing protective issues both these elements work exerted on the vessel [2].

To believe that the cost of sacrificial anodes a small boat is minimal compared to the cost of other aspects of maintenance of the boat itself is widely believed. This is because it is not analyzed and the negative impact and the costs induced by the lack of effectiveness of the anodes on the total costs of maintenance of the boat are valued [5]. For example, we can mention that anodes shaft installed poorly, can induce defects in the propellers and shafts themselves later when the repair processes of these teams are addressed, can mean the renewal of these components in a period much shorter the expected operation

These aspects of manufacturing quality anode affect the contact surfaces. In many cases, we have observed an incorrect cast that affects the anode contact with the carrier deck [8]. This carrier plate of the anode must be embedded in the melting of the material properly. The deck does not have to have porosity, and should be kept at a distance "identified" core. This distance is critical to keep the anode wear progressively throughout the period of protection, but this depends of its anchorage.

Figure 3- Pitting in 316L stainless



source: authors

Another common defect in certain anodes is the appearance during the wear of internal voids resulting in many cases of incorrect casting processes, favoring the occurrence of these defects, which significantly decrease the effectiveness of protection, as shown in the Figure 3.

3. WIRING INSTALLATION

Facilities anodes protection system can be considered a simple electrical circuit, however, the reality is that this simplicity does not correspond to a high percentage of correct facilities, 80% have defects in the electrical system ground (neutral pole).

In Spain, theoretically, electrical installations and wiring therefore ground of the vessels are subject to the Low Voltage Electrotechnical Regulations, whereby an accredited installer can perform electrical installations in a boat or craft. The professionalism and competence of these companies is to spare accredited to carry out this work, which is usually performed in ground facilities. But in certain sectors of boats, often these electrical work is carried out by technical services, whose workers are not specialized in electrical systems and much less in the electric ground, similarly, not all professionals in the electricity sector land know the peculiarities of the power system ground of a boat or craft, so it is common assembly mistakes, this is the fundamental reason why electrical installations are deficient vessels, causing damage from corrosion processes caused by defects (wiring in said ground of the ship or craft). These damages are manifested in increased levels of corrosion of equipment and components installed on board the ships and crafts [8]. Similarly generate electrical damage as a result of referrals from direct current electrical equipment (and hull) and may cause short-circuit situations, overvoltage and reverse polarity, causing serious direct damage to the circuit boards and components telephony equipment, navigation and fishing. Defects in this type of facility, summarized in Table 1.

Table 1 - Defects of the electrical connections of the anodes

Section and route of cables not appropriate
Type, shape and electrical contact terminals not appropriate
Screw terminal connections not appropriate
Anchorage of inadequate connections (painting, isolated elements, etc.).
Accidental polarity inversions by negligence and lack of adequate protection.
Interconnection wiring ground supply of electrical and electronic equipment.
Failure overvoltages connected by combining the same set of batteries for different voltages.

source: authors

3.1. DEFECTS IN THE WIRING INSTALLATION

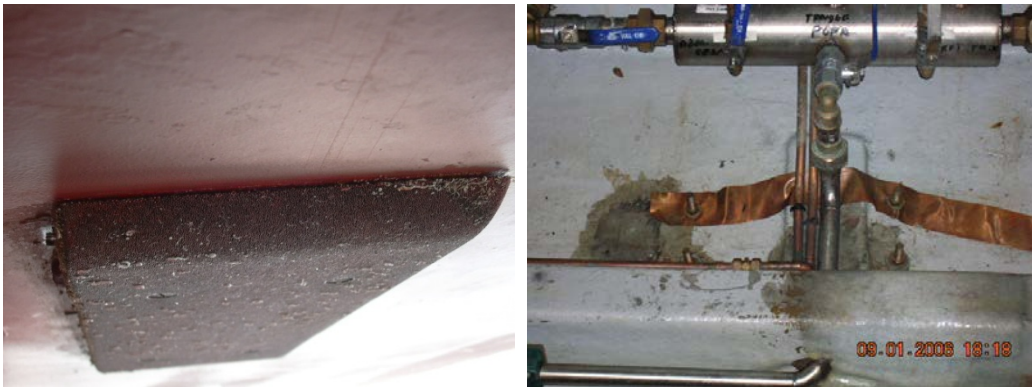
The wiring systems used in the internal connections of the electrical system of ground, not usually meet the rule on the use of color-coding. Typically this is used for wiring of wiring ground not appropriate varied color. This extremely difficult the task of identifying lines and knows who does the same. In small craft, equipped with an electrical system using current batteries, wiring not recommend using red or black color. These colors should be reserved for use in wiring of lighting and power distribution, corresponding to positive and negative pole of 12/24V direct current respectively.

From the technical point of view and based on the code wiring ground must always be designated by the rule, which in any case is the green/yellow wire so that the eye is identified, undoubtedly the driver used in the installation, such ground conductor wiring.

We must distinguish itself boat wiring, the electrical installation of galvanic protection. Usually the general electrical installation complies with the standard, often being the norm is breached in the electrical system circuit ground, especially the failure of the Electrical Regulations is carried out in this circuit. We have found that a high percentage of the technical documentation of boats and crafts does not provide information of the electrical system ground [3]. The main reason is that such facilities are normally required, wired and installed a posteriori (when the boat presents corrosion problems). Nor is often the boat is delivered with a technical study of corrosion, while this study present in 2% of cases consulted.

The facilities of telephony equipment and navigation sector boats, and coastal fishing are supplied without electrical equipment telephone, navigation and fishing have been mounted, and these optional apparatus and therefore installation almost always after the delivery of the vessel by the construction shipyard. In construction projects often aspects of power electronic equipment are stated in the plans. Rarely, detailing the project, ground installations of telephone equipment, sailing, fishing and installation of galvanic protection.

Figure 4 - External porous ground plane



source: authors

In contemporary electronic equipment, require a good ground. In the case of telephones, this ground is critical to obtain a good range and receiving equipment. The type of wiring and the use of the driver and the relevant section ensure that you get the maximum performance of on-board equipment. As a general rule for boats where the ground connection of telephony equipment and navigation is done in the common ground board connector (see Figure 4). We recommend connecting the ground to this element, are carried out safely. So the water and in his absence, the presence of abnormal levels of moisture and water in the bilge does not affect connections altering the contact [7]. This effect can generate leads through the fluid and cause alterations of the connection and wiring deterioration in moisture absorption (by immersion and / or capillary). To avoid this defect, the connections must be sealed or a porous plate placed at a suitable place.

4. PERIODIC CONTROL ACTIONS AND CORRECTION

The majority of the boats in the fishing sector, coastal shipping and recreation craft not perform periodic reviews of the protection system ground. Obviously not control actions are performed and maintenance (preventive or scheduled basis).

The controls on boats and crafts are a visual inspection of the anode in order to assess the conditions of wear. A control as periodic measurement equipment isolation, is not done with the right frequency, or simply never realized [6]. This causes the appearance of leads (which interact with the electric system of galvanic protection ground) producing potential variations can lead to changes in adjoining anodes wear boats moored in the dock itself in which the vessel is affected by the shunt (common in sports marinas, yacht clubs and fishing piers).

To verify the adequacy of the protection provided by the anodes of a vessel, the degree of wear and its evolution (as far as potential protection concerns) there is a team called "electrode potential". In the case of seawater, the electrode set for measurement of the electrode potential is "Silver / Silver Chloride (AgCl)" in mV. The electrode potential provides an accurate measure of the degree of protection for each boat. Professionals working in electronics equipment on ships commonly ignore this element.

The installation of sacrificial anodes, in many cases, stills very little rigorous criteria that are not based on measurements and periodic inspections. Many times its design responds to assessments or estimates randomly accessible points of vessel for installation. In boats for aesthetic reasons sometimes not zincs are placed. Even sometimes rule out a possible drop in speed sails or motor races.

The result of these wrong decisions in many cases involves the appearance of serious corrosion damage to the equipment and components of the boat or craft [1]. These defects cause the occurrence of faults, with the replacement of components and component parts of the equipment of the boat propellers. Such as the onset of corrosion in queues and outboard propulsion systems as well as external cooling components as shown in Figure 5.

Figure 5 - Serious corrosion in tail propulsion elements (power trim cylinders) and other elements



source: authors

In the majority of the cases, the function and the degree of protection of different anodes installed (both the hull and other equipment of the vessel). Connections in the anodes in wet areas of the vessel is unknown, as are bilges, installing connection is incorrect in many cases, not being sufficiently isolated and protected. The aggressive environment deteriorates and disables the connection, for this reason, please control the installation and connection of any anode installed on the bottom of the bilge of the vessel (verifying connections anode itself, as isolation is concerned).

In the installation of anodes in the bilge, internally install a watertight enclosure (with output piped to the upper bound for drivers) that protects the anode or plate ground of the aggressive environment (water and humidity). Failure to do so may decrease or even lose the connection and generate an increase in the rate of wear of the anodes [8]. The

painting is the main factor of the helmet and protective equipment, so that the anodes are willing to protect all small deficiencies that may occur in the progressive deterioration of this protection. Often the protective lining of the helmet and equipment be altered, for very different reasons, the final result being that the protection of hull plating and equipment is altered and diminished. In this case, protection systems act sacrificial anode, but the progression is disrupted and wears quickly, which eventually causes degradation and wear involving the elimination of such protection prematurely (see Figure 6).

In steel-hulled boats, paint protection thereof, is altered by the passage of time, appearing small dots of corrosion as they increase in number produce a detrimental effect on the anode produces accelerated wear. This reason makes no anodes protect the town during the groundings for maintenance. It is convenient to conduct periodic assessments of the state of the coating of the hull, propulsion systems and external elements installed as a surface protection is concerned [6]. We must assess the areas that may be exposed to corrosion processes. In many cases the best solution is to proceed to blast the surface to restart the implementation of various protective layers of paint coating that culminate with the application of antifouling paint on the hull.

When vessels have many deficiencies in the hull, the right decision is to renew the coating layer. This ensures good adhesion of the paint coating.

Figure 6 - Effects of severe corrosion



source: authors

In the case of machinery exposed to the corrosion process must distinguish between arranged inboard engines and equipment, as in the case of central provision propulsion

machinery and other equipment associated with these. This is the case of gearboxes, generators and other auxiliary equipment such as pumps of different services. In these cases the corrosion phenomena often focus primarily associated equipment such as heat exchangers and cooling circuits saltwater manufacturers generally endow their engines properly installed sacrificial anodes on the tops of the heat exchange components [4]. Often in the operation manuals and maintenance of the engine, the location of these anodes indicated, but usually the replacement approach is based on performing periodic visual inspections, some manuals indicate that at least should be checked and renewed annually.

The reason for this is not concrete aspect is that each engine reacts very differently to the phenomenon of corrosion, the main cause is that when you install the engine in the ship is part of a new set as potential corrosion concerns, because in the process of installing the engine in question integrates and interrelates with other system components, gear, tail shafts, pumps, electric battery system, cooling manifolds and other associated equipment, so that that end cohesion is dependent of the potential for corrosion of the set.

5. INCOMPATIBILITIES FOR INTERFERENCES

A decade ago, the boats did not have lots of telephony equipment and navigation, as is currently the case. Whether fishing, as cabotage and even the enjoyment of pleasure craft, were based on the experience of the crew. The teams were initially basic: telegraph, probe and navigation through the stars, there are now plenty of equipment aid to navigation, safety equipment and fishing, which make the cockpits of the boats are true electronic rooms. This has caused the electrical systems on ships and boats are complex. This fact implies that ships and boats (including boats) are to be clearly distinguished galvanic electrical installations protection, other facilities, both strength as lighting and especially the telephony equipment and navigation.

In the majority of blood vessels of these lines is continuing batteries and comes from 12 or 24V DC The current telephony equipment and navigation are not exempt from these facilities be disturbed if not satisfactorily meet a number of technical requirements.

5.1. ERROR GROUND ELECTRIC INTERPRETATION

A classic error is committed in numerous boats to consider the electrical system ground galvanic action is a good place to connect the ground negative (-) battery power and start the boat. In fact, most of the engines installed on vessels currently available and had until recently good systems unipolar system, as the start-up or starter motor takes power positive (+) battery starter and the negative of the same battery is securely connected to the engine block so that the block itself makes this negative conductor [3] [7].

Similarly, almost all the equipment associated with motor operating under the same principle. If now installed in the hull zincs different galvanic protection and engines and equipment connected to them to ensure their protection, will be the ship's electrical system with ground connected. Clearly, the system should not present any problem, since the negative pole that connects the whole only required to close the DC circuit, but when the boat, as in almost all cases, has telephony and navigation equipment installed on board, it is clear that the negative of these teams will also be grounded in this type of

installation, the system can operate and obviously works, but it does until a derivations appears. These derivations are produced by the presence of humidity and the very aggressive environment causes frequent referrals, generally these leads are sources of interference and faults in equipment operation. When the branch is derived directly (for example the starter is derived), in this case, all the computers are connected on board both telephony and navigation and other components suffer damage to their electrical circuits and electronics that make them unrecoverable.

6. NEED OF PERIODIC CHECKS

If possible actions to take to prevent serious malfunctions and defects in the installation of cathodic protection of a ship are analyzed, the most appropriate way to do this is from the maintenance of the ship or boat. Since it the galvanic protection essentially an electrical installation, the work of logic to perform maintenance on it not much different from those applicable to any industrial electrical installation.

There have been several electrical maintenance aspects treated in the development of this paper, all of them are well known and commonly used in industrial facilities, periodic measurements of insulation equipment status check circuit interconnections ground, etc. No clutch no issues concerning the maintenance of such facilities often are unknown, these issues affect aspects such as fixing the zincs, distribution, degree of wear, the type of material etc. Those aspects that should the industrial field and thus commonly not be controlled from the standpoint of maintaining a programmed manner, much less preventive [8].

The facilities of cathode protection must surrender from periodic form to reviews if there wants to be obtained the maximum degree of protection of the same ones, his special characteristics and the aggressiveness of the marine environment make advisable the production of protocols and procedures both of installation and of measurement and control of these facilities since any alteration or disturbance suffered by these facilities will be a producing direct reason of serious hurts in the equipment of on board.

It is advisable to proceed to the measurement of the potential of the craft (electro silver / chloride of silver) of periodic form, as minimum every six months independently of if the craft sails or remains static in port.

CONCLUSIONS

- An error in the installation of anodes is to think that the electrical system of ground of galvanic action is a good point to connect the negative of ground (-) of the batteries of supply and takeoff of the craft.
- The increase in the quality of manufacture of the anodes has to of centring on increasing the quality of the surface of contact, contributing notably in the efficiency of the protection.
- The accumulated defects of a part (as anode) and another (quality system) together constitute an important factor to consider, for the loss of effectiveness in inducing both protective labor issues.
- A check every six months the potential of the boat (electro silver / silver chloride) regardless have whether the boat is in port or remains static, avoid future problems in the joint facility of the boat or craft.

- The greatest cost savings, which causes corrosion, will come from better use of the knowledge already acquired, with proper application, dissemination and control of the state of current knowledge.

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